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UNITED NATIONS ENVIRONMENT PROGRAMME

*Environmental problems of  
the marine and coastal area  
of Maldives: National Report*

*UNEP Regional Seas Reports and Studies No. 76*

## PREFACE

The Regional Seas Programme was initiated by UNEP in 1974. Since then the Governing Council of UNEP has repeatedly endorsed a regional approach to the control of marine pollution and the management of marine and coastal resources and has requested the development of regional action plans.

The Regional Seas Programme at present includes ten regions<sup>1/</sup> and has over 120 coastal States participating in it. It is conceived as an action-oriented programme having concern not only for the consequences but also for the causes of environmental degradation and encompassing a comprehensive approach to controlling environmental problems through the management of marine and coastal areas. Each regional action plan is formulated according to the needs of the region as perceived by the Governments concerned. It is designed to link assessment of the quality of the marine environment and the causes of its deterioration with activities for the management and development of the marine and coastal environment. The action plans promote the parallel development of regional legal agreements and of action-oriented programme activities<sup>2/</sup>.

In May 1982 the UNEP Governing Council adopted decision 10/20 requesting the Executive Director of UNEP "to enter into consultations with the concerned States of the South Asia Co-operative Environment Programme (SACEP) to ascertain their views regarding the conduct of a regional seas programme in the South Asian Seas".

In response to that request the Executive Director appointed a high level consultant to undertake a mission to the coastal States of SACEP in October/November 1982 and February 1983. The report of the consultant on his mission was transmitted to the Governments of the South Asian Seas region in May 1983, and the recommendations of the Executive Director were submitted to the Governing Council at its eleventh session.

By decision 11/7 of 24 May 1983, the UNEP Governing Council noted "the consultations carried out in accordance with Council decision 10/20 of 31 May 1982" and requested "the Executive Director to designate the South Asian Seas as a region to be included in the regional seas programme, in close collaboration with the South Asia Co-operative Environment Programme and Governments in the region, and to assist in the formulation of a plan of action for the environmental protection of the South Asian Seas".

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<sup>1/</sup> Mediterranean Region, Kuwait Action Plan Region, West and Central African Region, Wider Caribbean Region, East Asian Seas Region, South-East Pacific Region, South Pacific Region, Red Sea and Gulf of Aden Region, Eastern African Region and South Asian Seas Region.

<sup>2/</sup> UNEP: Achievements and planned development of UNEP's Regional Seas Programme and comparable programmes sponsored by other bodies: UNEP Regional Seas Reports and Studies No. 1. UNEP, 1982.

As a first follow-up activity to decision 11/7 of the Governing Council, the Executive Director convened, in co-operation with the South Asia Co-operative Environment Programme (SACEP), a meeting of national focal points of the States of the region in order to seek their views on how to proceed in developing a comprehensive action plan for the protection and management of the marine and coastal environment of the South Asian Seas region (Bangkok, Thailand, 19-21 March 1984).

The meeting discussed the steps leading to the adoption of an action plan and reached a consensus on the items to be considered for further development of the action plan<sup>3/</sup>.

The meeting recommended that the Governments, with the assistance of UNEP and other organizations as appropriate, should initiate the preparation of country reports reviewing their:

- national environmental problems defined as priority areas of regional concern;
- activities which may usefully be carried out under the action plan to resolve or mitigate these problems; and
- national institutional and manpower resources which are, or may be, involved in dealing with these problems, including the identification of the need to strengthen their capabilities.

It was also recommended that UNEP prepare in cooperation with SACEP, and other organizations as appropriate:

- a draft overview report, based on the country reports, reviewing the environmental problems of the region defined as priority areas;
- a document addressing the essential legislative aspects relevant to the action plan; and
- a draft action plan reflecting the conclusions of the country and regional reports.

The present document is the country report on environmental problems in Maldives prepared by experts designated by the Government of Maldives. The assistance of a consultant, A.H.V. Sarma, was provided to the Government of Maldives to facilitate the preparation of this report. The authors' contributions are gratefully acknowledged.

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<sup>3/</sup> Report of the meeting of national focal points on the development of an action plan for the protection and management of the South Asian Seas region, Bangkok, 19-21 March 1984 (UNEP/WG.105/5).

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## INTRODUCTION

The Republic of Maldives is an archipelago consisting of a double chain of 22 coral atolls resting on a submerged mountain range and spread over an area of over 1 million km<sup>2</sup> of the northern-central Indian Ocean. It lies 750 km south-east of Sri Lanka and extends over 850 km in a north-easterly direction from 7°06'N to 0°42'S latitude between 72°31'E and 73°44'E longitude. The Maldivian archipelago is situated between two other archipelagoes. To the north, linked by the island chain Minicoy between the 8° and 9° channel, is the Laccadives archipelago, while 500 - 600 km to the south of the most southerly atoll of Addu, is the Chagos archipelago. The atolls are comprised of over 2,000 islands, only 215 of which are inhabited. The islands are small, with an average size of about 0.7 km<sup>2</sup> only, none being larger than 13 km<sup>2</sup>, with a total land area of about 260 km<sup>2</sup> for the entire archipelago. The islands are for the most part transient, building and eroding at a rapid rate. Large populated islands have completely disappeared within the memory of living natives, and because of this transient quality, the natives talk of reef types rather than islands. Many newly formed islands are nothing but sand banks a few centimetres above the sea level where some pioneering plant species and sea-birds colonize.

Most of the large islands have been planted with coconut palms among several species of succulent scrubs and low undergrowth that flourish on coral sand. A few islands have even developed large evergreen trees which eventually become small scrubby jungle growth.

The total population of the islands in 1982 was estimated at 160,000 (doubled since 1911), with a high population density of 600 persons per km<sup>2</sup>. Male, the capital, has a population of 40,000, which is expected to reach 65,000 by the end of the century. It is estimated that the population will level out at this peak for lack of land area.

The most important atolls are Addu, Ari, Fadiffolu, Felidhu, Hadummathi, Huvadhu, Madhosmadulu, Maladummadulu, Male and Mulakku atolls. The most important islands are the capital of Male, and Gan at the southern most extremity of Addu atoll (lying south of the equator).

The island surface consists of coral sand with scarcely any topsoil, which hardly supports vegetation other than coconuts and scrubby growth. Only 10 per cent is cultivated land (2,600 ha), mostly distributed on Thiladummathi, Huvadhu and Hadummathi atolls. Tropical fruits and vegetables such as breadfruit, coconut, pineapple, colocasia and banana are cultivated, and form a substantive part of the diet of the islanders. Millet, corn, pumpkin, sugarcane, and almonds are also cultivated to a much lesser extent.

The chief industry of the country is fishing, and fish forms one of the staples in the Maldivian diet. The annual export value of fish, exported mostly in the form of sun-dried "Maldivian fish", accounts for 90 per cent of the country's total exports. But the fisheries is organized on a small scale and technologically limited to local fishing grounds. Livebait fishing for tuna is the most common fishery. 35,000 tonnes of fish was landed in 1981, of which skipjack tuna alone accounted for 21,000 tonnes with an average catch per unit effort of 140 kg. Huvadhu and Madhosmadulu atolls were the most productive with annual landings of 6,400 and 5,300 tonnes respectively.

Major exports from the coral reefs are molluscan shells (40 to 50 tonnes), red coral products (25 tonnes in 1980), turtle shells (6 tonnes in 1977) and live ornamental fish (44,000 numbers in 1981). Export of black corals and turtle shells from Maldives is now prohibited and coral products are mostly exported in processed form only (such as jewellery). Plans are underway for declaring some atolls as biological preserves and/or sanctuaries for conservation purposes.

## THE PHYSICAL ENVIRONMENT

### Climate and seasons

Although located in the tropics, climatic conditions of the Maldives are equable being governed by the two monsoons, the south-west blowing from April to August and the north-east from October to February, bringing ample rains and cool winds to the islands. Rainfall is well distributed throughout the archipelago.

The average rainfall in the region amounts to about 1,950 mm per annum and is fairly well distributed throughout the year except for the January-March period which is considered to be the dry season. The country enjoys a typical tropical-island climate with the average daily temperatures ranging between 24° and 30°C. There is not much seasonal variation in temperature.

### Waves, tides and ocean current regimes

Tidal data for the area are scarce, but the U.S. Naval Hydrographic Office (1951) states that the mean high water intervals for Mukundu atoll in the north is 10 hrs 20 mins. Spring tide range on an average is about 1 m. Mean tide range is about 0.7 m. Tidal streams are irregular and much variation occurs because of the presence of numerous sand banks and shallow shoals.

The prevailing monsoon wind pattern regulates the seasonally reversing oceanic currents. In the northern parts of the Maldives the cross-bank currents move westwards from December to April, during the north-east monsoon season; they move more or less in an easterly direction from May through August during the south-west monsoon season.

