

# Human Impacts on Coral Reef Ecosystem

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## Abstract

Healthy, Coral reefs are the most spectacular, diverse and economically valuable marine ecosystems on the planet, Complex and productive, coral reefs are extremely important for biodiversity, providing a home to 35,000–60,000 species of plants and animals (over 25% of all marine life), many of which are not described by science. They are also vital for people and business. They provide nurseries for many species of commercially important fish, protection of coastal areas from storm waves. They are providing hundreds of billions of dollars in food, jobs and significant attraction for the tourism industry. Yet coral reef ecosystems have undergone phase shifts to alternate, degraded assemblages because of the combined human activities of unsustainable overfishing, intensive tourism, urbanization, sedimentation, declining water quality, pollution and primarily from the direct and indirect impacts of climate change. Most coral ecologists confirm that coral reef degradation has increased dramatically during the last three decades due to enhanced anthropogenic disturbances and their interaction with natural stressors. So, it is necessary to recognize the threats facing coral reefs from anthropogenic activities and try to minimize and mitigate these impacts.

**Keywords:** coral reef ecosystem, anthropogenic activities, natural threats, climate change, coral protection, proposed solutions

## 1. Introduction

Coral reefs are extraordinary living geological diverse underwater ecosystems held together by calcium carbonate structures secreted by corals. They represent the most conspicuous and magnificent community in the tropical and subtropical regions. Coral reefs are built by colonies of tiny living animals found in shallow sub-tidal marine waters that contain few nutrients. Most coral reefs are built from stony corals, which in turn consist of polyps that live together in groups. The polyps belong to a group of animals known as Cnidaria, which also includes sea anemones and jellyfish. The polyps secrete a hard carbonate exoskeleton which support and protect their bodies. Most reefs grow best in warm, shallow, clear, sunny and agitated waters. The oldest coral reefs on the earth occurred about 500 million years ago, as well as the first relatives of recent corals developed in the south of Europe from about 230 million years ago. Most corals get their color from the symbiotic single-celled algae called zooxanthellae. Millions of these single-celled algae are living as symbionts within polyp tissues, intercellular in the gastrodermis layer. Zooxanthellae produce organic nutrients and oxygen through photosynthesis thus helping the coral in the growth and the process of producing limestone or calcium carbonate. Corals grow

much faster with the help of the zooxanthellae. Corals get up 90% of their nutrients from their zooxanthellae. Zooxanthellae produce pigments visible through the clear body of the polyp and give the coral its beautiful color [1, 2].

Coral reefs provide a home for at least 25% of marine origin fauna, including fishes, echinoderms, crustaceans, mollusks, sponges, tunicates, and other cnidarians and so on. Coral reefs ecosystem (CRE) provides many services to tourism, fisheries in addition to coastline protection from wave action. The global economic value of coral reefs ecosystem is estimated between US \$29.8 and 375 billion per year. However, coral reef is a fragile ecosystem, because it is very sensitive to elevations of water temperature. Coral reef ecosystems are exposed to many threats most of them resulting from humans such as global warming, oceanic acidification, climate change, water pollution, Irrational tourism, blast fishing, overfishing, illegal fishing for aquarium fish, overuse of reef resources, harmful land-use practices including urbanization and agricultural runoff which may be harmful for reefs by enhancing algal overgrowth [3, 4].

Coral reef ecosystem degradation has increased dramatically during the last three decades due to enhanced anthropogenic disturbances and their interaction with natural stressors [5]. These stressors are thought to cause coral diseases and bleaching leading to a loss of coral cover. Unfortunately, very little is currently known about the prevalence, distribution and pathology of coral diseases in the Red Sea [1, 6].

The annihilation of the reef ecosystem will lead to the disappearance of 25% of marine habitats, and a quarter of marine life that needs to productive and diversified this three-dimensional building to stay alive. Graham et al. [7] found a serious decline in coral reef fish populations as a result of climate change. Coral reefs provide food and are a source of income for hundreds of millions of people scattered in many countries. The loss of this ecosystem will lead to unexpected effects with serious damages already beginning to appear. It has been estimated that the volume of services and natural resources offered by the coral reefs to humanity from 10 years ago to be about US \$30 billion per year, through benefits such as fisheries, tourism and shore protection; it is perhaps greatly increased now [8]. The mass coral bleaching and death of CRE is one of the most obvious effects of climate changes which warn the world that we should take global warming seriously. The loss of the oceans to most if not all effective CREs could lead to unexpected disasters. We are on the verge of these disasters, but they can be avoided if the necessary international efforts are combined for adverse impact mitigation [9].

