

Coral Reefs of Sri Lanka: Human Disturbance and Management Issues



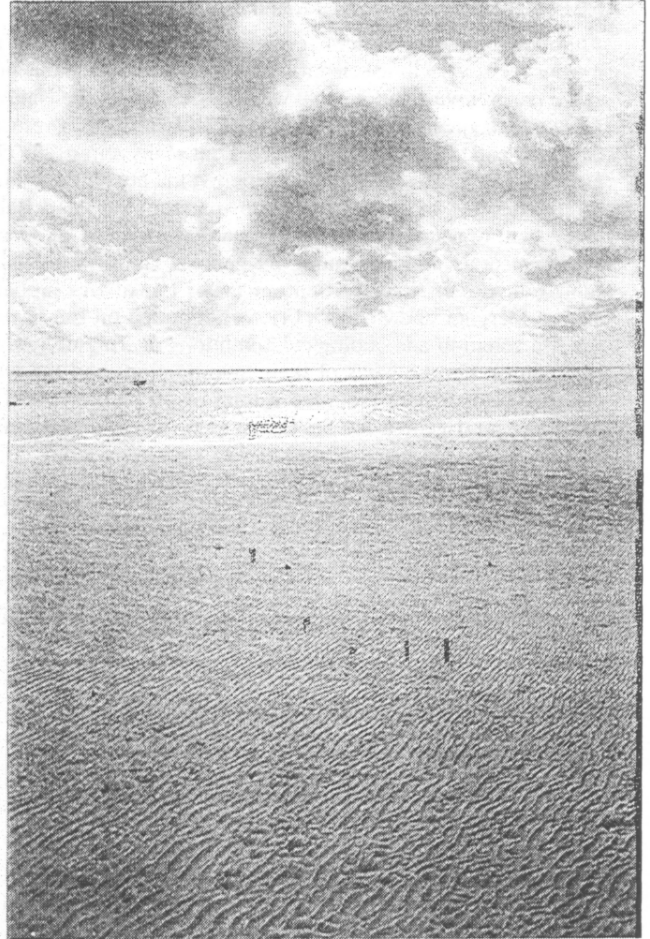
The coastal waters of Sri Lanka have well-developed reefs; the majority are made up of sandstone and rocky habitats that form extensive reefs around the island. The greatest extent of true coral reefs is located in the Gulf of Mannar region off the northwestern coast of the island. For centuries coastal people have been dependent on the harvest of reef fish and other resources. Corals have been utilized in the production of lime that is used in the construction industry. The exports of spiny lobsters, sea cucumber and ornamental reef fish contribute significantly to the foreign-exchange earnings of the country. Tourism has also benefited from the aesthetic value of coral reefs. However, due to unmanaged resource utilization, reef habitats are being depleted at an alarming rate. Research has revealed that the status of coastal reefs is declining steadily due to various human activities such as destructive fishing, coral mining, overharvesting, unplanned development, and sedimentation due to land-use patterns. Although laws have been introduced to protect reefs, few have been implemented due to inadequate institutional cooperation and political considerations. There is also a lack of awareness and concern among the general public. This paper reviews the status of coastal reefs in Sri Lanka; major disturbance factors are described and management issues are discussed. Research conducted on coral reefs in Sri Lanka is also reviewed.

INTRODUCTION

Sri Lanka is situated between 5° and 10° north of the equator and south of the Indian subcontinent and has a total land area of 65 000 km². The coastline of the island, which is about 1585 km, supports highly productive ecosystems such as coral reefs, mangroves, sea-grass beds and marshy lands. The continental shelf of Sri Lanka is relatively narrow averaging only a few km in width.

The reefs of Sri Lanka are divided into three categories: true coral reefs; sandstone reefs; and boulder reefs of crystalline rock. The latter two reef types are, in varying degrees, covered by coral (1). In comparison to its coastline, Sri Lanka has a limited extent of true coral reefs. It has been estimated that only about 2% of the coastline has fringing coral reefs (2). There are extensive areas of patch reefs, but the extent of these has not been determined in detail. Most fringing coral reefs are found on the southwestern, southern and eastern coasts. Well-developed offshore coral reefs occur in the Gulf of Mannar and west of the Kalpitiya Peninsula (1–3, 21). Coral reefs around the Jaffna Peninsula are less well developed, and occur mainly around the coastal islands. Many sandstone reefs are located along the bathymetric contours on the continental shelf. They are believed to have formed on ancient shorelines (2). Boulder reefs are commonly associated with the rocky shores of the southern and eastern coasts.

Reefs are a valuable resource for the people of Sri Lanka, in particular to the coastal communities. Coastal reefs have for



Beautiful sandy beaches with fringing coral reefs attract tourists. If these resources are managed properly, they will give long-term benefits for Sri Lanka. However, rapid unplanned tourism development has had negative environmental impacts in many areas especially in the south and west coast of the island. Photo: M.C. Öhman.

centuries, been utilized as a source of food and building materials. In the past two to three decades, the collection and export of coral reef associated organisms have contributed substantially to the foreign-exchange earnings of the country. Coastal tourism, which has been developed to a limited extent, has a tremendous potential for further expansion. However, proper planning and management steps must be taken to ensure that the sustainability of reefs is not compromised for short-term benefits. In Sri Lanka, the use of coastal reefs as a resource has often led to over-exploitation and destruction (Table 1).

Major causes of reef degradation are habitat loss due to destructive fishing methods such as the use of explosives and bottom-set nets, mining coral from the sea for lime production, uncontrolled harvesting, including the collection of ornamental fish and invertebrate species. Sedimentation due to unplanned land-

clearance practices, pollution from industrial development as well as agricultural runoff, and discharge of untreated sewage have also had negative effects on nearshore reefs. These patterns of destruction of coral reefs are seen in many other countries as well, particularly in the South and Southeast Asian region (4–6). It is comparatively recently that many countries have realized the adverse impacts from unregulated fishing and unplanned development activities. There is evidence that in a number of developing countries, coastal resources have already been overexploited (7–9).