### Soils, sands and sediments

Being exclusively of coral origin, the islands of the Maldives are composed of coral rock base, coral rubble and coral sand. The beaches are covered solely with sugar-white coral sand which provides the main attraction to the tourists. As mentioned previously, the islands have scarcely any top soil, and lacking fertility are therefore mostly unsuitable for cultivation.

### Swamps and wetlands

Being small islands of coral origin, none of which is larger than 13 km<sup>2</sup> and with an average size of only 0.7 km<sup>2</sup> land surface, the country does not have any rivers, lakes or other inland water bodies.

The islands are low-lying with an average elevation of not more than 1.5 - 2 m above mean sea level. The higher elevations tend to be located towards the seaward side of the islands and the inner shores are frequently marshy. However, because of the limited total land surface of the islands and the relatively small tidal range, such marshy areas are rather small and rarely acquire any ecological importance as habitats. Small clusters of pioneering mangrove species are often seen to colonize the seaward side of these marshes on the inner edge of the lagoonal beach. The most important mangrove species are Avicennia marina, Bruguiera cylindrica, Rhizophora mucronata, Sonneratia caseolaris and S. acida.

## MARINE RESOURCES AND SPECIALISED ECOLOGICAL AREAS

### Non-living (non-renewable) resources

#### Offshore oil, gas and minerals

There has not been any exploratory work for offshore oil, gas or minerals in the waters of the Maldives. However, there has been some preliminary work on the geophysics and seismics in the area to evaluate the potential for the existence of any such deposits, but the chances are rather remote. The archipelago rests on a submerged mountain range which is probably of volcanic origin, and although the reefs are of an average depth of 20 - 30 fathoms (1 fathom = 1.8 m), the open ocean just outside the reef often dips down to 2,000 fathoms and the technology for the exploration and/or exploitation of these deep waters are still prohibitively costly.

#### Construction materials

Coral rocks, rubble and sand are the only materials available in the country for construction purposes and are therefore extensively mined for constructing houses, walls and other structures. Skin-divers from sail-boats collect the coral rock and sand materials from lagoonal and sand bank areas of not more than 2 m depth in the Male atoll within an average travelling distance of not more than 1 - 2 hours from the capital island of Male. Most of the coral mining is concentrated around the islands of Mamigilili and Thimarafushi. About seven sailing boats (locally called dhonis) are engaged in such mining everyday. The mode of mining is rather primitive, by skin-diving, and a boat collects about 2 m<sup>3</sup> of coral rock which is carried out by 4 divers. According to the statistics maintained by the Department of Public Works and Labour, the amount of coral material mined during the last 5 years is as follows:

|      |                     |
|------|---------------------|
| 1980 | 202 m <sup>3</sup>  |
| 1981 | 1314 m <sup>3</sup> |
| 1982 | 6963 m <sup>3</sup> |
| 1983 | 6325 m <sup>3</sup> |
| 1984 | 6049 m <sup>3</sup> |

According to law half the quantity of coral rock mined is given to the government for public works. Most of the mined materials are used for construction work on Male itself. Coral chips and blocks are used for concrete manufacture and for construction work. Coral and sand is also used for surfacing the roads on Male. There is very little mining for coral on the other atolls. The demand for mined material is expected to increase for the currently envisaged development projects.

There are reports of several sand banks and coral shoals around Male disappearing because of such mining, and Fedifinou island almost completely disappeared because of extensive sand mining. In such cases, the divers move over to other nearby sand banks for mining.

In order to avoid user conflicts, legislation has recently been promulgated which defines areas for such mining. According to this legislation, coral and sand mining can now be undertaken only on reefs, and is banned on or around inhabited islands. However, the inhabitants of the islands are allowed to mine coral and sand on their island for private use only.

### Living (renewable) resources

#### Seaweeds

The seaweeds of the Maldives have been studied during several scientific expeditions but most of the studies have been taxonomic in nature giving the list of species recorded with very limited observations on their extent, distribution, zonation and ecology. The Stanley Gardiner Expedition, Percy Sladen Expedition, John Murray Expedition and the Siboga Expedition describe 17 species of red algae, 5 green algae and 2 brown algae. The Cambridge Expedition added 7 species of blue-green algae, 20 red algae, 25 green algae and 7 brown algae to this list and Sigee (1966) published ecological notes on some of these algae. The Vega cruises undertaken as part of the International Indian Ocean Expedition made extensive collections of seaweeds from 9 atolls and Hackett (1977) also made some studies on the zonation and distribution of these species in several habitats. Based on the collections made so far on the above several occasions, 163 species of red algae, 83 green algae, 21 blue-green algae and 18 brown algae have been reported from the Maldivian waters including one new species of Dictyurus. The most abundant species belong to the genera Chondria, Laurencia, Hypnea, Polysiphonia, Lithophyllum, Tydemania, Acrochaetium, Padina, Ceramium and a large number of calcareous species.

#### Fisheries

As mentioned above, the main industry of the country is fisheries. The entire fisheries of the country is marine in nature as the country is an oceanic island nation. Annual export value of fish, exported mostly in the form of sun-dried "Maldivian fish", accounts for 90 per cent of the country's total exports. But the fisheries is organized on a small scale and technologically limited to local fishing grounds. Livebait fishery for tuna is the most common fishery. 35,000 tonnes of fish was landed in 1981, of which skipjack tuna alone was 21,000 tonnes with an average catch per unit effort of 140 kg. Huvadhu and Madhosmadulu atolls were the most productive with annual landings of 6,400 and 5,300 tonnes respectively.

#### Mariculture

Aquaculture has not been practised in the country so far, but there is potential for its development in the vast shallow lagoon areas around numerous islands. The Government is aware of the potential for the development of mariculture, but lack of trained technicians and funds are some of the major constraints.



#### Other marine living resources

Being the largest coral atoll growth in the world, the country has vast resources of shell-fish, sponges and other species that grow in association with coral reefs and are commonly found in the reef region, although the extent of this resource has not, so far, been investigated. The major exports of products originating from the coral reefs are molluscan shells (40 - 50 tonnes), red coral products (25 tons in 1980) and turtle shells (6 tons in 1977). There has also been collection of shells and coral as souvenirs by tourists and for sale to tourists around the resort areas in recent years, which has not been quantified so far. Collection and export of black coral and turtle shells in any form, and other coral products in "unprocessed" form from the country are now prohibited by law. Coral products are nowadays mostly exported in processed form only, such as rings, bangles, amulets, necklaces and other jewellery, and a small scale handicraft industry for such products has recently developed in some islands around the tourist resorts. As this is still undertaken on a rather small scale, it should be expected that this does not pose any threat to the exploited resources at least in the near future. Plans are underway for declaring some atolls as biological reserves and/or sanctuaries for conservation purposes.

The archipelago is considered to be an important breeding ground for marine turtles in the Indian Ocean region. However, very little work has so far been done on their taxonomy, extent, distribution, ecology and lifecycle on the islands and atolls. Deraniyagala (1956) reported 4 species of turtles as breeding on Male atoll, viz. Chelonia mydas, Dermochelys coriacea, Caretta caretta gigas and Eretmochelys imbricata. As an initial step towards their conservation, collection and export of turtle shells from the Maldives have now been prohibited by law.

It is known that some species of oceanic birds colonize and nest on certain islands and atolls. The islanders eat any bird that has webbed or semi-webbed feet. Very little information is available on these bird colonies and no scientific study has so far been undertaken. During the Stanley Gardiner Expedition, Gadow and Gardiner collected 24 species of birds from the Maldivian atolls. Philipps and Sims (1958) recorded 63 species of birds from the islands, of which 15 were described as resident breeders and only 2 species of terns (Sterna spp.) as visiting breeders. It was also reported that the Lesser frigate (Fregata ariel iredalei) colonize and breed on Mahlosmadulu atoll from where they are caught and sold live on the market. Several species of terns also breed in large colonies on some islands. Hackett (1977) reported a tern rookery on Filadu island in Tiladummati atoll.

Sightings of dolphins, porpoises and whales in the Maldivian waters have occasionally been reported, although whales are rarely known to enter the shallow and narrow waters between the atolls. Deraniyagala (1956) recorded the toothed dolphin, Delphinus delphis from the Male atoll. The islanders recognise the toothed dolphin, a long-beaked edentulous form and a toothless form, which, according to Deraniyagala is probably the beaked whale, Ziphius cavirostris indicus, which is often found in Sri Lanka waters.

Of the island fauna, Philipps (1958) recognised 3 species of birds and the flying fox Pteropus giganteus ariel as indigenous to the Maldives.

## Ecosystems, habitats and specialised ecological areas

### Seagrass beds

Studies on the seagrasses of the Maldives are very scanty. Hackett (1977) mentioned that flats of Cymodocea and Thalassina are rare and tuft development is sparse in all the 9 atolls studied by him (for seaweeds). Seagrasses occur mostly on seaward reefs or adjacent to channels crossing the atoll rim, although small tufts of Thalassina may grow in almost any protected area. In the northern atolls, flats are composed of Cymodocea rotundata with some Thalassina hemprichii, which is usually poorly developed. Thalassidodron ciliatum was recorded from the Addu atoll.