## **2. The main components of the coral reef ecosystem**

Coral reefs form some of the world's most productive ecosystems, providing complex and varied marine habitats that support a wide range of other organisms. The coral reef ecosystem is a collection of diversified communities which interact together and with the environment. The primary source of energy for any ecosystem including coral reef is the sun. Phytoplankton, algae, and other plants use the sun light for photosynthesis. During photosynthesis, the light energy from the sun in the presence of water and nutrients is converted into chemical energy. The chemical energy that is made by photosynthesis is passed from plants to animals then other animals then to simple nutrients by bacteria through the food chain. Although, the corals are the main organisms that form the basic structure of reef ecosystem, members of all other animal phyla and classes may be found on coral reefs, in addition to the significant role for certain species of algae in reef formation. The following is a short summary of the more important and abundant groups that make up coral reef composition [9, 10].

1. **Algae:** Coral reefs are chronically at risk of algal encroachment. Overfishing and excess nutrient supply from onshore can enable algae to outcompete and kill the coral. There are three groups of algae, these are:
  - a. **The coralline algae:** These groups are very important in constructing and maintaining reef. They belong to the red algae, and can precipitate calcium carbonate as do corals, but tend to be encrusting and spreading out in thin layers over the reefs, cementing the various pieces of calcium carbonate together. These algae form what is called “the algal ridge” on reef which is the most rapidly calcifying zone on reef.
  - b. **Calcareous green algae:** These algae include certain species of green algae, such as *Halimeda*, which grow erect and secrete calcium carbonate, giving much of reef sand by breaking up.
  - c. **Other free living algae:** They include the free living algae that exist just below the surface layers of calcium carbonate in the coral colonies themselves but are inconspicuous on the reef.

## 2. Members of phylum Cnidaria

- a. **The stony corals:** These groups belong to the Order Scleractinia (*Madreporaria*) and form the major structure of reefs.
  - b. **Order Gorgonacea:** Its members are commonly called sea fan and sea whip, which have an internal skeleton of spicules. They are abundant in Atlantic Ocean.
  - c. **Order Alcyonacea:** This order comprises the soft corals, which may be abundant in some Indo-Pacific regions than the stony corals, but very rare in Atlantic. Several species of soft corals have internal spicules of calcium carbonates.
  - d. **Order Hydrocorallina:** It includes the hydrocorals, which belong to the class hydrozoa, and called “Fire corals,” for their powerful nematocysts. The hydrocorals are conspicuous in the Atlantic Ocean.
3. **Mollusca:** Mollusks have significant role in reef formation due to the ability of their species for calcium carbonate deposition. The most important of mollusk are the giant clam, *Tridacna* spp. and *Hippopus* spp. which may be up to 2200 individuals per square meter. Also there is a prominent role of other gastropods and bivalves in deposition of  $\text{CaCO}_2$  at the coral reefs.
  4. **Echinodermata:** Some species of echinoderms have adverse effects on coral reef, particularly the sea star, *Acanthaster planci*, which predate the coral polyp and cause coral bleaching. However, other species of sea urchin, sea cucumbers, starfish and feather stars are found but their role in reef ecosystem is understood.
  5. **Crustaceans and Polychaetes:** Members of these groups are very abundant on coral reefs but there is little information about their role in reef formation.
  6. **Sponges:** They are essential for the functioning of the coral reefs ecosystem. Algae and corals produce organic material. This is filtered through sponges

which convert this organic material into small particles which in turn are absorbed by algae and corals. It was recorded that, some species of Siliceous sponges (class: Demospongiae) may be important in holding coral and rubble together, and prevent loss from reef until it can be fused together by coral-line algae. Other sponges have symbiotic blue green algae responsible for net primary productivity.

7. **Coral reef fishes:** Fishes are very conspicuous and abundant and many of them may have an adverse effect on coral structure due to their feeding regime.
8. **Bacteria:** The role of these organisms is very important in reefs structures. This group is very abundant and is responsible for the decomposition and quick cycling of organic matter.
9. **Other communities:** Sea eels and snakes as well as marine birds; such as boobies, pelicans, gannets and herons, all feed on fish and other coral reef components. Land-based reptiles such as monitor lizards, marine crocodile and semiaquatic snakes such as *Laticauda colubrina* can be intermittently associated with reefs and feed on some of their components. Sea turtles, such as hawksbill sea turtles, feed on sponges between reefs.

