

## Review

# Coral Reefs in Indonesia: A Review on Anthropogenic and Natural Disturbances

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**Abstract** Coral reefs are among the most dynamic and various ecosystems on tropical ecosystem. They provide a large number of important ecosystem services. Despite their importance, they appear to be one of the most susceptible marine ecosystems. Dramatic decreasing of coral reefs has been reported from every part of the world. Indonesia contains 18% of coral reefs of world's total. Unfortunately the status of coral reefs in Indonesia is already in critical and poor condition. Coral reefs communities in Indonesia are subjected to a variety of environmental disturbance. Threats to Indonesia's coral reefs resources can be divided into two main types: anthropogenic and natural disturbances. The major anthropogenic disturbances on coral reefs in Indonesia are destructive fishing, pollution, coastal development, mining and harvesting live fish and coral, tourism. The natural disturbances such as cyclones, volcanic eruptions, earthquakes, tsunami and predator also contribute to coral reefs destruction in Indonesia. In my paper I tried to compare between natural and anthropogenic disturbances on coral reefs in Indonesia and raised these questions: (i) how the natural disturbances differ from anthropogenic area (ii) which type of disturbances has caused the greatest impact on coral reef ecosystem. My finding is that both of anthropogenic and natural disturbances give major impact on coral reefs in Indonesia. The important issue here is coral reef resilience could be disturbed by synergistic effects between various anthropogenic and natural disturbances. This phenomenon has significant conservation and management implication. The appropriate management should be conducted to protect coral reefs ecosystem in Indonesia. Mangrove management will succeed only when local people are involved and get sustainable benefits from mangrove ecosystem. Community based management and Integrated Coastal Zone Management (ICZM) are type of management that can be applied on coral reef ecosystems in Indonesia.

**Key words :** Coral reefs, anthropogenic, natural, disturbances, Indonesia

## Introduction

Coral reefs are one of the oldest continuous and important ecosystems on earth [3,34]. The fundamental unit of coral reefs are scleractinian coral (phylum: Cnidaria) itself which associates with many other invertebrates, vertebrates and plants. Coral reefs are found throughout the tropical and subtropical regions of the Pacific, Indian and Atlantic Oceans [41]. The coral reefs of the Indo-West Pacific vary much more so than those found in the Atlantic and Caribbean. Southeast

Asia contains one-quarter of world's reefs. Indonesia and Philippines account for a major portion of these habitats [3].

Indonesia is the world's largest archipelago nation with more than 17,500 islands and a 95,181 kilometer (km) coastline, rich in coral reefs, seagrasses and mangroves. Tomascik *et al.* (1997) estimated area extent of coral reefs in the Indonesian Archipelago stands at roughly 85,707 km<sup>2</sup> which is about 18 % of the world's total. Coral reefs in Indonesia are important both for human and for the marine environment because

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of their ecological and economical functions. Ecologically, coral reef ecosystems play an essential role as nursery, spawning and feeding ground for many species. Economically, the total product from coastal and marine activities is estimated at 24.5% of Indonesia's gross domestic product (GDP) [46]. Unfortunately, like many other ecosystem, coral reefs communities are subjected to a variety of environmental disturbances. The disturbances occurred in the coral reefs ecosystem can be grouped into two classification, anthropogenic disturbances and natural disturbances. The main purposes of my paper are to identify and assess anthropogenic and natural disturbances on coral reefs in Indonesia and to propose type of management that can be applied in coral reef ecosystems in Indonesia.

### Coral reefs in Indonesia

Indonesia is the largest archipelago nation in the world containing roughly 17,508 islands. It has coastline length approximately 85,707 km<sup>2</sup> - 95,181 km<sup>2</sup> (Figure 1) [4]. Indonesia's coral reefs resources are among the richest and most diverse in the world. Indonesia lies at the center of diversity for corals [42]. The total area of coral reefs in Indonesia is 51,020 km<sup>2</sup> (Table 1) that represents about 18% of the world's total as well. They contain of fringing reefs, patch reefs, barrier reefs and atolls (Table 2). All of those forms are found throughout Indonesia, spread out from Sumatra to Papua Island. The biodiversity of coral reefs in Indonesia are among the highest of the world's coral reefs (Table 1).