### Mangrove swamps and forests

There are no mangrove swamps or forests worth the name in the country and suitable habitats for the establishment and growth of mangrove species are very rare. However, small clusters of mangrove plants are occasionally seen here and there in protected sites along lagoonal beaches on a number of islands such as Feladhoo, Kelaa and Kuludhuffushi, all of which are in various stages of establishment. The mangrove species recorded from these islands are Avicennia marina, Bruguiera cylindrica, Rhizophora mucronata, Sonneratia caseolaris and S. acida. Avicennia marina is the primary pioneering species.

### Coral reefs

The atolls of Maldives are distinguished by the formation of Faros or small atoll-shaped reefs round their rims. Microatolls and patch reefs/knolls are also known from the Maldives. Although the major part of the Maldivian coral reefs are yet to be investigated, they are still the best-known of all coral reefs in South Asia.

Investigations on the coral reefs of Maldives probably date back to Moresby's expedition to the atolls during 1834 to 1836. However, these reefs were first studied in depth during Stanley Gardiner's expedition to the islands during 1899-1900 (Pillai and Scheer, 1976). The results of his expedition were published in two volumes (Gardiner, 1903-1906) containing elaborate discussions on the reef formations of Maldives and Laccadives, and systematic analyses of the zoological and botanical specimens collected. Gardiner was followed by Alexander Agassiz, who spent two months cruising through the whole archipelago in 1901-1902 (Agassiz, 1903). However, his work is of less value when compared with that of Gardiner (Stoddart, 1966).

Deraniyagala made a collection of specimens from the Maldivian reefs in 1932 for the Colombo Museum (Deraniyagala, 1956). This was followed by the John Murray Expedition led by R.B. Seymour Sewell (1933-1934) which conducted gravity surveys and deep soundings in the Maldives and published physiographic descriptions of Addu and Goifurfehendu atolls (Sewell 1936, 1936a).

Although several subsequent expeditions visited the Maldives, no major contributions were made to the knowledge of the corals and coral reefs of these islands until the 'Xarifa' Expedition led by Hans Hass (1957). Based on the work done in Addu atoll during this expedition, Hass (1962, 1965) formulated a new hypothesis on atoll formation. Further, Pillai and Scheer (1976) described and summarized the geographical distribution of 143 species of hermatypic corals belonging to 49 genera and 4 ahermatypic corals belonging

to 3 genera collected during this expedition. They also listed a total of 241 species of corals belonging to 75 genera from the Maldives together with their known occurrence in the various atolls.

Subsequent major attempt to study the reefs of the Maldives was made in 1964 by a team of scientists from the University of Cambridge led by D. R. Stoddart (1966). They studied the geomorphology of Addu atoll and zonation of corals (Stoddart, Davis and Keith, 1966; Davis, Stoddart and Sigee, 1971; Stoddart, 1972), coral fauna (Wells and Davis, 1966; Clark and Davis, 1966) and other aspects of the Maldives. Purdy (1981) presented a new insight into the possible evolution of the Maldivian atolls based on a combination of seismic stratigraphy and the results of a single well.

Despite the work done by several expeditions, information on the corals and coral reefs of Maldives are restricted to a handful of atolls, of which Addu atoll has been the center of attention.

#### Reef zonation

The reefs of Maldives have been described by Gardiner (1903-1906), Sewell (1936), Kohn (1964), Stoddart (1966) and Scheer (1972). Scheer (1971), commenting on the reef zonation of atolls in general and the atolls of Maldives in particular, stated that: "As far as atolls are concerned, there are the outer reef slope, the groove-and-spur system, the outer reef, etc. Leeward and windward reefs are distinguished. Concerning the lagoon reef the expressions reef flat, reef edge, reef slope, and lagoon floor are used". A diagrammatic view of the general zonation of Maldivian reefs is given in Eible-Eibesfeldt (1964). It is also possible to divide these reefs into zones based on biological criteria. Davies, Stoddart and Sigee (1971) were able to distinguish several biological zones on the Maldivian reefs studied by them. For the windward side lagoon reefs at Gan, Addu atoll they were able to recognize the following zones and sub-zones:

Reef flat - the region between the shore and the reef edge (rim). The following sub-zones were recognized in this zone:

- Inner zone - nearest to the shore and characterized by the absence of living corals;
- Mixed zone - characterized by the presence of living corals which increase in number with increasing distance from the shore;
- Acropora formosa zone - a mixed zone characterized by the presence of forests of Acropora dominated by Acropora formosa. Coral cover increases to 60-70 per cent through this zone towards the lagoon; and
- Outer zone - a mixed coral associated with large hemispherical massive corals forming an important component.
- Reef-edge - the reef edge (rim) including the upper 3 m of the reef slope was considered by Davies, Stoddart and Sigee (1971) to be the most vigorous zone of coral growth. This zone is characterized by a luxuriant growth of foliaceous corals. Massive corals present; colonies small.

Reef-slope - a mixed coral zone. Percentage live coral cover decreases with increasing depth.

For the seaward reef at Gan, Addu atoll, Davies, Stoddart and Sigeo (1971) recognized the following zones and sub-zones:

Seaward reef flat - a zone extending from a narrow steep beach to the reef-edge (rim) and divided into four sub-zones:

- Rubble zone - exposed at low tides and composed of small boulders, usually 0.25 m or less, but occasionally upto 1 m in diameter. Pools containing living corals present;
- Reef flat platform - a zone formed of coral rock, widely scattered colonies of *Heliopora* and *Porites* present in areas covered with water at low tides;
- Moat zone - a zone covered with at least several centimeters of water even at lowest low tides. Algal growth less luxuriant than further seaward. Percentage cover by living corals less than 5 per cent; and
- Algal ridge or platform - the outer zone of the reef flat formed by encrusting algae of the *Porolithon* type. It rises to a level slightly above that of the main reef flat platform and is exposed only at extreme low water. At low tide, water breaks outside this zone. Growth of algae near the edges of surge channels is luxuriant.

Reef edge - formed almost entirely by the growth of calcareous algae.

Seaward reef slope - groove and spur formation well developed on the reef front in some areas. The steepness of the slope increases beyond 25 m depth as compared to shallower areas.

The Maldivian reefs have a high diversity of coral species with a total of 241 species of hard corals belonging to 75 genera (Pillai and Scheer 1976). Available information indicate that many of the reefs studied in the Maldives are in a fairly good condition with a live coral cover of between 70 - 80 per cent for Addu atoll, 40 - 70 per cent for Rasdu atoll, 60 - 90 per cent for Fadiffolu atoll and 20 - 50 per cent for Ari atoll (Scheer 1974). There is no mention of any human or other factors contributing to the deterioration of the Maldivian reefs. Although coral rock is used in some islands as building material and some reefs have traditionally been exploited for fish and shells, no information is available on the impact of these activities on the coral reefs of these islands. Sporadic use of explosives to catch fish is apparently carried out in some islands.

An ESCAP/SACEP Overview of Coral Reefs in the South Asian Region (1985) concluded that coral mining and souvenir collection are the major causes of coral reef degradation in the Maldives so far. The impacts of recreational activities on coral reefs are also beginning to be felt around the island resorts.

Spear-fishing was indiscriminately practised by the tourists around such resorts until it was recently banned in the country by legislation. However, there are occasional reports of spear-fishing still being practised around tourist resort islands which is very difficult to control for lack of regular surveillance and enforcement machinery. There are also reports of sporadic use of explosives for fishing on the reefs.

Ornamental fish are collected in some coral reefs by private parties for export purposes in recent years, and there are unconfirmed reports that certain species of ornamental fish have already been locally depleted in some parts of the exploited reefs, but this is yet to be scientifically investigated. Export of ornamental fish from the country is now controlled by law, which stipulates the maximum number of fish that may be exploited from the country every year. 44,500 live ornamental fish were exported in 1981.

#### Island ecosystems

The Republic of Maldives is an island nation of over 2,000 islands spread over 22 coral atolls in the northern central Indian Ocean. The islands are small, the average size being about 0.7 km<sup>2</sup>, and none is larger than 13 km<sup>2</sup> with a total land area of about 260 km<sup>2</sup> for the entire archipelago. The islands are exclusively of coral origin and low-lying with an average elevation of about 1.5 to 2 meters above sea level. The islands are for the most part transient, building and eroding at a rapid rate. Large populated islands have completely disappeared within the memory of living natives, and because of their transient quality, the natives talk of reef types rather than islands. Many newly formed islands are nothing but sand banks a few centimeters above the sea level where some pioneering plant species and sea-birds colonize. The higher elevation tends to be located towards the seaward side of the island and the inner shores are frequently marshy. Based on their utility to man, four main types of islands may be differentiated as follows:

- the capital island of Male;
- fishing village islands;
- tourist resort islands; and
- uninhabited islands usefully leased to individuals and used for coconut cultivation and agriculture.