### 3. The importance of the coral reef ecosystem

Coral reef ecosystems are one of the most diverse and beautiful natural environments on earth. Coral reefs have an important role in the marine and coastal environments. They provide valuable habitat (food and shelter) for a great diversity of plants and animals, including important breeding and nursery grounds for many marine organisms [10].

Coral reefs also provide protection from coastal erosion by acting as natural breakwaters for big waves and storms. Also, the breakdown of corals and other organisms living in the reef habitat creates beaches, which are an important resource for the survival of many coastal organisms, including endangered sea turtles and monk seals. Coral reefs are an important environmental and economic resource for people. In addition to shoreline protection, reefs provide food, recreational and employment opportunities, and are a potential source for new medicines [11, 12]. Coral reefs also provide economic benefits to coastal communities from tourism. The major benefits from coral reef ecosystem will be described as follows:

#### 3.1 Reef as a source of income

The diversity of marine life and coasts protected and supported by coral reefs supply attractive conditions and ambience for visitors, reef lovers, divers and snorkelers. Actually, there are more than 8.5 million certified divers in the USA who spend money on diving during each year. The coral reef destruction generates a considerable loss of tourism employment, marine recreation industries and fishing activities. These can have huge impacts on inhabitants of coral reef areas that essentially rely on income from tourism [13, 14].

The coral reefs ecosystem provides a significant protein source for millions of people, and is considered as part of their lives. The people inhabiting coral reef areas madly love it, because the coral reef is considered a part of their lives, providing them

with the major part of their food through fishing and tourism services. Coral reefs are also strongly linked with cultural, spiritual and traditional values of many people who live in areas nearest to reefs [10].

### **3.2 Coral reefs act as protector from storm and wave action**

Another benefit to people from coral reefs is that they act as the guards of our coast. They serve as a buffer and protection for the shore areas from the pounding of ocean waves. In the absence of coral reefs, many of beaches and coastal cities would become vulnerable to storm damage and wave action. In the Maldives, when the coral reef and sand were mined away along the coast, it cost \$10 million American dollars for each kilometer to construct a wall for coastline protection. In Indonesia, the value of this protective service of coral reefs is estimated at 314 million American dollars [15].

### **3.3 Coral reefs save our lives**

Just as in the rain forest, plant and animal life in reef ecosystem contain promising medicinal components, several of which are just being detected. Already, many important drugs have been developed from chemicals extracted from coral reef organisms. AZT is the most famous of these drugs, it is a treatment for HIV infections, which relies on chemicals extracted from sponge inhabiting Caribbean reef [16].

Several unique compounds extracted from coral reefs have also produced the treatments for skin cancer, leukemia, ulcers and cardiovascular diseases. In addition, the unique skeletal structures produced from reef have been used to produce the advanced forms of bone grafting materials. Surprisingly, more than half of all new research related cancer drug discovery focuses on marine organisms. The fragile and beautiful organisms of coral reefs have the potent to make even huge contributions to our lives through providing new treatments for diseases that are threats to our lives [11, 12].

### **3.4 Coral reefs serve as a home for fishes**

Over the last 350 million years, coral reefs have developed to become one of the most and largest complex ecosystems on the earth planet. Coral reefs provide shelter for about 25% of all known marine species. They serve as a home to 4000 fish species, 700 corals species and thousands of other forms of flora and fauna. Ecologists estimate that more than one million of biota species are associated with the coral reef ecosystem [15, 17].

## **4. Global threats facing reef ecosystems**

Coral Reef ecosystems are facing many natural and anthropogenic threats. Many human impacts are resulting in the destruction and degradation of coral reefs ecosystem to cause loss in biodiversity, fundamental supplies for food and reef economic revenue. Combined with threats from nature in the form of diseases, earthquakes, climate change, typhoons and storms, coral reefs are struggling to survive. Natural stressors are made worse by human disturbances. For example, the diseases may be present at a higher level in corals stressed by human influences such as pollution and mechanical damage [18].