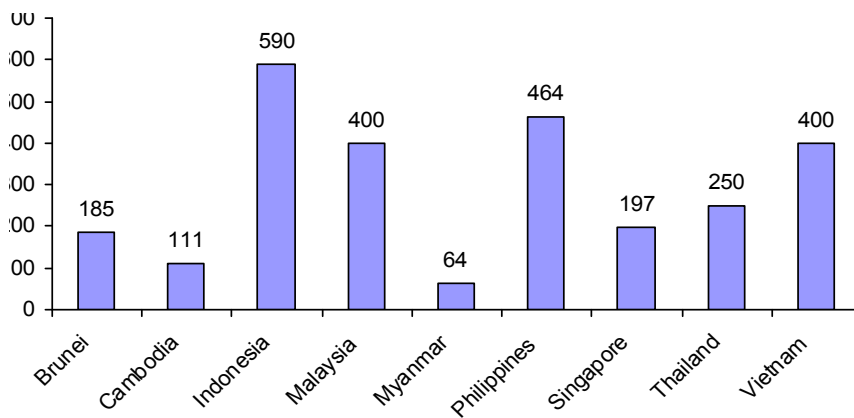


Fig. 1. Number of coral species in Southeast Asia [46].

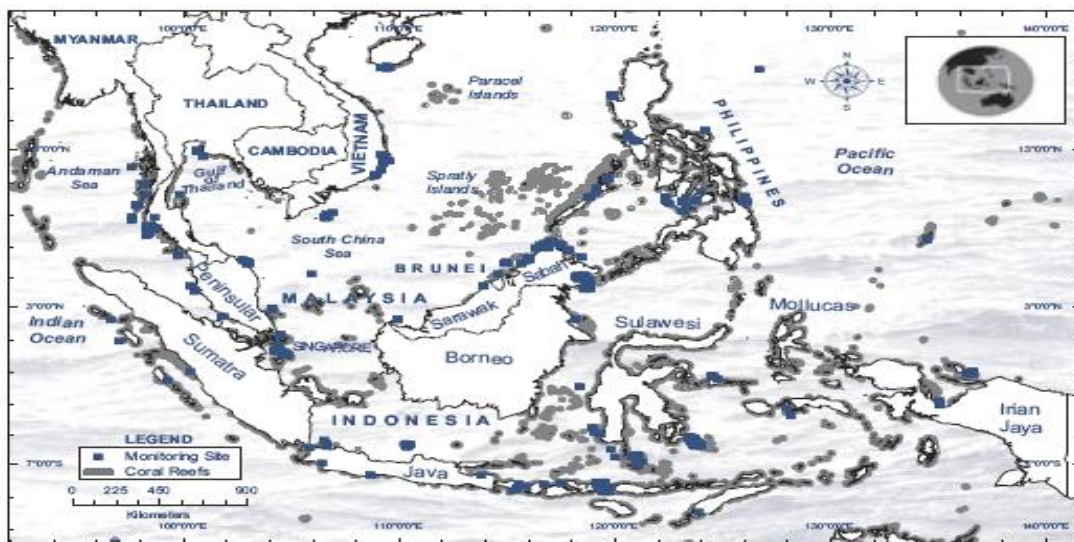


Fig. 2. Coral reefs distribution in Southeast Asia [4].

**Table 1.** Total reefs area and coral diversity in Southeast Asia [46]

	Brunei	Cambodia	Indonesia	Malaysia	Myanmar	Philippines	Singapore	Thailand	Vietnam
Coastline length (km)	269	435	95,181	9,323	14,708	36,289	268	2,614	11,409
Coral reefs area (km <sup>2</sup> )	210	<150	51,020	3,600	1,870	25,060	<100	2,130	1,270
Coral reefs present	Fringing, patch, atoll	Fringing, patch	Fringing, atolls, barrier reefs	Fringing, patch, atolls	Fringing, patch	Fringing, atolls, barrier reefs	Fringing, patch	Fringing, patch	Fringing, patch

**Table 2.** Number and Areas of Coral reefs in the Areas Defined as Central and East Indonesia [38]

Type	Number	Area (Km <sup>2</sup> )
Fringing reefs	n.a	7,000
Barrier reefs	67	20,158
Atolls	50	15,891
Ocean platform reefs	40	1,402
Total		44,451

More than 590 hard coral have been recorded in Indonesia; approximately 60 percent of the world described hard coral species (Figure 1) [46]. The diversity is not only limited to coral species but also including the other organism which associated with coral reefs. Over than 1,650 reef fish species have been recorded in Eastern Indonesia [4]. Indonesia is also the coral biodiversity center of the world with about 70 genera and 450 species of corals [41].

### Economical functions of coral reefs

Coral reefs play important economical and ecological functions. Coral reefs provide an essential part in economical as source of food, tourism, raw materials, and pharmaceuticals. The total annual net benefit of sustainable coral reefs fisheries across Southeast Asia is estimated to be US\$ 2.4 billion per year [4]. Indonesia's coral reefs help to support one of the largest marine fisheries in the world, producing 3.6 million tons of total marine fish production in 1997 [35].