REEF RESEARCH IN SRI LANKA

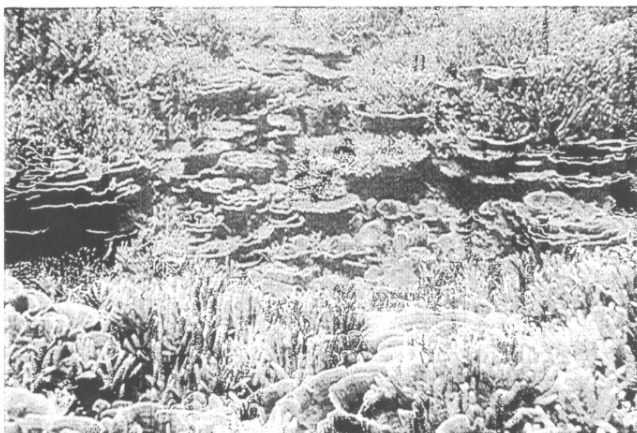
Although the coastal waters of Sri Lanka are endowed with numerous reefs, very little scientific information was available prior to the recent investigations that were carried out by the National Aquatic Resources Agency (NARA) of Sri Lanka. Early research on corals and coral reefs were carried out at the turn of the century (10–12). These early studies reported mainly on the solitary corals collected by Professor Herdmann from the Pearl Banks in the Gulf of Mannar. Pillai (13) recorded a total of 90 species of stony corals divided among 39 genera. The first published comparative reef study carried out in Sri Lanka was probably that of Mergner and Scheer (14) who reported on the physiographic zonation and ecological conditions of fringing reefs at Hikkaduwa. On the basis of their investigations and the work of Pillai (13), Scheer recorded a total of 40 hermatypic (reef building) coral genera for Sri Lanka (15). In 1988, Rajasuriya and De Silva (16) listed a total of 171 species of stony corals divided among 65 genera of which 64 species and 15 genera were new recordings for Sri Lanka. Their list of coral species was based on previous records and the extensive coral collections they made from Tangalle on the south coast to Kandakuliya on the northwestern coast (Fig.1). In 1994, Rajasuriya updated the list of corals to contain 183 species of stony corals divided

among 68 genera by adding 12 species and 3 genera not previously recorded for Sri Lanka (17).

Much of the recent research on Sri Lankan reefs has focused on reef monitoring programs that are essential to address environmental and management issues. The first investigations geared towards the management of coral reefs were carried out at Hikkaduwa (Fig.1) by De Silva and Rajasuriya (18). After extensive investigations that included studies on reef quality and user patterns, they proposed a zonation and management plan



Coral-reef resources are important for the fisheries industry in Sri Lanka. Photo: A. Rajasuriya.



An undamaged area of the coral reefs within the Bar Reef Marine Sanctuary. Implementation of sanctuary regulations is needed to prevent reef degradation due to human activities and other natural causes. Photo: A. Rajasuriya.

Table 1. Major causes of reef degradation in Sri Lanka.

Human Disturbance

Coral Mining

Coral mining from the sea for lime production

Fishing

Blast fishing

Overharvesting

Bottom set nets to catch spiny lobsters and reef fish

Using nonselective fishing gear

Indiscriminate netting in reef areas

Ornamental Fish Collection

Uncontrolled collection of live marine organisms for the aquarium trade

Using 'moxy nets' for ornamental fish collection

Excessive collection of shells and other invertebrates

Pollution

Pollution from land-based sources

Sewage disposal

Pollution from shipping

Sedimentation

Sedimentation due to unplanned land clearance practices and coastal erosion

Sedimentation due to construction of ports and harbours

Boats

Damage caused by boats and anchors

Glass bottom boats and fishing crafts colliding against reefs

Discharging waste oil and bilge water from boats

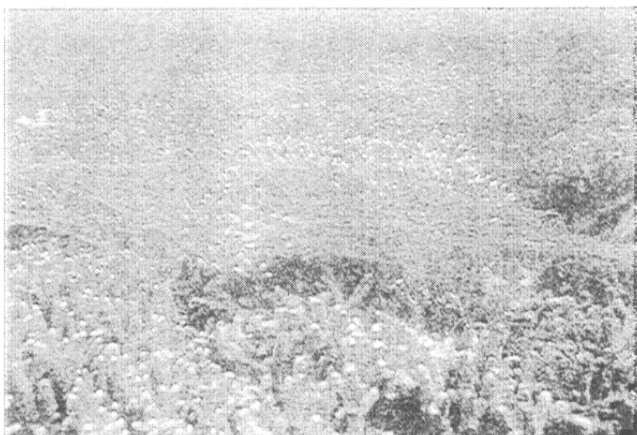
Natural Impacts

Starfish

Crown of Thorns Starfish (*Acanthaster planci*)

Storms

High wave action and storm surges during the monsoons



Bottom-set nets cause immense damage to reef habitats; a fishing technique that needs to be banned. Photo: A. Rajasuriya.

for the Hikkaduwa Marine Sanctuary. An environmental profile of the Hikkaduwa coastal area, prepared by Nakatani and colleagues (19) under the Coastal Resources Management Project (CRMP), reconfirmed the zonation proposed by De Silva and Rajasuriya (18). Investigations at the Bar Reef by Rajasuriya (20) led to the declaration of the Bar Reef as a Marine Sanctuary (BRMS) in 1992. Reef degradation due to human-related ac-

tivities, particularly mining coral from the sea for the manufacture of lime, have been reported by several authors (18–23, 25). De Bruin (42) reported on the destruction of coral reefs off the east coast by the coral predating starfish *Acanthaster planci* in the early 1970s. Later work by Rajasuriya and Rathnapriya (24), revealed that in 1994 the coral reefs in the northwestern coast were disturbed by *Acanthaster planci*.

The major part of Sri Lanka's coral-reef research program at NARA was supported by the Swedish Agency for Research Co-operation with Developing Countries (SAREC). Through this program, research has been conducted on coral-reef ecology as well as on the impact of human activities on resource utilization and habitat conditions. A limited amount of support has also been provided by the Coastal Resources Management Project of USAID for management oriented research at the Hikkaduwa Marine Sanctuary (19).

RESOURCE UTILIZATION AND ITS IMPACTS

Coral Mining

Coral is used in coastal areas as a raw material for lime production. It is burnt in a kiln to produce a white powder, which is then mixed with cement and sand to produce mortar. The construction industry accounts for nearly 92% of the lime used in Sri Lanka. Sometimes lime is also used in agriculture to reduce acidity in soils (27).

There are two types of coral mining primarily targeting lime production; traditional mining of ancient fossilized coral reefs found inland and below ground, and a more recent and harmful activity of mining both live and dead coral from the sea. If this activity continues, the remaining coral reefs in the presently mined areas will be completely exhausted in the near future.