The most important atolls are Addu, Ari, Fadiffolu, Felidhu, Hadummathi, Huvadhu, Madhosmadulu, Maladummadulu, Male and Mulakku atolls. The most important islands are the capital of Male, and Gan at the southern most extreme of Addu Atoll (lying south of the equator).

The total population of the islands in 1982 was estimated at 160,000 (doubled since 1911), with a high population density of 600 persons per km<sup>2</sup>. Male, the capital, has a population of 40,000, which is expected to reach 65,000 by the end of the century. It is estimated that the population will level out at this peak for lack of land area.

The island surface consists of coral sand with scarcely any topsoil, which hardly supports any vegetation more than coconuts and scrubby growth, and cultivable land is only 10 per cent (2,600 ha) of the land area, mostly distributed on Thiladummathi, Huvadhu and Hadummathi atolls. Tropical fruits and vegetables such as breadfruit, coconut, pineapple, colocasia and banana are cultivated, and form a substantive part of the diet of the islanders. Millet, corn, pumpkin, sugarcane, and almonds are also cultivated to a very small extent.

Because of the limited land area of the island surface, the Republic of Maldives is one of the most thickly populated island nations in the world in terms of population per m<sup>2</sup> of land area. Being coral islands mostly without surface soil, the potential for agricultural development is very limited. The pressure of population growth upon the limited available land resources is enormous and this is emerging as the most serious environmental problem of these islands. The fuelwood resources on the islands are fast becoming scarce

and such species as Hibiscus tiliaceus, Pemphis accidula, Scaveola taccada, Thespesia populnea and Tounfertia argentina which have mostly low calorific heat value are now being used as firewood for lack of better materials. Scarcity of firewood could become a very serious problem in the country before the end of the century.

Fully recognizing the seriousness of the problem, the Government has launched a large scale tree-planting programme in the various atolls, mainly aimed to increase the fuelwood supply but subject to the availability of funds. The President also announced a national tree-planting programme in 1981, inviting every citizen to plant trees, which received a good reponse. About half a million trees were planted in 1984 by the Government, the most predominant of which were the following species:

Calophyllum inophyllum (184,000)  
Cocos nucifera (90,000)  
Thespesia populnea (45,000)  
Hibiscus tiliaceus (37,000)  
Terminalia catappa (32,000)  
Cordia subcordata (32,000)  
Adenamthera pavonina (27,000)  
Guettarda speciosa (10,000)

Maldives is also developing philately as a source of revenue and earned foreign exchange worth US \$ 223,600 from the sale of postage stamps in 1978 (sales outside the country only). This constituted 7.5 per cent of the country's total revenue that year; an income of US \$ 1.52 per person from the sale of stamps alone. Recognising the useful role of philatelic motives in promoting the cause of conservation, several stamps have been issued recently with conservation as the central theme and representing fauna which are characteristic to the country either from the point of view of their commercial or conservational importance. A new series of coins have also been issued recently which show representative fauna that are characteristic to the country and as such identified with the Republic.

Increasing demand for stamps is a usual outcome of tourism development as souvenirs or for collector's as long as reasonably good quality, attractiveness and variety of motives are maintained. This could be a good source of income for resource-poor island nations and have no ecological impacts upon the island environment. In addition to historical events, landscapes, wildlife and pristine features are the most commonly used motives on the stamps. Island philately therefore has an as yet largely untapped potential role as a visual media for promoting environmental awareness among largely urban populations, who constitute most of the island tourists.

## ENVIRONMENTAL ASSESSMENT OF MARINE POLLUTION

### General aspects

With very limited agricultural activities, and practically no industrial growth or commerce except for limited shipping, the major environmental concerns in the country are pollution from human settlements, problems of water supply, and sanitation as discussed below.

### Pollution from domestic sources

Because of the limited land surface and the high population density of 600 persons per km<sup>2</sup>, on an average, pollution from domestic sources is the most important environmental issue in the country together with the supply of drinking water. The problem is multiplied several fold for the capital island of Male because of the abnormally heavy population density of 40,000 people living in an area of less than 1 km<sup>2</sup>.

There is no public sewerage system in any of the islands except for a short length of sewer (500 m long) in Male, which was specially laid for the prevention of pollution in the boat harbour. This sewer serves only about 100 households and the Government offices. Approximately 15 per cent of the households in Male have installed water closets with or without septic tanks. The effluents from such septic tanks or raw sewage is directly discharged into the sea by means of private sewer pipes or to a large number of outlets provided all over the island.

Maldivians traditionally adopt the 'Gifili' system of waste disposal which is still widely in use, especially in the atolls although decreasing in extent. This system essentially involves digging a small hole in a specially designated private area which is covered immediately up after use. A new hole is dug for every subsequent use.

Two public latrines have been constructed in Male for the use of the residents and the labourers. However, open beaches are still commonly used as latrines by the islanders. This causes constant pollution of the coastal areas from human wastes. The status of sanitation in the rural islands is far from satisfactory. Except for a small number of private toilets with septic tanks, there are no other latrines available for public use.

The water supply in Male and in the islands is mainly from the underground freshwater lens existing from the collection of rainwater. The problem of water supply in the country is aggravated by the contamination of the groundwater aquifer due to the insanitary methods of human waste disposal. The 'Gifili' system further enhances the chances of pollution when rain water percolates through these areas. Waterborne diseases are therefore a common occurrence and diarrhoea in particular is prevalent all through the year, occasionally assuming epidemic proportions. Children in particular are most affected and the infant mortality rate is as high as 125 persons per thousand; waterborne diseases are the major cause of this mortality.

Lack of health education among the islanders constitutes another problem in the use of safe drinking water and consequent prevention of diarrhoeal diseases. The Government now chlorinates all mosque wells in Male (22 in number) which is the most common source of drinking water. Bleaching powder is also distributed free by the Government for chlorinating private wells and other sources of drinking water in Male. In spite of these facilities provided by the Government, all drinking water wells are not chlorinated regularly, and even when chlorinated many people do not use such water because of its unpleasant taste. The problem is further complicated because of the limited availability of water for personal hygiene and for kitchen use.

A study conducted on Male reported that a 20 m thick freshwater lens existed under Male during 1973. Subsequent measurements in 1983 showed that this had depleted to a thickness of 6 - 8 m. It was concluded that if the

depletion continued in the same way, the freshwater reserves on Male could be completely exhausted within a couple of years. The natural means of replenishment of the freshwater lens by the percolation of rainwater from the surface had, in the meantime, decreased considerably because of increased building and compacting of the road surface.

It was suggested that the problem could be partially solved by increasing the collection of rainwater from the roof tops and increasing the facilities for their storage. It was also felt that it might be possible to conserve the quality of the remaining groundwater by minimising the contamination of this water by human wastes through improved sewage disposal facilities on the island. Bacterial measurements also showed that almost all available freshwater on the island (except for rainwater) was contaminated by Escherichia coli, bacteria of faecal origin, to a greater or a lesser extent.

It was also reported that the Maldivians use the abnormally high quantity of 200 litres of water per day for various needs. Conservation of the water supply would therefore also depend upon training in a more rational use of freshwater.

The Government has also given consideration to the extreme measures of importing freshwater by ships and collecting rainwater in floating tanks over the lagoon.

#### Pollution from industrial sources

There is practically no major industry in the Maldives except for one fish-canning factory. The first fish canning-factory in the country was opened in 1978 in Felivaru island on Lhaviyani atoll, which has a capacity at present for processing up to 15 - 20 tons of tuna per day for export purposes. When fully in operation, the factory produces up to 5 tons of fish waste and effluents which finds its way into the sea and is dispersed by the currents. Because of the vast open seas around the islands, these wastes are soon diluted and no markable ill-effects have so far been noticed. The potential for utilizing these wastes as fertilizer or to produce bio-gas has been explored. The construction of fish processing plants in some of the atolls is presently under consideration.

The only industry on Male is one aerated drinks bottling plant. There is virtually no scope for establishing other industries on the island for lack of land area and the extreme scarcity of fresh water.

#### Pollution from agrochemicals

For lack of fertile top soil on most of the islands, agricultural activities and the potential for agricultural development is very limited in the country. Coconut is cultivated on most of the islands, in addition to tropical fruits and vegetables such as bread-fruit, pineapple, colocasia and bananas. Millet, corn, pumpkin, sugarcane and almonds are also cultivated to a much smaller extent.

Agriculture is almost exclusively undertaken at a subsistence level and only small quantities of a few types of pesticides are annually imported into the country for the control of agricultural pests. Information on the quantity imported and mode of their application is very scanty.



Pesticides are imported by the State Trading Corporation. There are at present no regulations on the import or application of the pesticides.

DDT was extensively used in an extensive WHO-assisted malaria eradication campaign on some of the atolls. In addition to controlling malarial mosquitoes, this campaign is said to have drastically reduced the rodent population on these atolls. Malaria still exists today but only on some remote atolls.