A majority of the problems threatening coral reefs are the direct (and indirect) result of human activities on land, and in the marine environment. Marine debris, water pollution, sedimentation, overfishing, careless recreation, and global warming are some examples of human-caused threats to the coral reef habitat. Each of these threats has a significant impact on the health of coral reefs. Coral reefs grow very slowly and can take hundreds of years to form. If damage to coral reefs continues at the current rate, over half of all reefs in the world could disappear in our lifetimes. Currently, millions of acres of reef have already been severely damaged or destroyed. Through education, awareness, and action, people can help to preserve and protect coral reefs [15]. The threats facing coral reef ecosystems can be summarized as below:

## **4.1 Natural Impacts**

### *4.1.1 Earthquakes and storms*

Disasters such as earthquakes and storms occur periodically and naturally and devastate massive areas of coral reefs. These natural events can be more severe if the communities of coral reef are already weakened by other influences and recovery is inhibited by algal overgrowth due to the lack of grazing organisms, removed by fishing.

### *4.1.2 Climate change and acidification*

Climate change impacts have been identified as one of the greatest global threats to coral reef ecosystems. If the temperatures of sea water stay higher than the usual for some weeks, the symbiotic algae “zooxanthellae” that corals rely on for their food leave the coral tissue. Actually, without zooxanthellae the corals turn to white color, because it gives corals their color. Unhealthy white corals are called bleached. Bleached corals are weak and lose their ability to combat diseases and then die [18]. As climate change continues, bleaching will become more common, and the overall health of coral reefs will decline [19, 20].

Since the late nineteenth century, the global temperature of oceans has risen by 1.3°F (0.74°C), causing more frequent and severe corals bleaching around the world. At the recent increasing emissions rate of greenhouse gases, the global temperature could rise up to 7.3°F (4.1°C). These changes in global temperature already have harmful effects on coral reef ecosystems and will continue to impact on coral reef ecosystems over the world during the next century. The decline and loss of coral reef ecosystems have significant social, cultural, economic, and ecological bad impacts on people and communities around the world [21].

As water temperature rises, infectious diseases and huge bleaching may likely become more frequent. In addition, carbon dioxide absorbed into the sea water from the atmosphere has begun to reduce the calcification rates in reef-building corals and organisms associated with coral throughout change of water chemistry by decreases in pH (ocean acidification). In the long term, the failure in addressing carbon emissions and the impacts of rising water temperatures and ocean acidification could make the several efforts to coral reef ecosystems managements futile. In summary, climate change and ocean acidification have been identified as the most important threats to CRE on a global basis [22].

In the last decades, 33–50% of corals were significantly degraded, because of the negative impacts that accompanied climate change [10]. Recently, some areas have lost about half or more of their living coral and more deterioration can occur over the next two decades due to continued temperature rise. Because of the destruction

of the CRE, 25% of marine species would be in danger while the economic losses will showcase hundreds of millions of people to the lack of food security and increasing poverty [23]. Wilkinson [10] recorded bleaching and death of about 16% of the global reefs communities together with high average of surface temperature in 1998. Since then, the bleaching and death of coral occur on a large scale, with increasing severity of these effects over the successive decades [24].

Other reasons for coral bleaching are the extreme lowering in tides levels, increased UV radiation and changes in salinity and nutrient levels. Coral reefs may recover but this extreme incident is generally presumed to weakened it. The death may be occurring largely due to starvation, although it is thought that some autolysis (tissue destruction) occurs. The physiological mechanisms involved with bleaching are not fully understood and are currently a source of investigation.

#### 4.1.3 Crown-of-Thorns

Historically, tropical cyclones and poor water quality that cause outbreaks of crown of thorns starfish have been the major causes of coral loss. Current increases in the Crown-of-Thorns starfish populations that eat corals are considered as another natural threat to reefs. When present in huge numbers, these stars are able to destroy massive areas of coral reef. Recovery of the coral reef from the outbreaks of Crown-of-Thorns may take up to 20–40 years, where the damage is not severe. However, coral recovery in some world areas may never occur when the coral is being taken over by sponge, algal cover and other coral species. *Acanthaster planci* can produce many million babies during 1 year. People have contributed to their population increase through increase of the nutrients from sewage and over harvesting of their natural predator Triton Trumpet and so on. Crown-of-Thorns babies gave more plant food (seaweed) to survive and become devastating adults for coral [25].

#### 4.1.4 Coral diseases

Coral reefs when are under stress, suffer many bacterial infections as a result of growing production of protective mucus. The coral production for excessive mucus due to natural and man-made influences (e.g., global warming, toxic chemicals, increased sedimentation and so on) can also promote the growth of many blue green algae; this algae is thought to be responsible for black band disease (Intense black band of filaments across coral colonies). This disease kills the Coral polyps and the black band advances then leaving the reef as a white limestone behind it [16].