Some of the ancient reefs that date back to more than 5000 years (26) are located on the southwestern and southern parts of the country. The most exploited and extensive ancient reefs are concentrated along the coastal belt from Akurala to Hikkaduwa on the southwestern coast and in the Matara District in the southern coast (Fig.1). These deposits are found 2 to 3 km inland, and in some locations they occur at depths more than 10 m below the surface. It is likely that these ancient coral deposits indicate the position of a coastline that existed in the past. Land-based coral mining does not contribute to coral-reef degradation, but can cause other environmental problems; it results in large dugout pits in the ground, which are generally filled with water. Initial experiments in rearing edible fish varieties such as *Tilapia* spp. in these pits have been successful, but improved marketing techniques have to be worked out before they can become commercially viable.

In Sri Lanka, the coastal zone is defined as the area of land 300 m wide along the coast from the high-waterline and a 2 km wide strip of sea from the low waterline. Where a river or another body of water meets the sea, the landward limit extends to 2 km upriver from the baseline at the outfall. It is prohibited to mine, remove, possess, transport or burn coral within this zone. A survey conducted in 1984 by the Coast Conservation Department (CCD) on the southwestern and southern coastal areas, revealed that 18 000 tons of coral are being supplied annually to the lime industry. A major portion of this (42%) originates from mining inland coral deposits beyond the coastal zone, while 16% is mined on land within the coastal zone (27). Another 12% comprises coral debris collected from the shore. The balance, 30%, constitutes coral illegally mined from the sea. This activity is one of the major causes of coral-reef degradation in Sri Lanka. Impacts from coral mining have been recorded in other countries in the region such as the Maldives where coral mining, in certain areas, has caused habitat destruction and ecosystem depletion (28–30). In Sri Lanka, these activities are

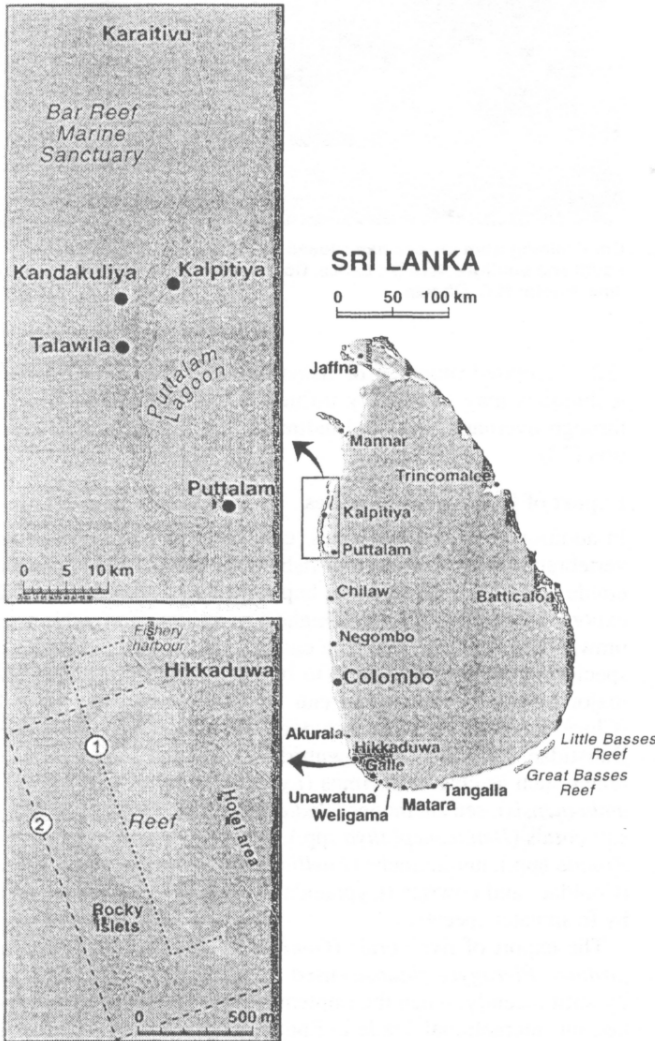
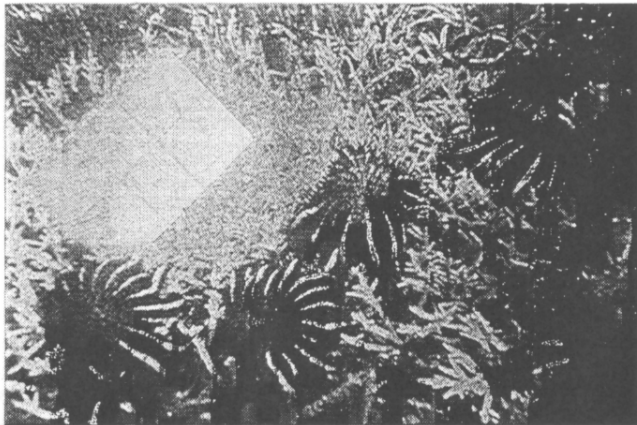


Figure 1. Map of Sri Lanka with existing sanctuaries indicated. In the map of Hikkaduwa Marine Sanctuary (below left) no.1 indicates "original sanctuary boundary" while no. 2 indicates "existing sanctuary boundary".



A long-term program is necessary to eradicate the 'Crown of Thorns' Starfish (*Acanthaster planci*) that has devastated coral reefs of Sri Lanka. Photo: A. Rajasuriya.

mainly carried out in the southwestern and southern coastal areas where there is easy access to fringing reefs.

These human activities have contributed to large-scale reef destruction particularly from Akurala to Hikkaduwa and from Habaraduwa near Unawatuna to Matara, and at Rekawa east of Tangalle (Fig. 1). Destruction of living reefs is also reported from the east coast around Kalkudah and Passikudah Bays north of Batticaloa. Coral mining from the sea has resulted in severe coastal erosion in all these areas, where the government has spent large sums of money to build coast-protection structures. Although coral-reef protection has been a stated national policy for a number of years very little action has been taken to prevent large-scale reef degradation. In 1993 and 1994, the Coast Conservation Department introduced a ban on operation of lime kilns within the coastal zone. The local police force was also more vigilant in catching violators of the law on sea-coral mining. However, actions to apprehend the miners were discontinued after a short period, due to political pressure. Further, the shifting of kilns beyond 300 m from the shoreline (coastal zone) was not sufficient to prevent the miners from transporting coral from the sea to the kilns.