#### Siltation, sedimentation and reclamation

There has been extensive dredging around the airport island of Hulule for reclamation of land to extend the airport runway. Dredging has also been undertaken in Male lagoon to increase the surface area of the capital island by about 0.2 km<sup>2</sup>. For the reclamation of Male alone, about 600,000 m<sup>2</sup> of the lagoon was dredged to an average depth of 1.5 m for the collection of coral and sand as landfill. Siltation from these dredging activities has been reported to have affected and damaged some coral growth on the edge of these lagoons, even smothering some coral heads in extreme cases. Mining for coral and sand, and such activities as jetty construction in the atolls and in resort islands also cause some amount of sedimentation which could damage or destroy coral growth in the vicinity. However, considering the vast extents of coral resources in the country, such localised damage should be considered very negligible. At the same time, any damage to coral growth around resort islands which could affect the beauty of the underwater landscape could potentially affect the attractiveness of these resorts to tourists. Damage to coral reefs is already becoming evident around some such resort islands.

#### Oil pollution

Male is the only harbour in the country visited by ocean-going vessels. The state-owned shipping company has 22 vessels with a total DWT of 195,000 tons which includes two oil tankers. All the essential commodities and staples are imported into the country mostly from India, Sri Lanka or Singapore by smaller vessels. Fishing was traditionally undertaken by sailing boats locally called 'dhonis' and mechanisation of fishing vessels has been introduced only in recent years, but these crafts are still supplemented with sails. A larger number of assorted smaller crafts have also been introduced to service the booming tourist industry. On the whole, the number of mechanised crafts around Male has multiplied several fold during the last 5 - 10 years.

The operation of these vessels is causing some amount of oil pollution in Male harbour, as is evidenced by occasional oil slicks seen drifting about in the harbour. Although no studies have so far been undertaken, such pollution should still be considered to be only of a limited extent.

There has been only one oil spill so far in the harbour, when a Greek vessel ELKA ran aground at the mouth of the boat harbour. The oil spill was, however, very limited and the Shipping Company was asked to pay for the cleaning operations.

There are no plans for an oil spill contingency plan at present, and as there are no major shipping lanes plying through the territorial waters of the country such a plan has not been given any priority in planning. The major oil tanker lane lies to the north of Maldives (called the equatorial channel) and occasionally vessels also ply through the one and a half degree channel. The threat of an oil spill catastrophe to the Maldives is therefore very remote.

## Environmental health

### Health aspects

The prevalence of waterborne diseases such as diarrhoea, worms and infectious hepatitis has been affecting the health of the community to a large extent due to lack of safe drinking water and insanitary methods of human waste disposal. The ground water used for domestic purposes is grossly polluted and causes spreading of diarrhoea in endemic form. A survey undertaken in Male recently showed that almost all sources of fresh water (except for rainwater) are faecally contaminated to a greater or lesser extent. Diarrhoeal diseases of various types are therefore constantly present in the country throughout the year and are an important source of mortality especially among the children. The infant mortality rate in the country shows a high figure of 120.7 per thousand, while the child death rate between 1 - 4 years is 21.2 per thousand according to the census of 1977. A large majority of the deaths is attributed to water-borne diseases.

After a recent epidemic of cholera the Government is chlorinating the major supplies of drinking water on Male. However, people are reluctant to accept the taste imparted to the water by chlorination.

Of the various vector-borne diseases conveyed through the environment malaria was the most prevalent until recently. A WHO-assisted malaria eradication programme has helped to control malaria in Male and other areas, and malaria is today present only on some remote atolls. An initial survey before the launching of the malaria eradication project showed that the parasite rate in children of the 2 - 9 years age group was 23.7 per cent. The general trend indicated higher parasite rates in the northern atolls, the highest rate recorded being in Noon atoll. The main vector was Anopheles tessellatus with A. subpictus as a secondary vector. The secondary vector still remains in small active foci in some parts of the northern atolls.

### Water supply and sanitation

There is no piped water supply in any of the islands. The main source of drinking water is a freshwater lens floating on sea water within the confines of the coral sand of each island. The groundwater is recharged by the percolation of rainwater from the surface of the island. But during this process of percolation, this water gets polluted and contaminated with human and other organic wastes. Water required for domestic purposes is drawn from shallow wells dug in such aquifers. It was estimated that about 5,000 such wells exist in Male and 22,700 in the other islands.

Drinking water in Male is generally collected from mosque wells which are now chlorinated everyday. A few private wells are also considered as drinking water wells but are chlorinated only at the discretion of the owner, although bleaching powder for chlorination is distributed free by the Government. The

only other source of drinking water is the collection and storage of rainwater from roof catchments, but the quantity so collected is still insignificant compared to the overall needs of the population. Plans are presently under consideration to augment the supply of drinking water by increasing and improving the roof collection facilities on Male.

There are practically no facilities for the supply of drinking water in the outlying atolls in the island. A majority of the population draw their requirements from mosque wells or private drinking-water wells, but a few residents use well-water from private wells which are not always safe for consumption. A few rainwater tanks of small capacity have recently been installed in some islands with the assistance of UNICEF.

When the groundwater is pumped in large quantities through the aquifer and the freshwater lens gets depleted in size, salt water percolates into this lens from the sides. The salinity of ground water then increases rapidly from the centre of the island towards the shore which further limits the reserve of freshwater in the lens. On Male, it was reported as mentioned earlier that a freshwater lens of 20 m thickness existed at the centre of the Island in 1973. Studies in 1983 showed that this had depleted to 6 - 8 m because 2,000 m<sup>3</sup> of water was pumped out everyday in excess of what was percolating as replenishment. This has caused an enormous seepage of seawater from the sides of the lens. The salinity of freshwater at the centre of the island has therefore increased from about 50 ppm towards the end of the 1960s to over 200 ppm in 1984, indicating a 4-fold increase which is a sure sign of extreme seepage. As a result well-water on the rim of the island has become unsuitable for consumption during the last two or three years.

The freshwater lens in some islands is very thin sometimes hardly 10 - 15 cm and the use of drinking water wells is practically zero. In such islands, people draw small quantities of drinking water by scooping out sand and collecting water through small wooden ladles. In extreme cases water is even imported from neighbouring islands. The problem of drinking water is further aggravated by the contamination of the groundwater aquifer due to insanitary methods of human waste disposal as discussed earlier.

Several approaches have been considered to enhance the supply of freshwater on Male such as improvement in the collection of rainwater from roofs and storage, conservation of the quality of groundwater through improvement of sewage disposal facilities on the island, reduced daily use of freshwater by islanders, collection of rainwater in floating tanks on the lagoons and import of freshwater by ships. Although freshwater could also be produced by desalination, this is at present considered to be the costliest of all the methods, especially because all the fuel for running the desalination plant would have to be imported.

#### Other environmental aspects of development and resource exploitation

##### **Tourism development**

Tourism in the Republic of Maldives is of the island resort type, where the entire island is developed into a resort, and there will only be one resort on one island which is usually a few hectares only. The Government of Maldives has designated islands on selected atolls for such development, and these islands are leased by the resort

developers for a specific period. Resorts are not allowed to be built on other islands and atolls, and the Government aims to limit tourism development to a specific zone through such controls.

Tourists are taken directly to the resorts from the airport island of Hulule and back after their stay, and contacts with the local inhabitants are therefore only minimal. The islanders are also not usually allowed to visit resort islands without a specific purpose. Only uninhabited islands are developed as tourist resorts and therefore local villages of islanders are never found together on the same island with the tourist resorts. Resorts are usually very self-sufficient and self-contained in nature. However, Master Plans for large scale planned development of tourism throughout the country are presently under consideration by the Government.

Tourism has expanded considerably in the Maldives since 1972 and is fast becoming a major source of revenue to the country, already US \$ 1.86 million in 1982 which was 15 per cent of the country's total revenue that year. The number of tourist resorts have boomed from only two in 1972 (with a bed capacity of 280) to 52 resorts in 1984 with 4,476 beds. During the same period, tourist arrivals increased from 1,096 in 1972 to 83,814 in 1984. The number of island resorts have doubled since 1979 and the number of tourist arrivals have doubled since 1980.

The Government is aware of the tremendous stress such a pace of tourism development is exerting on the limited land resources of the resort islands. The major problems of land use are water supply, sanitation and solid wastes (garbage) disposal. In extreme cases, water is even brought from other nearby inhabited islands to the island resorts which can cause water scarcity on the supplying island. Sanitation is maintained through septic tanks and sink pits. Garbage is partly burnt and buried or unburnt metallic wastes are compacted and suitably disposed of offshore. The impact of recreation on the coral reefs is already emerging in the waters around some resort islands. Indiscriminate disposal of plastic materials and empty cans also spoils the pristine beauty and attractiveness of the underwater landscapes around the affected island resorts. The Department of Environment, which administers the tourism sector in the country, is undertaking campaigns to promote awareness of the importance of environment protection and to propagate sound environmental management through appropriate technology. The Sanitation Code for Tourist Resorts lays out the regulations for water supply, sewage and human waste disposal, garbage disposal, pest control, and personal hygiene to be observed on the tourist resorts.