Although this disease is rare, the pathogenic bacteria and parasites resulting from fecal contamination may cause some diseases in coral reefs, particularly if corals are stressed by unfavorable environmental conditions. Naturally, the diseases occur for corals in healthy ecosystems, but the pathogen-containing pollution inputs could exacerbate the intensity and frequency of disease outbreaks [16].

A change of environmental conditions such as higher temperatures or a change in salinity but also disease can cause the polyps to expel the zooxanthellae algae. The coral becomes totally white (= coral bleaching). If the coral regains some algae it might survive, but bleaching can be irreversible and then the coral dies. Coral bleaching is the loss of intracellular endosymbionts (zooxanthellae) from coral tissue, when corals are stressed by changes in conditions such as temperature, light, or nutrients, they expel the symbiotic algae living in their tissues, causing them to turn completely white [2].

#### *4.1.5 Invasive alien species*

Invasive alien species are non-native (exotic) species that may cause huge environmental damages and can have effects on fisheries stock, economy and even on human health. They should not be confused with introduced species which are also non-native and have been deliberately introduced for a benefit or purpose within the limits imposed on them. It is estimated that of the several of the introduced species to different habitats and different climates have threats to native ecosystems. These invasive alien species have the ability to rapidly grow, vigorously compete with the native species. These species in the absence of their natural predators can lead to the pushing out native species and finally to ecological havoc. They can be able to change and threaten native biodiversity and contribute to economic hardship and social instability, placing constraints on environmental conservation, economic growth and sustainable development [26]. Actually, the threat to global biodiversity from Invasive Alien Species is the second after habitat destruction. Ballast water is the major channel of spreading Invasive Alien Species in marine habitats. Ships discharge their cargo of ballast water at ports; with this discharge, they also release organisms that were taken in accidentally with the ballast water from other ports [27].

### **4.2 Anthropogenic impacts**

#### *4.2.1 Use the coral reefs in construction and curio trade*

Coral reefs are used as a construction tool for many purposes. They may be used for the construction of house foundations, canals, streets, embankment of fish ponds and lime kilns. Large businesses also are keen on collecting coral reefs for selling them as souvenirs or in the aquarium trade.

#### *4.2.2 Chemical pollution*

Coastal waters suffer from huge amounts of a variety of agricultural and industrial chemicals that are released into them. Fertilizers and pesticides used in agricultural development projects are discharged into the sea and might lead to coral reef destruction. Pesticides pollution may destroy or harm to reef communities. They lead to further deterioration through accumulating in tissues and may affect physiological processes of animals. Herbicides may impact the basic food chain; they can destroy and damage symbionts zooxanthellae algae in coral reef, other algal, sea grass and even free living phytoplankton communities.

The chemical spillage from oil tankers, harbors and pipelines have heavy impacts on feeding, growth rate, reproduction, defensive responses and even on cell structure in coral reefs. Industrial activities such as dredging, mining and refining produce heavy metals and hydrocarbon pollutants that are released into coastal waters. Many coral species are more sensitive to these pollutants, which can damage the ecosystem of coral [28]. Herbicides and pesticides can affect coral reproduction, growth, and other physiological processes, in particular, can affect the symbiotic algae (plants). This can damage their partnership with coral and result in bleaching.

#### *4.2.3 Nutrients loading/sewage*

The discharge of aquacultural and agricultural inputs such as fertilizers, herbicides, pesticides, feed waste and other materials can result in more nutrients loading into coastal areas. These organic compounds lead to increases of eutrophication

status of coastal areas and subsequent oxygen depletion. When the nutrient loading into coastal areas and eutrophication occur, the community becomes dominated by algae and seaweed, to the limit transcend grazing organisms' capacity to control. These can leads to light reduction, oxygen depletion and perhaps death of the communities living there. When coral reef ecosystems are subjected to huge quantities of nutrients, they are easily taken over by algae and may be severely damaged, if not killed.

#### *4.2.4 Fishing and overfishing*

Illegal fishing such as blast “dynamite,” cyanide or poison (duva) fishing and hunting by gum boots, are all destructive of any ecosystem. Other injurious practices of fishing include reef structure disintegration in order to remove hiding places, weight traps and herd fish into nets by beating coral surfaces. Accidental grounding of boats and anchor damage may be significant threat to coral reef ecosystem. Such practices lead to annihilation and degradation of habitat of coral reef ecosystem. For instance, 3150 km<sup>2</sup> of coral reef were destroyed when one cruise ship anchored on one occasion [29].