Fishing Activities

Today, Sri Lanka has a population of slightly more than 17 million people almost 50% of whom live in the coastal areas. The majority of economic centers are also located within these areas. Fishing is the most important economic activity connected with the coastal region, and many communities depend on it for their livelihood. Fish constitutes approximately 65% of the animal protein consumption and 13% of the total protein intake of Sri Lankans. Over 90% of the total fishing population belongs to the marine sector and the marine fisheries have supplied over 97% of the total fish production during 1987–1988 (31). The greatest development of the fisheries' sector occurred during the 1977–1983 period when fish production increased up to 8.4%, exceeding the overall growth rate of the country (32). According to the National Fisheries Development Plan of 1990, peak fish production was recorded in 1983 when 220 806 tons were harvested. Export of fish and other aquatic products reached a climax in 1988, with earnings of up to USD 16.5 million (31). The amount harvested from coastal reefs has never been calculated as a separate category; however, adding the catch data for 1989 from categories such as large demersals, Carangids and Scombrids, indicates that reef and reef-associated species comprise about 15% of the total fish landings.

Fishing is concentrated in coastal waters, classified as within the first 40 km from the shore (31). Prior to the last two decades, fishing in Sri Lanka was primarily carried out from non-motorized craft such as dugout canoes, catamarans, and log craft using nondestructive fishing techniques such as angling, gillnetting and beach seining. Recently introduced highly efficient techniques such as bottom-set nets to catch spiny lobsters and reef fish, cause severe damage to coral reefs. Overexploitation of spiny lobsters by bottom-set netting and scuba diving has caused a steady decline in their production (32). Traditionally, harvesting of sea cucumber has been limited to the estuarine environments. The demand for sea cucumber for export has caused many divers engaged in the collection of ornamental species to use scuba equipment to collect this resource from the reef habitats. Presently, very large numbers are being collected in the Kalpitiya and Batticaloa areas.

The current rates of exploitation may have a negative impact on the resources. Blast fishing using explosives is commonly practiced in many parts of the country, being most prevalent in the southern coastal waters in the Galle District. The number of fishermen is expected to increase by 50–60 000 by the year 2000, and a significant drop in their per capita income has been predicted, due to the scarcity of resources in the nearshore areas



Coral mining from the sea has caused massive coastal erosion in south and southwestern Sri Lanka. Corals are burnt in kilns to produce lime. Photo: M.C. Öhman.

(32). Increased numbers of fishermen and the use of modern techniques may negatively influence reef fish fauna directly through overharvesting and indirectly through habitat destruction (33).

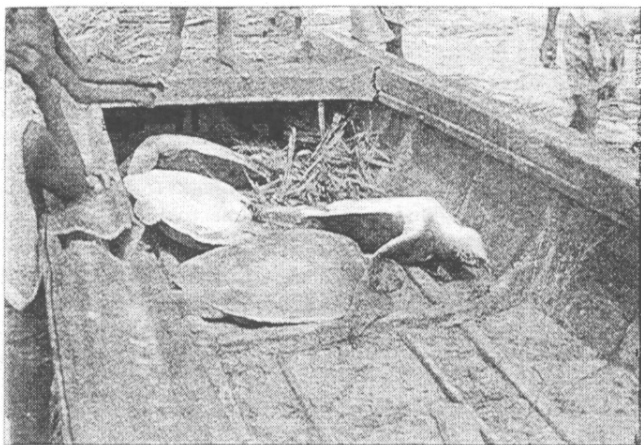
Export of Ornamental Species

In addition to fishing activities, collection of reef fish and invertebrates for the ornamental-fish export industry is of considerable importance. In fisheries export products, ornamental fish exports are rated as the third highest in volume and value after prawns and lobsters (31). The current value of the ornamental species exported is estimated to be about USD 2 million. The major portion of this value can be attributed to marine fish (Chaetodontidae, Pomacanthidae, Acanthuridae, Gobiidae, Balistidae, Labridae, Pomacentridae, Blennidae, etc.) invertebrates such as cleaner shrimps (*Lysmata debelius* and *Lysmata amboinensis*), sea anemones (*Radianthus* spp., *Cerianthus* spp.), soft corals (*Dendronephthya* spp.), starfish (*Protoreaster lincki*, *Fromia* spp.), nudibranchs (*Phyllidia* spp., *Jorunna* spp.), cones (Conidae) and cowries (Cypraeidae) while the balance is taken by freshwater species.

The export of live corals (*Goniopora stokesi*, *Catalaphyllia jardinei*, *Plerogyra sinuosa*) used to be an important commodity until recently, when the implementation of CITES (Convention on International Trade in Endangered Species) regulations forced the Sri Lankan authorities to implement the ban on coral exports. Uncontrolled collection and destructive collecting methods such as the 'moxy net' technique tend to deplete high-value species and cause habitat destruction (21, 34–37). Collection and export of ornamental fish have increased severalfold in recent times. Statistics from the Export Development Board indicate an increase of over 150% in value in the 1980s (34). The Sri Lankan government does not possess accurate records of the numbers of fish and their species. In contrast, the Maldivian Government is known to keep accurate records of fish exported and a 300% increase has been recorded since 1980 (35). Several species that are rare or not found in Sri Lanka are imported from the Maldives by Sri Lankan exporters to be re-exported with local species.

Tourism and Recreational Activities

Benefits from tourism in Sri Lanka have varied over the years. There was a steady increase from the mid-1960s to early 1980s, which was followed by a decrease as a result of civil unrest. In the 1990s, the industry caught up with almost 400 000 arrivals in 1993. Coastal areas, particularly beaches and areas with fringing reefs have become favored sites for tourism develop-



Due to the absence of law enforcement protected species such as the sea turtles are killed in many places in Sri Lanka. Photo: A. Rajasuriya.



Tourist hotels constructed on the beach at Hikkaduwa. Unplanned coastal construction contributes significantly to beach erosion. Photo: A. Rajasuriya.

ment. Snorkeling, scuba diving and viewing corals through glass-bottom boats are popular activities. A large number of hotels have been constructed along the coast. One of the most popular coastal resort areas in Sri Lanka is Hikkaduwa (Fig. 1) which had almost 300 000 guest nights in 1992. This area has undergone rapid development of the available tourist facilities, from only one hotel in the 1960s to nine big hotels and 125 guest houses, 40 restaurants, 157 shops, and 5 dive stations in 1994. Only 9% of these establishments are approved by the Ceylon Tourist Board (19). Rapid unplanned tourism development has had negative environmental impacts on coastal reefs, particularly within the Hikkaduwa Marine Sanctuary.