#### Coastal erosion

The islands of the Maldives are for the most part transient, building and eroding at a rapid rate. Large populated islands have completely disappeared within the memory of the living natives. Strong currents, swatches and wind-influenced water movements through the narrow water channels, and in between and around the islands during the monsoon seasons further accentuate beach erosion. In addition to lack of oceanographic information on these waters, frequently shifting sand banks and shallow shoals are constantly changing the course and pattern of these currents. Dredging and reclamation activities in the surrounding lagoons for development activities further complicate and contribute to the problem. Many island resorts also suffer from beach erosion caused by strong seasonal currents. Construction of rivets and groins to prevent and control such erosion, although it helps in bringing

about sand deposition and beach consolidation, also often leads to further complications, especially if the constructions are improper. Such situations have sometimes accelerated and caused additional erosion instead of overcoming it. It is essential to study the current patterns around islands, shoals and in lagoons at a micro-level before any development activity is undertaken that could alter or interfere with the natural oceanographic and current patterns.

Every island resort has one or more jetties built for landing purposes. For the construction of such jetties and to provide access for boats into the lagoon, some amount of coral growth is destroyed which causes small amounts of local deterioration and degradation of the reef. Anchoring of boats inside the lagoon also causes some amount of disturbance in the lagoon area. There are also unconfirmed reports of construction of landing jetties altering the local current patterns.

#### Coastal constructions

Dredging and reclamation activities in the lagoons for development activities contributes to the problem of erosion. This has happened around the airport island of Hulule, where extensive reclamation was undertaken by dredging the surrounding lagoon in order to extend the airport runway for modern jumbo jets. This is now causing beach erosion problems in some parts of the island mainly due to changed current patterns. Many island resorts also suffer from beach erosion problems especially when landing jetties affect and change the course of the local currents.

Male is the biggest harbour in the country but it has no landing jetties. There is an enclosure for boats with a breakwater. Ships anchor offshore and cargo is landed by small boats. Most of the islands except for the tourist resorts do not have any landing jetties and the boats land directly on the beaches. These islands do not have any other coastal construction. Plans are underway to construct secondary harbours in some of the atolls mainly for fishery purposes.

#### Overfishing and harmful fishing activities

Tuna fishing from sailboats using live-baits constitutes the traditional fishery in the Maldives and mechanisation of the fishing crafts has only very recently been introduced and popularised. There are unconfirmed reports in recent years of some decrease in commercial tuna populations in certain areas and seasons at certain depths in the fishing grounds, but this has yet to be scientifically investigated and confirmed. Considering the low intensity of fishery so far, the chances for such a decrease, if at all true, being caused by overfishing is very remote.

There are occasional reports (ESCAP/SACEP Report 1983) of sporadic use of explosives of various types on coral reefs for fishing which causes localised damage to coral growth, in addition to destroying fish fry and juvenile fish. No information is available on any other harmful method of fishing practices.

Spear-fishing for resident coral fishes and pelagic fish species was occasionally practised mainly by tourists around tourist resorts in recent years. This has now been banned by law and the import of spear-fishing gear into the country is prohibited. However, there are occasional reports of spear-fishing still being practised around the resorts which are difficult to check or control for lack of regular surveillance and enforcement machinery. Ornamental fish have been collected on some coral reefs by private

parties for export purposes in recent years, and there are unconfirmed reports that certain species of ornamental fish have already been locally depleted in some parts of the exploited reefs, but this has yet to be scientifically investigated. Export of ornamental fish from the country is now controlled by law, which stipulates the maximum number of live fish that are allowed to be exported annually from the country. Under these regulations 44,000 live ornamental fish were exported in 1981.

#### Souvenir collection

Tourism developed in the country on a large scale only since 1972 and there has been frequent collection of corals, shells, and other species as souvenirs from coral reefs around resort islands by tourists, in addition to spear-fishing for sport. Although no quantitative estimates have been attempted so far, there have been some reports of such exploited species becoming rare in the environment. Legislation has been promulgated in recent years to ban the export of black corals and turtle shells in any form, and 'unprocessed' coral products from the reefs, which has controlled souvenir collection to a great extent, although it is still reported to be continued on a small scale here and there. Shells and corals are today exported from the country mostly in processed form such as rings, bangles, amulets, necklaces and other jewellery. Processing of such artifacts by local craftsmen has become a lucrative small scale industry around tourist resorts in the country.

### ENVIRONMENTAL MANAGEMENT AND PLANNING

#### Legislative developments

There is no legislation so far in the country to deal with environmental management and environmental conservation as such in an integrated manner. However, the various legislations dealing with and controlling the different development sectors, and on the utilization of natural resources, include several clauses, sections and regulations that either directly or indirectly, deal with environmental aspects. The legislation is drafted by the office of the Attorney General, the Ministry of Justice or other Ministries dealing with the respective sector/resources, and are submitted to the office of the President for approval. The draft legislation is then discussed and voted into law by the Citizen's Majlis (Parliament). The legislation is then promulgated by the President. The various Ministries and Departments which administer the different resources and different development sectors, such as the Ministries of Agriculture, Fisheries and Health, and the Department of Tourism are responsible for the implementation of the legislation. As a nation of oceanic islands, where the fishing sector plays a dominant role in providing both occupation and staple food to the people, the Ministry of Fisheries is fast acquiring a co-ordinating role as a central agency to oversee the various aspects of the marine environment and its resources.

As the administrative head of the Government at the atoll level, the Atoll Chief is responsible for enforcing the legislation through the respective island head. Local problems including conflicts of resource utilization are often settled through discussions at the village level and through mutual consent. Being an isolated society, traditionally very much dependent upon the marine environment and its resources for their sustenance and survival, the islanders are very much aware of the need to utilize their

resources rationally and to avoid unnecessary destruction of the environment, in order to co-exist with nature. Almost all the environmental problems have arisen in the country only in recent times because of the increased exploitation of the resources at a commercial level.

Of the legislation dealing with the management of the different sectors and resources, mention may be made of the following.

In order to avoid resource conflict, coral and sand mining is permitted to be undertaken only on the coral reefs and not on the inhabited islands. Only the islanders are allowed to undertake mining on their respective islands, and that, too, only for their private purposes.

Because of complaints of over-exploitation and local depletion, export of ornamental fish from the country is now controlled by law which stipulates the maximum number of live fish that is allowed to be exported from the country every year. A license needs to be obtained for the collection of such fish. Legislation has recently been promulgated to prohibit sports fishing by spearguns and equipment for spear-fishing is not allowed to be imported into the country today.

Similarly, to prevent uncontrolled collection of coral products as souvenirs by tourists (or for sale to tourists), and to conserve the more rare species, possession and export of the slow growing deep sea black coral and turtle shells is now totally banned, while other coral products could be exported only in processed form such as jewellery. This also has created a local handicraft industry for the production of coral products.

Considerations are also underway to demarcate zones as multi-purpose marine parks and/or sanctuaries in order to further strengthen conservation.

In the tourism sector, the Sanitation Code for Tourist Resorts lays out the regulations for water supply, sewage and human waste disposal, garbage disposal, pest control, food sanitation and personal hygiene. For example, solid wastes are burnt and the unburnt material is either buried or compacted and disposed offshore.

Environment has not yet become a major issue in the Maldives except perhaps in the case of water supply and sanitation. However, at the accelerated pace of present development, it might soon become necessary to strengthen legislation on the environment in order to avoid depletion or unnecessary destruction of the natural resources.

#### Institutional arrangements

There is no separate agency, department or organization to deal with environmental aspects. The various ministries and departments which administer the different development sectors and resources have also looked after the environmental aspects as an integral part of the overall sector/resource management, with the Ministry of Fisheries playing a coordinating role in view of its special interest in the marine environment and its resources.

A need was felt for some time for the establishment of a common platform to discuss environmental issues on a holistic basis as against a piecemeal discussion from the point of view of specific resource or development

sectors. Accordingly, the President has in 1984 established a National Environmental Commission to co-ordinate and advise on environmental matters. The Commission comprises of representatives from the following Ministries, Departments or Agencies:

Ministry of Home Affairs (Chairman)  
Ministry of Planning & Development  
Ministry of Fisheries  
Ministry of Health  
Ministry of Atoll Administration  
Ministry of Agriculture  
Ministry of Transport  
Ministry of Education  
President's Office  
National Security Services  
Department of Tourism  
Voice of Maldives (Broadcasting Services)

The Commission discusses the various environmental problems from time to time, and brings issues to the notice of the department, agency or ministry concerned for appropriate action, but has no legislative authority to undertake any action on the matter. This Commission, which brings together various interested parties for the first time on a common platform, could well be the best starting point for the development of a full-fledged national environmental agency.