Overfishing may alter food-webs structure of coral reef ecosystem and cause cascading impacts, such as decrease of the grazer fish numbers that remove algal overgrowth and keep corals clean. Blast fishing (kill fish by explosives) may create physical damage to coral reefs [30].

The vast majority of the world's reefs are affected by over exploitation of resources. This may lead to decrease of average size of the fish and reduction of target predatory fish. Removal of main predator and herbivores species may result in change of large scale reef ecosystem. When grazers are removed from reef ecosystem, the algae quickly take over and dominate, particularly if the ecosystem is also suffering from organic pollution [31].

#### *4.2.5 Construction and sedimentation*

Sedimentation is an extremely important cause of destruction of coral reef ecosystem. Predominating, coastal development and construction can lead to heavy amounts of sediment. There are other effects caused by inadequate land management and deforestation, where sediment run off from farms and land and settling on the reefs. In this context, Watersheds that are cleared of their vegetation cover are vulnerable to flooding and erosion and can lead to increase of sedimentation levels reaching coral reefs. Agriculture chemicals also make their way reaching coral reefs through run off from land, streams and rivers [32].

Dredging has several serious impacts on coral reefs ecosystem. The most spectacular effects are produced by sedimentation, turbidity, silt suspension, reduction of oxygen and release of bacteria and toxic substances. Great quantities of either fine or coarse particles can cover corals, which are unable to withstand cover for more than 1 or 2 days [33].

The corals secrete protective mucus in a bid to rid themselves of the sedimentation. This process requires high energy levels, which have to be diverted away from essential processes. If this problem is exacerbate by other stresses, for example, temperature change, then the reefs become extra stressed and may die. The mucus secretion for sediment clearing makes the reefs more susceptible to infection by bacteria and therefore more probable to suffer from diseases [15]. The higher level of sedimentation that exceeds the clearing capacity of mucus secretion of coral reefs can reduce light breakthrough and may change the vertical distribution of plants and animals on coral reefs [34].

#### *4.2.6 Cutting of mangroves*

Mangroves destruction by obvious cutting or pollution has resounding consequences on reef ecosystem. Mangroves destruction leads to the removal of the main source of leaf litter, a food resource for the set of reef animals. Also, mangroves provide the nutrient rich feeding grounds for several marine species. Moreover, mangroves protect the shoreline against storms and cyclones and give it stability against land loss by erosion.

#### *4.2.7 Rubbish/litter*

Trash such as discarded fishing gear, bottles and plastic bags that get to the coast may settle on reefs and prevent the sunlight required for photosynthesis or decomposition and kill reef organisms and damage or break corals. Degraded plastics and small pieces of plastic can be ingested by coral, turtles, fish and other reef animals, which can block their digestive tracts and kill them.

Litter and rubbish are one of the groups of largest problems facing any ecosystem. The decomposition of this artificial rubbish takes a very long time. Plastic bottles decomposed in 150 years, plastic bags 50 years, batteries in 200 years, paper in 1 year and cigarette in 75 years. A turtle facing a plastic bag similar to jellyfish may swallow it and can choke it. Batteries leak poisons as they breakdown and can contaminate the fish we eat, as well as kill corals and other marine life. Rubbish should be disposed of properly, by recycling or taking it back to the mainland dump. If rubbish is left lying around, it can easily get blown into the sea.

#### *4.2.8 Tourism*

Tourism has a large potential to contribute to sustainable socio-economic development and environmental conservation. It can support the protection of natural resources, as local residents realize the value of their assets and try to preserve it. Tourism can also provide another form of land use (other than agriculture) which supports land conversion. It can also contribute to maintaining livelihoods and preserving cultural practices. Opportunities arise for education and awareness-raising to understand and respect cultural diversity along with biodiversity. All these benefits can be derived from the tourism if optimally used and controlled in the required form to preserve the environment, biological diversity and natural habitats. The uncontrol and misuse of tourism can lead to the degradation and collapse of ecosystems and biodiversity that are essentially the real attraction of tourism [4, 14, 35].