Environmental Pollution

Environmental pollution due to the dumping of garbage into city waterways and beaches is a growing problem. The volume of nonbiodegradable garbage such as polythene products in nearshore waters increases daily particularly near cities and coastal towns. In addition, untreated industrial effluent is discharged directly into rivers or canals and eventually ends up in the sea, which may negatively influence adjacent reefs and affect the productivity of nearshore waters.

Oil pollution in major harbors is a chronic problem. It is also a problem where fishing boats are anchored in protected bays formed by fringing reefs or estuaries. Waste oil and bilge water are dumped overboard; as a result some of the estuaries such as the Negombo Lagoon have become highly polluted. This is also a common occurrence in coral-reef lagoon areas of Hikkaduwa and Weligama.

MANAGEMENT

Sri Lanka has taken steps to protect marine resources. As far back as the late 19th century, Chanks Ordinance of 1880 was introduced to control the collection and export of chanks from the Gulf of Mannar region. A ban on the removal of corals was introduced in 1929 under the "Crown Lands Ordinance". Several locations, including offshore islands, have been declared as sanctuaries since 1940. They include the Hikkaduwa rocky islets and the Ambalangoda rocky islets which are 10 km north of Hikkaduwa, the Great and Little Sober Islands in Trincomalee, the Naval Headworks on the northeastern shore of the Trincomalee Harbor, Paraithivu Island west of the Jaffna Peninsula and the Pigeon Islands 15 km north of Trincomalee (see Box). However, the protected offshore islands and rocky out-

crofts do not include the adjacent marine waters. As a consequence, there is uncontrolled resource exploitation around these sites.

An Inter-Ministerial Committee on Marine Parks and Sanctuaries formed under the National Aquatic Resources Agency in 1982 had identified more than 20 locations around the coast of Sri Lanka to be declared as marine parks and sanctuaries. However, Bar Reef is the only location that has been declared since 1982. Most other locations that were originally recommended are now degraded due to heavy resource exploitation and loss of habitats.

There are a number of government organizations that are directly responsible for the management of coral reefs (Table 2). The National Aquatic Resources Agency is entrusted with research and management of coral reef resources, while other government organizations such as the Coast Conservation Department, the Central Environmental Authority, the Department of Wild Life Conservation and the Department of Fisheries under the Ministry of Fisheries and Aquatic Resources Development are entrusted with conservation of coral reefs and the implementation of laws that govern activities with regard to resource exploitation.

The main focus of marine environmental conservation in Sri Lanka has been on the protection of the coastline and activities that have an impact on coastal stability. In the early 1980s the Coast Conservation Department (CCD) was formed, primarily to combat coastal erosion problems and to carry out mitigatory measures. Preventing coral mining in the sea and the unplanned development of coastal industries has been CCD's main focus. The Coastal Zone Management Plan, as well as the National Environmental Action Plan identify the need for coral-reef conservation and integrated coastal-zone management, which is also the stated policy of the Sri Lankan government. Nevertheless, there is a lack of coordination at different levels of government, particularly at the provincial level where authorities do not have the required knowledge and understanding to manage the environment. In addition, political considerations at provincial level undermine the efforts of the centrally based government departments that are attempting to reduce the adverse impacts of human activities. As a result, there is very little or no implementation of the existing laws.

Bar Reef Marine Sanctuary and Adjacent Reefs

Bar Reef, which was declared a Marine Sanctuary (BRMS) in 1992, is located west of Kalpitiya Peninsula in the vicinity of Puttalam Lagoon (Fig 1). The extent of the sanctuary is 306.7

km². The landward boundary borders the northern section of Kaipitiya Peninsula and Karaitivu Island to the north (Fig.1). The sanctuary is divided into a core zone, and buffer zone with different degrees of human influence allowed (Table 4). The core zone, with an area of 70 km², supports true coral reefs while the buffer zone (236 km²) contains extensive areas of sandstone, sandy patches and, to some extent, sea-grass beds. Surveys carried out in 1990 and 1991 revealed that Bar Reef was in excellent condition with an average live-coral cover of around 80% in the coral-reef areas (21). The sanctuary is located in a relatively remote area of the country, where a few small fishing communities are situated on a coastal zone that is made up of sand dunes and coconut palm groves. Therefore, the reef has not been adversely affected by the human activities that contribute to reef degradation elsewhere in Sri Lanka. However, increasing numbers of fishermen and fish collectors in the Kalpitiya region have become a threat to the Bar Reef (Table 5). In addition, the Crown-of-Thorns starfish (*Acanthaster planci*) that were found only in relatively small numbers during surveys carried out by NARA in 1989–1993 (21, 41), have increased in numbers and have caused significant damage to sections of the reef (24). The threat from *Acanthaster planci* and from human impact emphasizes the need for protective management.

Bar Reef supports a large species diversity and abundance of fish, invertebrates and other organisms (21). A total of 138 species of stony corals divided among 50 genera have been recorded within the sanctuary. More than 300 reef and reef associated fish species belonging to 51 families have been identified. A number of them such as the butterfly fish *Chaetodon semeion* have been

recorded only on Bar Reef in Sri Lanka. There are yet many more fish species to be identified. Spiny lobsters (including *Panulirus versicolor*, *P. ornatus*, *P. pencillatus*) are found in some habitats of the reef, especially among tabulate and massive corals. Black-tip Reef Sharks (*Carcharinus melanopterus*) and White-tip Reef Sharks (*Traienodon obesus*) are encountered in the shallow coral areas. Whale Sharks (*Rhyncodon typus*) have also been sighted over the sandstone reefs close to the edge of the continental margin, which is also the western boundary of the sanctuary. Three species of sea turtles have been recorded in this area. The Hawksbill Turtle (*Eretmochelys imbricata*) is rare, while the Green Turtle (*Chelonia mydas*) and the Olive Ridley Turtle (*Lepidochelys olivacea*) are often sighted among the patch reefs. These species are also threatened by the exces-

Table 2. Ministries and government departments directly or indirectly responsible for the coastal waters. (*) direct authority over coral-reef management or research.