### Conservation

#### Conservation of coral reefs

Being a country of coral reefs the Government is aware of the important role of coral reefs in preventing soil erosion, and in sustaining fisheries and the tourist industry. Over and above everything else, attractiveness of the pristinity and beauty of the island environment and underwater landscapes in developing and sustaining tourism cannot be ignored. The island community has traditionally depended upon coral reef resources such as fish (especially live-bait), shells, etc. The potential for recreational uses especially for the development of highland resort tourism has only recently begun to be exploited.

Practically no information is available on the quality of the reefs in terms of their biological richness and diversity, live and dead coral cover, and economic value, although it could very well be the richest and the most vast coral growth in the world with an unlimited potential to yield chemicals of pharmaceutical value, full investigations on which are yet to be initiated. Information on the structure of reef communities and their physiological zonation is limited to only a few reefs.

There is an urgent need to determine the status and enhance the knowledge of the coral reefs in the country. A clear-cut need also exists to promulgate legislation to ensure rational use of coral reef resources, to prevent unnecessary wanton destruction and achieve their long range sustenance. However, acute lack of trained manpower, effective surveillance and enforcement machinery, as well as funds are severe constraints in achieving this objective.



Legislation has recently been promulgated which bans the export of black coral and turtle shells in any form, and 'unprocessed' coral products from the reefs. However legislation alone is not enough to prevent the degradation of the coral reefs. A proper understanding of the marine processes and a better realization of realistic strategies for management are necessary starting points. Proper management strategies could be adopted only through promotion of environmental awareness of the importance of conserving the environment among the atoll residents, islanders and government planners.

It has been recognised that the designation of marine parks as multiple use areas, with facilities for recreation, research and education, in addition to preservation, might go a long way in the environmentally sound management of coral reefs in the country. As a first step in this direction, the Government is presently developing strategies for the zoning of coral reefs and atolls based on their present uses and future potential, including demarcation of areas for future conservation.

#### Protection of endangered and threatened species

Because of the vast extent of coral growth, collection of certain species as souvenirs or for commercial purposes at a scale at which it has so far been going on in the country does not pose any immediate conservation threat, even when it might be causing localised degradation of the exploited habitat. There have been unconfirmed reports of the slow-growing deep sea black coral getting more rare in recent years, but this has not been scientifically investigated.

As an initial step towards the conservation of marine turtles such as Chelonia mydas, Dermochelys coriacea, Caretta caretta gigas and Eretmochelys imbricata, exports of turtle shells from the Maldives have now been prohibited by law.

#### Fisheries

There have been unconfirmed reports in recent years of some decrease in commercial tuna populations of certain species in certain areas and seasons at certain depths. The reason for this is not clear as this has far been scientifically investigated, although it would appear that it is difficult to assign this to over-fishing, considering the low intensity of traditional fishing in these waters. Ornamental fish are also reported to be getting locally rarer in some of the reefs from where they are caught in large numbers. Again, no information is available on this trend. Export of ornamental fish from the country is now regulated by law.

#### Marine parks, sanctuaries and protected areas

The vast extents of the coral reefs of the country which are spread over a geographical area of over one million km<sup>2</sup> of the northern central Indian Ocean, only magnifies the problems of their management, protection and surveillance. The enormity of the problem could easily be imagined when one considers the total lack of manpower trained in conservation in the country. It might therefore be more judicious to make a beginning by stopping the degradation of the most undisturbed of all coral reef areas, however limited the designated area might be, rather than attempting to manage all the coral resources as a whole. Simultaneous efforts should also be made to formulate general legislation that would prevent or stop activities that cause degradation of the reefs as a whole, and to develop an appropriate machinery for their enforcement.

One such approach in managing specialised coastal environments is to establish limited areas as zoned marine parks. Considering the various benefits and uses of the coral reefs, such an approach will adopt the principle of "multiple use" idea where different zones within the designated marine park could cater to different uses including fishing, recreation, education, research and other purposes, while providing for conservation as well. Some of the zones that could be included within such a marine park are as follow:

- general use zones which allow for the greatest freedom of activities;
- temporal zones which are general use zones with temporal management directed towards critical elements of biological communities which are particularly vulnerable at specific seasons, e.g. breeding grounds of fish and other marine organisms that have specific or peak egg-laying seasons;
- marine national park zones which provide for the protection of the natural resources while allowing certain uses such as recreational fishing and approved scientific research;
- scientific research zones where approved research can be carried out without disturbance from recreational activities, fishing and collecting; and
- preservation zones which allow for the greatest protection of areas from disturbances from human activities other than for scientific research directly related to the preservation of these areas.

As a first step in this direction, the Government is presently developing strategies for the zoning of coral reefs and atolls based on their present uses and future potential including demarcation of areas for future conservation.

#### Research/management programmes and institutions

Extreme scarcity of trained manpower, almost total lack of even basic scientific equipment for research and survey, and severe scarcity of funds are the major constraints that stand in the way of indigenous development of research and survey programmes and institutions in the field of marine environment. As a result, no research or survey programmes have been initiated despite the severe lack of and urgent need for scientific information on marine resources. Fully recognising the need to initiate basic efforts in this direction, the Ministry of Fisheries has, in 1984, opened a Marine Research Section, staffed by 5 fisheries officers. This section is at present building up a small library of publications and reference material on marine sciences, and collating scientific information available from the past oceanographic expeditions in the region and limited scientific investigations on the Maldivian waters. It is expected that, after the required basic training in scientific methodology, the staff could begin research and survey programmes on their own with special emphasis on fishery biology, fish population studies as well as coral reef ecology. With the availability of funds, equipment and sufficient trained manpower, it may be expected that this marine research section might one day develop into a full-fledged national marine laboratory.

## ENVIRONMENTAL PROMOTION

### Environmental information

Until recently, there has not been any programmes and institutions and very few trained manpower in the field of marine environmental research in the country. With the establishment of the Marine Research Section under the Ministry of Fisheries, initial efforts are being made in this direction. This section, although very small and presently staffed by only 5 fisheries officers, could develop into an information center on the marine environment in the country, in addition to becoming a full-fledged national marine laboratory, and a co-ordinating center for all activities dealing with marine affairs in the future. In view of the very limited information presently available, there appears to be no need for any additional information and data collection centers in the country.

### Environmental education

Education facilities are available in the country only up to the high school level, and the only school in the English language medium in the country is located in Male. Educational facilities at the elementary school level and for religious study are available in all the atolls. Basic environmental studies are incorporated in the educational curricula at all grades in the school and create an awareness of the atoll environment and the importance of resources among the students. The curricula covers methodology and helps children to learn concepts and ideas relating to the environment of their islands and atolls. The environmental curricula are also regularly covered by the daily school broadcasts directed towards the atolls by the "Voice of Maldives" broadcasting programme based in Male.

Because of severe lack of teachers in the country, the Institute of Teacher Education located in Male operates to train school teachers and offers a 1 - 2 year training course. The curriculum of this institute includes environmental studies which cover, among other things, the atoll type of environment, marine and land forms, plant and animal types as well as island, lagoonal and atoll ecology. Special emphasis is laid on factors which most influence the livelihood, health and well-being of the islanders.

The Fisheries Science Curricula for Grades 8 - 10 covers the marine environmental aspects in more elaborate detail, including life forms in the sea, their life cycles, ecology, food chains, reef environment and its resources, hydrography and fish biology.

The Educational Development Centre in Male is involved in the development of curricula for the schools and gives special attention to the development of curricula on the marine environment.

### Environmental awareness

Being an island nation composed of coral reefs and atolls, creation of awareness among the public of the importance and need to manage this ecosystem is possibly one of the surest ways of ensuring the protection and conservation of the islands and the coral reefs in the long run. Involvement of the local

residents in managing the ecosystem could go a long way towards achieving this aim. As the residents of the atolls are very dependent upon the resources of the reefs and islands, which are in certain cases very limited, training in rational utilization of resources is required to ensure their long range maintenance. The establishment of conservation areas such as marine parks could also serve as a means of creating awareness among the general public through formal and non-formal educational programmes.

Lacking trained personnel, the country does not, so far, have any nation-wide awareness promotion programmes in the field of environmental curricula at the elementary to the high school level (Grade 1 to 10). The Atoll Radio Programmes frequently broadcast programmes of environmental interest, including such aspects as the importance of corals and the need to avoid their wanton destruction for long range maintenance. Environmental curricula are also broadcast over the daily radio programme of the Atoll Radio Services. Other non-formal activities for promoting environmental awareness include dissemination of information, advice and warnings through the atoll chiefs and islands heads as well as Government officials during their atoll trips, and group discussions at the island level on local problems and issues which have environmental origins and implications.

#### CONCLUSIONS

Being an oceanic island nation with a traditionally isolated society, the Republic of Maldives is deeply dependent upon the marine environment for its survival, and marine resources for its sustenance. Marine fisheries has traditionally provided the main occupation and the staple food for the population, and until very recently was also the main foreign exchange earner for the country. Fully aware of its dependence upon the marine environment, the Maldivian society had learnt to co-exist with nature, to utilize resources rationally and to avoid unnecessary destruction of the environment and its resources. Concepts of environmental protection and conservation are therefore not new to the country, although the environmental issues, if existent, were negligible, as stress on the environment was minimal.