Tourism and biodiversity are closely linked both in terms of impacts and dependency. Many types of tourism rely directly on ecosystem services and biodiversity (ecotourism, agritourism, wellness tourism, adventure tourism, etc.). Tourism uses recreational services and supply services provided by ecosystems. Tourists are looking for cultural and environmental authenticity, contact with local communities and learning about flora, fauna, ecosystems and their conservation. On the other hand, too many tourists can also have a negative, degrading effect on biodiversity and ecosystems. Therefore, the tourism sector has both a strong influence on biodiversity loss and a role to play in its conservation [36]. Regrettably, the tourism-environment relationship is unbalanced; tourism is depending on an environment that is vulnerable to the tourism impacts [37]. Yet it's not easy to achieve sustainable development in many developing countries that heavily rely on tourism income, particularly in ecologically sensitive areas. Other influences come from the tourists services area such as domestic wastes, garbage and many bad practices from site

visitors. The main harmful human activities that can destroy the biodiversity stock in any area result from uncontrolled tourism and fishing activity [1].

#### *4.2.9 Coral harvesting for the aquarium trade*

Coral harvesting for the aquarium trade, jewelry, and curios can lead to over-harvesting of specific species, destruction of reef habitat, and reduced biodiversity. The practice of keeping marine aquaria as a hobby has increased in the last decade. It is reported that, globally, between 1.5 and 2 million people keep saltwater aquaria [38, 39]. Murray et al. [40] confirmed that the areas of southern California rocky shores which have been used by humans intensely for recreational activities such as fishing, exploration, walking, enjoyment of the out-of-doors, and educational field trips had suffered from reduction of species abundance and diversity due to visitors collection of intertidal organisms for consumption, fish bait, home aquariums and other purposes. The most direct effects of intensive collection are decreased abundances of exploited species and because humans preferentially collect larger individuals, altered population size structures. El-Naggar et al. [4] attributed the reduction of certain gastropod shells (Cypraeidae) from Aqaba Gulf to their intensive collection by visitors because they have beautiful shells.

#### *4.2.10 Fish-feeding*

The feeding behavior of reef fishes, eels, sharks and even rays has come to a “selling point” through commercial fish feeding dive tours and “interactive diving.” However, many do not realize the harmful effects this activity has on these animals. Studies done around the world have indicated that fish feeding significantly alters behavioral patterns by “training” these wild creatures with human food handouts. In addition, fish feeding causes health problems for the fed animals and disrupts the natural processes within the marine community. Here in the Mamanucas, particularly at sites where fish feeding occurs, there has been an increase in aggressive behavior within schools of surgeonfish, fighting amongst themselves and causing injury, even to the point of destroying their own reef habitat by breaking hard corals. Triggerfish have also been observed biting and destroying the reef structure. Sergeant Damsel fish swarm around snorkelers or divers expecting to be fed. The fish that are fed often “peck” at the snorkelers or divers entering the water, taking away the pleasure of observing the reef and its inhabitants in a calm and inoffensive manner. By feeding the algae eaters that control algae growth, they become handout feeders that soon neglect their important role of eating algae, which in turn can overgrow corals. Major conservation organizations, including UNEP, DAN, WWF and Environmental Defense, encourage passive interaction with marine life and avoiding feeding and petting, which may lead to accidental injury.

### **5. Proposed solutions to mitigation of the coral reef threats (methods for conserve the coral reef)**

The aggregate effects of these stressors can decrease resilience of the reef overall and increase susceptibility to disease and invasive species. The anthropogenic stressors on coral reef ecosystem are suggested potential factors responsible for the degradation and instability of any ecosystem. Any bad practices from human; directly and indirectly can have effects on coral reef ecosystem. So, it is necessary to create new strategies to protect coral reef ecosystems. Given that 20% of the coral reefs in the world have already been destroyed much has to be done in the future for the preserve of coral reef ecosystem.

## **5.1 Establishment of marine protected areas**

One of the key techniques of conserving coral reef ecosystem is the establishment of Marine Protected Areas (MPAs). Marine Protected Areas (MPAs) are important tools for marine conservation and management. Although there are many types of MPAs, in all them, there are areas set aside for unlimited human activities. When the MPAs restriction is highest, they are considered as “no-take” areas, where the dealing with all forms of marine life is prevented; even recreation, research and education are restricted. Many of MPAs were constructed specifically for management of a special purpose (for instance, for biodiversity preservation, as a refuge of a certain species to breed, for conservation of a historical site or even for recreation). Multiple use management protected areas are zones to permit for complete limitation on dealing in some areas and managed use in others [41]. However, a main problem in MPAs is that they fail to achieved their management objectives and become parks on paper only [42]. Even though MPAs may be gazetted legally, enforcement of relevant laws (zoning, prohibiting certain activities) is often poor.