Ministry of Fisheries and Aquatic Resources*	Development and management of all fisheries activities, including licensing of fishermen, crafts and gear, also construction and maintenance of fisheries harbours
Ministry of Transport, Environment and Women's Affairs	Responsible for terrestrial and aquatic environments
Ministry of Ports and Shipping	Activities connected with shipping and commercial harbours
Ministry of Media, Tourism and Aviation	Responsible for planning and developing the tourist industry
Department of Wild Life Conservation*	Management of protected areas and species
National Aquatic Resources Agency*	Research and development of all aquatic living and nonliving resources
Central Environmental Authority*	Establishing national environmental standards and the principal coordinating body for all environmental related activities, which includes overseeing Sri Lanka's environmental impact assessment (EIA) process
Coast Conservation Department*	Regulating development activities within the coastal zone and safeguarding coastal resources. Responsible for implementing the Coastal Zone Management Plan
Urban Development Authority	Responsible for planning and development of towns, cities and their networks of garbage disposal systems, etc
Ceylon Tourist Board	Planning and development of tourist facilities and licensing authority for tourist related activities
Ceylon Fisheries Harbors Corporation	Development and maintenance of fishery harbours
Sri Lanka Ports Authority	Supervises port development and management
National Drainage and Water Supply Board	Supply of drinking water and sewerage facilities

Box 1. Protected Areas.

Although Sri Lanka has a long history of protection of forest areas, establishing marine protected areas is a relatively new concept. However, more than a century ago, there was Legislation to protect marine organisms. An example can be traced to the late 19th century when the *Chanks Ordinance*, 1880 was introduced which controlled the collection and export of chanks from the Gulf of Mannar region and around the Jaffna Peninsula. Later this legislation was expanded to introduce a ban on the collection of chanks, sea cucumber (beche-de-mer), coral and shells from Mannar to a point 2 miles south of Talawila. Subsequently, protection of marine organisms had been provided under the *Crown Lands Ordinance*, 1929, where removal of coral and certain organisms was prohibited from specific locations. Sanctuaries in marine areas were declared as far back as 1940. The Ambalangoda and Hikkaduwa rocky islets were declared sanctuaries by Gazette notification No. 8675, 25 October 1940. The Naval Headworks in Trincomalee as well as the Great and Little Sober Islands within the Trincomalee harbor were declared in 1963. The Paraitivu Island west of the Jaffna Peninsula and the Pigeon Islands north of Trincomalee were declared as sanctuaries in 1973 and 1974 respectively (Gazette No. 136, 1 November 1974). However, the adjacent marine waters of these off shore islands have not been protected. In 1973, regulations were drafted to declare the sea area between Mt. Lavinia and Galle Face on the west coast as a Lobster Reserve, but there is no evidence to indicate that it was ever gazetted. In 1980, Cabinet approval had been granted to the Ministry of Fisheries to declare the Hikkaduwa Harbor area, Polhena Reef area, Great and Little Basses reefs, Passekuda and Kalkuda Bay and Pigeon Island as marine sanctuaries under the *Fisheries Ordinance*. Again, there is no indication that these areas were ever declared as marine sanctuaries under the fisheries ordinance.

In 1982, an *Inter-Ministerial Committee on Marine Parks and Sanctuaries* formed by the National Aquatic Resources Agency (NARA) had identified more than 20 coral reef areas around the island to be declared as marine parks and sanctuaries. At present there are only two sites that have been declared as marine sanctuaries to conserve coral reefs. They are the *Hikkaduwa Marine Sanctuary* (declared in 1979), and the *Bar Reef Marine Sanctuary* (declared in 1992) declared under section 2(2) of the *Fauna and Flora Protection Ordinance* (Chapter 469) as amended by Act No. 44 of 1964 and Act No. 1 of 1970.

sive use of gillnets. Many are killed by fishermen from Kandakuliya who carry out large-scale gill-netting in the entire area. Large schools of Spinner Dolphins (*Stenella longirostris*) and smaller pods of Bottlenose Dolphins (*Tursiops truncatus*) can be seen regularly on the outer areas of the reef approximately 10 km offshore. The latter species can also be seen within Puttalam Lagoon together with the rare Indo-Pacific Humpback Dolphin (*Sousa chinensis*) during the months of February and March. Several species of seagulls, terns and waders are widespread along the coastal areas especially close to Puttalam Lagoon.

Fishing occurs within the sanctuary; it is done mainly by drift gillnets in relatively deeper waters. In addition, sea cucumber (beche-de-mer), are collected from Puttalam Lagoon as well as in the sea. More recently, ornamental fish collection has spread into these areas. Excessive collecting and the use of destructive collecting methods (moxy nets) are a cause for concern (21). Fishing with explosives may have been carried out in the region in the past but there are no recent reports of blast fishing. Bottom-set nets, commonly used on Kandakuliya Reef south of Bar Reef, could become a serious threat to the sanctuary.

The well-being of the Bar Reef Marine Sanctuary is of vast ecological and economical importance for the region, as the reefs within the sanctuary function as an integral part of a larger ecosystem of Puttalam Lagoon and the adjacent coastal waters. The zonation plan for the sanctuary allows for some activities of economic importance (Table 4). Considering the varied biotopes present in the region including coral reefs, mangroves, sea-grass beds, sand dunes, and lagoon systems, the Bar Reef Marine Sanctuary is a promising area for ecotourism.

Unregulated utilization of reef resources in this area has led to severe reef degradation, particularly at Kandakuliya. In the mid-1980s De Silva and Rajasuriya (16, 20) reported that the Kandakuliya Reef was in a healthy state, resembling Bar Reef. They recommended that the area should be managed properly to prevent irreversible damage from overexploitation. As proper action was not taken the fish stock at Kandakuliya Reef has been overharvested and the reef degraded by destructive fishing methods (21). With the destruction of the coral reef, coastal erosion has become an acute problem. The population increase in the area is another critical factor for the future well-being of the reefs in the region.

Hikkaduwa Marine Sanctuary

The Hikkaduwa Marine Sanctuary was declared in 1979, primarily to protect the coral reefs in the nearshore area. The absence of proper management and a variety of human activities have led to degradation of the coral reef within the sanctuary (Table 3). The sea-grass patches that existed in the reef lagoon have disappeared due to sedimentation and destruction caused by anchoring of fishing boats. The freshwater canals that empty into the reef area are polluted by coconut-husk retting and effluents from domestic sources and unregistered tourist establishments. In addition, various hotels located within the sanctuary continue to discharge effluents into the sea. Although there are no recent reports on the collection of ornamental species, colorful shells such as cowries (Cypraeidae) and cones (Conidae) have become very rare. A patch of black corals (*Antipathes* spp.) that existed at a depth of 20 m west of the sanctuary has been completely devastated. Some of these organisms are prominently displayed in nearby curio shops.