The introduction of commercial exploitation of resources and an accelerated pace of development have drastically altered the picture in the Maldives during the last decade. Because of population growth and increasing stress on the limited resources for development, environmental issues are today in various stages of emergence. The Government is aware of the urgent need to moderate and regulate the utilization of the resources through appropriate action. The country was lacking any institutional framework until recently to regulate this sector. This has now been rectified by the appointment of a National Environmental Commission to discuss environmental matters and issues. However, of all the maritime countries in the South Asian Seas region, the Republic of Maldives suffers most from severe constraints in this field due to lack of trained manpower in environmental management, lack of scientific equipment and research facilities, as well as severe limitation or lack of funds. Undoubtedly, the development of a South Asian Seas programme, as a co-operative effort for the management of the marine environment of the region is thus most timely for the Maldives. The country stands to benefit enormously from its participation in the programme for the development of trained manpower in the field of environmental management,

development of environmental management programmes, and establishment of infra-structure facilities for their implementation, as well as to upgrade national expertise in environmental management skills. Over and above everything else the programme would promote awareness of the supreme importance of the marine environment to the island nation and provide the modern scientific tools and technical skill to achieve its scientific management.

**PUBLICATIONS IN THE UNEP REGIONAL SEAS REPORTS AND STUDIES SERIES**

- No. 1 UNEP: Achievements and planned development of UNEP's Regional Seas Programme and comparable programmes sponsored by other bodies. (1982)
- No. 2 UNIDO/UNEP: Survey of marine pollutants from industrial sources in the West and Central African region. (1982)
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- No. 4 IMCO/UNEP: The status of oil pollution and oil pollution control in the West and Central African region. (1982)
- No. 5 IAEA/UNEP: Survey of tar, oil, chlorinated hydrocarbons and trace metal pollution in coastal waters of the Sultanate of Oman. (1982)
- No. 6 UN/UNESCO/UNEP: Marine and coastal area development in the East African region. (1982)
- No. 7 UNIDO/UNEP: Industrial sources of marine and coastal pollution in the East African region. (1982)
- No. 8 FAO/UNEP: Marine pollution in the East African region. (1982)
- No. 9 WHO/UNEP: Public health problems in the coastal zone of the East African region. (1982)
- No. 10 IMO/UNEP: Oil pollution control in the East African region. (1982)
- No. 11 IUCN/UNEP: Conservation of coastal and marine ecosystems and living resources of the East African region. (1982)
- No. 12 UNEP: Environmental problems of the East African region. (1982)
- No. 13 UNEP: Pollution and the marine environment in the Indian Ocean. (1982)
- No. 14 UNEP/CEPAL: Development and environment in the Wider Caribbean region: A Synthesis. (1982)
- No. 15 UNEP: Guidelines and principles for the preparation and implementation of comprehensive action plans for the protection and development of marine and coastal areas of regional seas. (1982)
- No. 16 GESAMP: The health of the oceans. (1982)
- No. 17 UNEP: Regional Seas Programme: Legislative authority. (1985)
- No. 18 UNEP: Regional Seas Programme: Workplan. (1982)
- No. 19 Rev. 2. UNEP: UNEP Oceans Programme: Compendium of projects. (1985)
- No. 20 CPPS/UNEP: Action Plan for the protection of the marine environment and coastal areas of the South-East Pacific. (1983)

- No. 21 CPPS/UNEP: Sources, levels and effects of marine pollution in the South-East Pacific. (1983) (In Spanish only)
- No. 22 Rev. 2. UNEP: Regional Seas Programme in Latin America and Wider Caribbean. (1985)
- No. 23 FAO/UNESCO/IOC/WHO/WMO/IAEA/UNEP: Co-ordinated Mediterranean Pollution Monitoring and Research Programme (MED POL) - Phase I: Programme Description. (1983)
- No. 24 UNEP: Action Plan for the protection and development of the marine and coastal areas of the East Asian region. (1983)
- No. 25 UNEP: Marine pollution. (1983)
- No. 26 UNEP: Action Plan for the Caribbean environment programme. (1983)
- No. 27 UNEP: Action Plan for the protection and development of the marine environment and coastal areas of the West and Central African region. (1983)
- No. 28 UNEP: Long-term programme for pollution monitoring and research in the Mediterranean (MED POL) - Phase II. (1983)
- No. 29 SPC/SPEC/ESCAP/UNEP: Action Plan for managing the natural resources and environment of the South Pacific region. (1983)
- No. 30 UNDIESA/UNEP: Ocean energy potential of the West and Central African region. (1983)
- No. 31 A. L. DAHL and I. L. BAUMGART: The state of the environment in the South Pacific. (1983)
- No. 32 UNEP/ECE/UNIDO/FAO/UNESCO/WHO/IAEA: Pollutants from land-based sources in the Mediterranean. (1984)
- No. 33 UNDIESA/UNEP: Onshore impact of offshore oil and natural gas development in the West and Central African region. (1984)
- No. 34 UNEP: Action Plan for the protection of the Mediterranean. (1984)
- No. 35 UNEP: Action Plan for the protection of the marine environment and the coastal areas of Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. (1983)
- No. 36 UNEP/ECLAC: The state of marine pollution in the Wider Caribbean region. (1984)
- No. 37 UNDIESA/UNEP: Environmental management problems in resource utilization and survey of resources in the West and Central African region. (1984)
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- No. 39 IUCN/UNEP: Marine and coastal conservation in the East African region. (1984)
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- No. 41 UNEP: Socio-economic activities that may have an impact on the marine and coastal environment of the East African region. (1984)
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- No. 48/ Appendices SPC/SPEC/ESCAP/UNEP: Hazardous waste storage and disposal in the South Pacific. (1984)
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- No. 51 UNEP: Socio-economic activities that may have an impact on the marine and coastal environment of the East African region: National Reports. (1984)
- No. 52 UNEP: Arab co-operation for the protection and development of the marine environment and coastal areas resources of the Mediterranean. (1984)
- No. 53 UNEP: UNEP Regional Seas Programme: the Eastern African Experience. (1984)
- No. 54 UNIDO/UNEP: Contingency planning for emergencies associated with industrial installations in the West and Central African Region. (1985)
- No. 55 FAO/UNEP: Marine mammals: global plan of action. (1985)
- No. 55/ Annex FAO/IUCN/IWC/UNEP: Marine mammals: global plan of action. (1985)



- No. 56 GESAMP: Cadmium, lead and tin in the marine environment. (1985)
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- No. 58 UNEP: Co-operative programmes sponsored by UNEP for the protection of the marine and coastal environment in the wider Indian Ocean region. (1985)
- No. 59 UNEP: Environmental problems of the marine and coastal area of India: National Report. (1985)
- No. 60 IUCN/UNEP: Management and conservation of renewable marine resources in the Indian Ocean region: Overview. (1985)
- No. 61 UNEP: Action Plan for the protection, management and development of the marine and coastal environment of the Eastern African region. (1985)
- No. 62 IUCN/UNEP: Management and conservation of renewable marine resources in the South Asian Seas region. (1985)
- No. 63 IUCN/UNEP: Management and conservation of renewable marine resources in the Kuwait Action Plan region. (1985)
- No. 64 IUCN/UNEP: Management and conservation of renewable marine resources in the Red Sea and Gulf of Aden region. (1985)
- No. 65 IUCN/UNEP: Management and conservation of renewable marine resources in the East Asian Seas region. (1985)
- No. 66 IUCN/UNEP: Management and conservation of renewable marine resources in the Eastern African region. (1985)
- No. 67 UN/UNEP: Coastal erosion in West and Central Africa. (1985)
- No. 68 GESAMP: Atmospheric transport of contaminants into the Mediterranean region. (1985)
- No. 69 UNEP: Environment and resources in the Pacific. (1985)
- No. 70 UNESCO/ROPME/UPM/UNEP: Proceedings of the Symposium/Workshop on oceanographic modelling of the Kuwait Action Plan (KAP) region. (1985)
- No. 71 IUCN/ROPME/UNEP: An ecological study of the rocky shores on the southern coast of Oman. (1985)
- No. 72 IUCN/ROPME/UNEP: An ecological study of sites on the coast of Bahrain. (1985)
- No. 73 SPC/SPEC/ESCAP/UNEP: Ecological interactions between tropical coastal ecosystems. (1985)
- No. 74 UNEP: Environmental problems of the marine and coastal area of Sri Lanka; National Report (1986)

- No. 75 UNEP: Environmental problems of the marine and coastal area of Bangladesh; National Report (1986)
- No. 76 UNEP: Environmental problems of the marine and coastal area of Maldives; National Report (1986)
- No. 77 UNEP: Environmental problems of the marine and coastal area of Pakistan; National Report (1986)
- No. 78 GESAMP: Organosilicons in the marine environment (1986)