## **5.2 Prevention of over-harvesting through legislation**

Many species are protected under general species protection laws across the region. Most of this protection is afforded to marine vertebrates, but some countries—such as India and Sri Lanka—have laws protecting several species of coral, mollusks and echinoderms. In India, all Stony corals, all Black corals, all Fire corals, and all Sea fans are protected by law [43]. In Sri Lanka, all Stony corals are protected by law [44].

## **5.3 Monitoring**

Coral reefs monitoring is a substantial process for developing efficacious strategies of management. Only through monitoring only, is it possible to assess patterns and trends of coral reefs health and use. There are many worldwide organizations specializing in monitoring of coral reefs status. The Global Coral Reef Monitoring Network (GCRMN) devote their efforts and coordinates in order to improve coral reefs management in the whole world, this through capacity building and knowledge sharing and works closely with Reef Base (Global database about coral reef related information) and Reef Check. After the coral bleaching event in 1998 and with the continuous threat of coral degradation as a result of other anthropogenic activities, Coastal Ocean Research and Development in the Indian Ocean (CORDIO) commenced in 1999. CORDIO supports and funds the scientists and organizations in the Indian Ocean Region, for assurance of monitoring of coral reefs status in the region with focus on both socio-economic and ecological impacts of coral reef degradation. Monitoring plays a critical role in managing Marine Protected Areas. The importance of monitoring and research is in guiding management of the fisheries and biodiversity resources. It is necessary to develop a long term monitoring plan for management of abundance and diversity of biota coupled with an assessment of fishing and habitats quality including coral reef [1].

## **5.4 Building awareness**

Building awareness about coral reef ecosystems, their biodiversity, services they provide and their business are highly supportive of mitigation of the threats that are facing these fragile ecosystem of coral reefs. Awareness at the community levels is extreme efficient as it may help to encourage coral reefs users to change their behavior

to sustainable use of these ecosystems. On the other hand, the awareness at national level through conservation education by the media and other means is necessary to guarantee that decision makers integrate coral reef preservation into all development stages. It is also important to ensure that some environmental issues, such as poorly planned or unplanned inland development and pollution, are prevented in order to protect coastal ecosystems such as coral reefs. Worldwide, 1997 was designated as International Year of the Coral Reef Because of growing threats to coral reefs in the whole world. Also, 2008 was designated as International Year of the Coral Reef.

### **5.5 Support of sustainable livelihoods and participation in reef dependent communities**

The relationship between reef ecosystems and poverty is very significant, whereas 67% of all countries having reef areas are developing countries and about 25% of these countries are least developed countries [45].

Coral reef ecosystems contribute to the national economies and provide significant resources for poor people. The current direction of growing threats to coral resources is projected to impact poor communities dependent on reef ecosystem. To make matters worse, the predominating objectives of reef ecosystem management for preservation restrict community access to their resources thus reducing livelihood options for these communities. Oftentimes, these restrictions are not followed by communities which may have weak understanding or low participation in the process of reef management.

It is now well recognized that these communities need to be offered alternatives for livelihoods in order to assure that reefs are not further damaged, as well as to mitigate poverty for these communities. Therefore, managers of coastal areas are highly switching toward more integrated as well contributory approaches for coral reefs conservation and management. These approaches include identifying and supporting alternate livelihoods for reducing reliance on reef components, in addition to promoting the activities of current livelihood to make them more cost and resource use effective. Rather than comprehensive restrictions on reefs resources use, recently, limited and controlled uses of these resources are advocated in certain circumstances. The reef access rights, resolution of struggles over resource uses, local community involvement and cooperative reef management are now being integrated in to reefs resources management [46].

### **5.6 New management initiatives**

It is now understood that the standard approaches of management of coastal zones have not been successful in realizing sustainable development and reef preservation aims and there is need for change in approaches [16].

The shifting from small and isolated efforts of management to large-scale networks using cooperative management is a new trend. Increasing reefs area under high conservation is a main propulsion for this shifting, thus now 33% of Great Barrier Reef has been declared as a highly protected areas or as no-take zones, where no activity is permitted except in the narrowest limits. The cooperation for creating greater network of Marine Protected Areas is another method that has been favored by main Non-governmental organizations (NGOs) such as Conservation International, the Nature Conservancy and the World Wildlife Fund who are developing training modules to identify and develop a network of Marine Protected Areas in Asia depending on zones of highest biodiversity. Another shift is in the effort to focus research on real-life problems that resource managers face [16].

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