Collection of live corals by glass-bottom boat operators to be sold as souvenirs was a common occurrence in the past. This activity is uncommon today although local visitors sometimes remove corals. Studies have shown that coral reef fisheries may reduce the number of selected species (target species), in particular larger carnivorous individuals such as groupers, snappers, and emperors, etc. (38-40). This appears to be the effect of

fishing in and around the Hikkaduwa reef where larger individuals of many reef species have become scarce probably as a result of fishing activities immediately outside the sanctuary as well as the use of destructive fishing methods such as bottom-set nets.

Blast fishing, which is prevalent in the entire Galle District, is commonly practiced outside the sanctuary limits. Spearfishing is still carried out by locals near the southern area of the sanctuary. Collection of spiny lobsters continues although this has become a very rare resource. The rocky islets near the southern boundary used to attract seabirds in the past. At present the birds no longer roost at this location due to disturbances caused by glass-bottom boats and tourists walking on the rocks. The condition of the coral reef on the leeward side of these islets has degraded including the disappearance of most reef fish.

A water-quality study carried out by the National Aquatic Resources Agency in 1993 and 1994 indicated that some of the effluents released by the hotels are toxic to marine life, but have a low impact on the reef due to rapid flushing within the sanctuary (19). Fishing boats dump waste oil and wash bilges while anchored within the sanctuary. De Silva and Rajasuriya (18) made recommendations to deepen the area bound by the granite groyne outside the sanctuary to accommodate the boats that are now anchored within the sanctuary. Attempts to have these boats removed from the sanctuary have so far been unsuccessful. The so-called fisheries harbor (Fig. 1) outside the northern end of

Table 3. Main causes of reef damage in the Hikkaduwa Marine Sanctuary.

Tourist activities	
Boat anchoring on live coral (glass bottom boats)	
Glass bottom boats banging against the reef	
Reef walking (visitors and glass-bottom boat operators)	
Coral and shell collection	
Fishery	
Boat anchoring on live coral and damage caused by anchor chains	
Discharge of oil and bilge water from fishing boats	
Dumping of fish offal within the sanctuary	
Ornamental Fish Collection	
Reef fish invertebrate and live coral collecting	
Pollution	
Effluents discharged from hotels	
Discharge from freshwater canals polluted due to coconut husk retting	
Sedimentation	
Sedimentation due to coastal construction, coastal erosion and river runoff	

Table 4. Recommended control measures to limit human activities within zones of the Bar Reef Marine Sanctuary.

Activity	Core zone	Buffer zone
Bottom set nets	(*)	(*)
Gill nets (surface)	(*)	(lic)
Gill nets (bottom)	(*)	(lic)
Moxy nets	(*)	(lic)
Angling	(*)	(lic)
Collection of ornamental fish	(*)	(lic)
Collection of spiny lobsters	(*)	(lic)
Collection of sea cucumber	(*)	(lic)
Collection of mollusks	(*)	(lic)
Collection of other invertebrates	(*)	(lic)
Spear fishing	(*)	(lic)
Trolling	(*)	(lic)
Trawling	(*)	(lic)
Recreational diving	(lic)	(lic)
Glass bottom boats	(*)	(*)
Boat anchoring	(*)	(*)

(*) not permitted
 (l) permitted
 (l) (lic.) permitted with license
 (*) only at designated locations

the sanctuary, had in fact been created as a sand trap to prevent the Hikkaduwa river outfall being clogged up with sand. There are ongoing discussions with regard to the development of this area into a proper fishing harbor that can accommodate more fishing boats. Removal of fishing boats and the glass-bottom boats from the sanctuary is considered a priority, to mitigate degradation of the coral reef within the sanctuary.

Glass-bottom boats cause considerable physical damage to the reef as they may break corals by running over shallow coral patches. In order to give a better view of corals to the visitors the operators often stop their boats over shallow coral patches and stand on the reef to keep the boats in place as well as dropping anchor on live coral. Reef walking by visitors is also a major cause of damage to the corals, particularly during low tide.

Although a protected area since 1979, the Hikkaduwa Marine Sanctuary lacked a management plan for many years. De Silva and Rajasuriya (18) proposed a management strategy in 1985, organizing the sanctuary as a multiple-use marine park separating the reef area into three zones. More recently, a survey has been carried out to increase the size of the sanctuary from 45 to 101 ha, but the new boundaries have not been gazetted (Fig. 1).

The Department of Wild Life Conservation has initiated some of the steps recommended by De Silva and Rajasuriya (18). Large colorful boards indicating the sanctuary area and its regulations have been installed on the beach and near the southern end of the sanctuary. Glass-bottom boats are being licensed through the local government authorities and steps have also been taken to zone the reef area. The sanctuary has been the focus of a Special Area Management (SAM) program since 1992. The overall objective is to develop and implement at the local level a coastal-resources management plan by facilitating the participation of all relevant government organizations and local community groups (19). The Hikkaduwa Marine Sanctuary Development Committee established in 1991 meets regularly to direct and monitor the progress under the SAM process.

Fishing is still carried out within the sanctuary by local fishermen using traditional fishing gear, such as cast nets, and rod and line. Such activities do not cause much damage to the reef structure, but deplete the fish stock and need to be gradually phased out. Prior to the declaration of the marine sanctuary the reef area of Hikkaduwa had been declared as a fishery protected area in 1961 under the Fisheries Ordinance. A limited number of permits have been issued by the Department of Fisheries to traditional fishermen to fish within the protected area. An attempt by the Department of Wild Life Conservation in 1993 to stop fishing within the sanctuary was unsuccessful due to conflicting interests and legislation.

Through the SAM process a large number of local people have been educated on the value of coral reefs and the need to safeguard this valuable resource. These groups include local government officials, hotel owners, managers, glass-bottom boat users, tour guides and others. The Department of Wild Life Conservation has also assigned several guards to protect the reef from destructive action. However, the guards are not successful in preventing the major causes of reef damage that are due to boat anchoring and discharging of effluents from hotels and other



Garbage dumped on the beach at Kalpitiya. The absence of a proper garbage-disposal system increases pollution in coastal waters. Photo: A. Rajasuriya.

sources. Furthermore, the absence of boundary markers prevent the authorities from implementing sanctuary regulations.

Recommendations for Reef Management in Sri Lanka

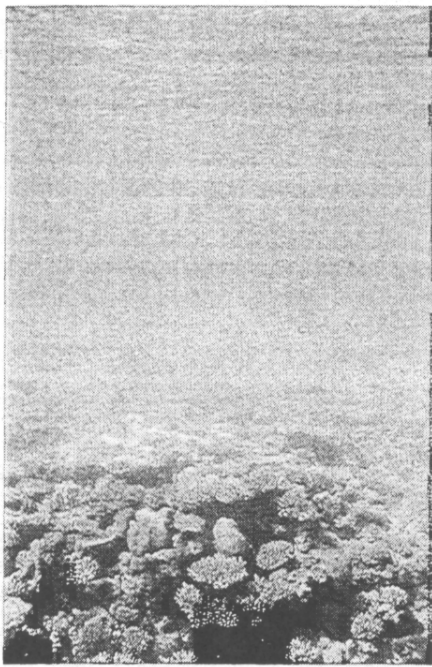
- Loss of reef habitat has the greatest impact on abundance and diversity of marine species in Sri Lanka. Therefore, conservation of reef habitats should be given prime consideration.
- Existing laws to prevent habitat degradation as well as resource depletion must be strictly enforced as it would be futile to formulate management plans in the absence of law en-



Branching corals make up the major part of Sri Lanka's coral reefs. These corals are easily broken by boat anchors and destructive fishing techniques. Photo: M.C. Öhman.

Table 5. Major threats to the Bar Reef.

Fishery
Overharvesting of reef resources
Use of bottom-set nets to catch spiny lobsters and reef fish
Boat anchoring on live coral
Laying nets on coral patches
Ornamental Fish Collection
Reef fish collecting and overharvesting
Use of 'moxly nets'
Boat anchoring
Natural Disturbance
Destruction by the 'Crown of Thorns' starfish



Shallow fringing reefs benefit the people of Sri Lanka in many different ways. Proper management of these resources is needed, not least to hinder coastal erosion. Photo: M.C. Öhman.



Coastal fishery has a long tradition in Sri Lanka. Although old fishing methods are still used by some fishermen, the major part of the coastal fishery use modern, highly efficient fishing techniques. This has had a profound impact, not only on the marine environment, but also on the people of the fishing community which need to adapt to a new social situation. Photo: M.C. Öhman.

forcement and political will with regard to reef conservation.

- Capabilities for reef management and law enforcement should be improved in the appropriate government organisations.
- Destructive gear such as the bottom-set nets used in reef fishery and the moxy nets used to catch ornamental species should be banned under the Fisheries Ordinance.
- All users of reef resources should be licensed by the Department of Fisheries and Aquatic Resources Development through their respective provincial councils. Licenses should specify conditions regarding fishing techniques and types of gear to be used depending on the type of habitat and area of operation.
- Coral mining needs to be addressed through a comprehensive program that will provide alternatives to the use of lime and to make dolomite-based lime available in the coastal region at a subsidized rate. Alternative sources to coral lime should be given publicity in order to popularize them. The Sri Lankan government should earnestly address the problem of providing alternative sources of income to people engaged in sea-coral mining.
- Future management efforts should concentrate on the protection and development of the declared sanctuaries of Hikkaduwa and Bar Reef. Additional protected areas are further needed in order to prevent fragmentation of habitats as well as to maintain biodiversity and viable breeding populations. As larvae of reef-dwelling species are transported by oceanic currents, sanctuaries could function as seed areas, hence a network of protected areas should be established.
- Artificial reefs should be introduced within the buffer zones of sanctuaries and other areas in order to prevent overfishing, and to divert fishing activities from sensitive habitats. They could also be used to restore habitats lost due to coral mining and destructive fishing.
- Marine organisms that have been given protected status should be listed under one ordinance (ideally in the Fauna and Flora protection ordinance while organisms that can be exported with a permit should be listed in the Fisheries Ordinance).
- A 'Crown of Thorns' starfish (*Acanthaster planci*) eradication program should be carried out under the guidance of NARA.

- Local community user groups should always be incorporated in the development, conservation and management of reef resources.
- Quotas should be introduced for the harvesting of vulnerable reef and reef associated species.
- A proper database should be developed to monitor the harvesting of reef resources and the export of ornamental species.

Box 2. Management Recommendations for the Bar Reef Marine Sanctuary.

A comprehensive awareness program must be carried out to educate fishermen and other users of the sanctuary and adjacent reef areas. Destructive fishing techniques such as bottom-set nets and moxy nets should be banned. All user groups in the area must be licensed and quotas should be introduced in order to monitor and control harvesting within and outside the sanctuary.

Permanent staff from the *Department of Wild Life Conservation* should be assigned to manage the sanctuary. Personnel should be provided with adequate facilities and equipment in the form of patrol crafts, vehicles and other necessary material. Park offices should be built in Kalpitiya and at the northern point of the Kalpitiya Peninsula.

Boundaries of the sanctuary need to be demarcated clearly, indicating core and buffer zones. These should be clearly indicated on large sign boards installed at strategic locations that provide access to the sanctuary. Mooring buoys have to be provided for fishing and other crafts to minimize the damage caused by boat anchors.

Ongoing monitoring and research programs carried out by NARA should continue together with a program to eradicate the 'Crown of Thorns' starfish (*Acanthaster planci*) from the sanctuary and surrounding areas.

- Government organizations involved in ICZM should function within a single framework, as conflicting interests and overlapping responsibilities of different organisations could create problems for efficient management.

Research Needs

- Studies on distribution patterns, species composition and abundance of reef organisms should be carried out together with research on larval dispersal and recruitment.
- Research should be conducted on interaction of species and to determine how fish assemblages relate to the various reef habitats in Sri Lanka.

- Taxonomic lists need to be compiled to determine the biodiversity of coastal reefs.
- Remote-sensing techniques should be applied to map the locations and the extent of coastal reefs.
- Regular monitoring programs to study human impact on different reef habitats should be carried out within the sanctuaries as well as at other sites (under the guidance of NARA) to determine the health of coastal reefs and to monitor changes over time scales.
- Economic models should be developed to determine the value of reef resources and how they can be used on a sustainable basis.

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