The resources derived from coral reefs are essential to the food security of people living within tropical coastal communities [22,34,43]. Coral reefs provide fish, molluscs, crustaceans, turtles and algae that are consumed by humans [40,43]. Coral reefs provide between 10 to 12% of the harvest of finned fish from tropical countries and up to 25% in developing nations

[43,46]. Clearly, in developing countries fisheries in coral reefs ecosystem also have an important impact providing protein source for humans. In those countries 25% of the fish catch is provided from coral reefs fisheries [3,22]. In Southeast Asia one-quarter of fish catch come from coral reefs ecosystem. It means that coral reefs perform their crucial function as sources of food [4,22].

The tourism industry is one of the fastest growing sectors of the Indonesian economy. Coral reefs attracts millions of snorkelers, scuba divers, recreational fishers, and others visitors. They have attracted millions of tourists both domestic and international to come. Over than 100 countries were benefited from the recreational value of their reefs [3].

Coral reefs provide raw materials for building construction. Some local people in Indonesia mine coral to build house. They used in building materials for extracting lime for cement production. Some of them decided to use coral reefs as building material rather than the others materials because it has cheap price.

Coral reefs also provide broad ranges of natural products for pharmaceuticals and other industrial uses. At the present time, scientists are exploring the oceans, searching for new cures for many diseases [3]. They have been identified antifungal and antibacterial substances from reef organisms [25,34]. Additionally, reefs organisms contain numerous compounds useful for a variety of other commercial applications, such as amino acids, vitamins, lipids, waxes, polysaccharides and pigments [25,34].

### Ecological functions of coral reefs

Ecologically, coral reefs ecosystem play a crucial role as centre of biodiversity, nursery, spawning, feeding and foraging ground for many species and coastal

protection. Coral reefs are residence to a great variety of marine life in the sea. They are among the most biologically rich ecosystems on earth and the second most diverse ecosystem in the world only compare to tropical rainforests, containing 32 phyla of 33 phyla that exist on this planet and 15 phyla occur are endemic to this ecosystem [3]. About 4,000 species of fish and 800 species of reef-building corals have been described in these ecosystems [26]. Coral reefs resemble tropical rainforests because of their high biodiversity and their nutrient poor condition, where nutrients are largely tied up in living matter [3]. Indonesian coral reefs are a center of global biodiversity containing over 2,500 species of mollusks, 2,000 species of crustaceans, 6 species of sea turtles, 30 marine mammal species and over 2,000 fish species [8].

Coral reefs serve as breeding, spawning, nursery, feeding and foraging habitats for a enormous array of marine organisms which associated with them. They present shelter to marine organisms. Many organisms such as tunas, mackerels, flying fish, jacks, and shark are dependent on functional coral reefs system for support, breeding, nursery or feeding ground [39].

Coral reefs protect coastlines and other coastal ecosystems (seagrass and mangrove) from storm damage, erosion and flooding by reducing wave action. The protection offered by coral reefs also facilitates the formation of associated ecosystems (e.g. sea grass beds and mangroves) which allow the formation of essential habitats, fisheries and livelihoods [3]. The benefits from this protection are widespread, and range from maintenance of highly productive mangrove fisheries and wetlands to supporting local economies [3].

### Status of coral reefs in Indonesia

Coral reefs around the world have been transformed significantly over the past two decades [3]. Current estimates show that 10% of all coral reefs are degraded beyond recovery [46]. Coral reefs have faced dramatic

occurrences. At least 11 % of coral reefs in the world categorized as ‘hot spot area’ of biodiversity [32]. Their degradations occur in response to both natural and anthropogenic stresses. They are changing the condition of reefs. Twenty nine percent of coral reefs in Indonesia are in critical condition and may die within 10-20 years (Table 3).

### Anthropogenic disturbances

In Indonesia the major disturbance of coral reefs caused by anthropogenic and natural factor as well. As human population and coastal pressures increase, reef resources in Indonesia are more heavily exploited and many coral habitats continue to decline. Human activities, both direct and indirect, are driving the loss of coral reefs. The major anthropogenic disturbances on coral reefs in Indonesia are destructive fishing, pollution, coastal development, mining and harvesting live fish and coral, tourism

The fishing activities involving the use of home made bombs, cyanide and *muro ami* that involves as destructive fishing [46]. Blast fishing was introduced in Indonesian Archipelago in the Second World War as an easy and profitable way to catch schooling reef fish. The actual impact of destructive fishing practices on coral reef ecosystems and their functions is difficult to measure [5,45]. However, blast fishing is considered as one of the most destructive anthropogenic threats to coral reef ecosystems. The direct effect of blast fishing will influence on fish and invertebrate and also the fishers themselves [28,29]. Indirectly it also affect on ecological and economical function of coral reefs ecosystem [22,28,29]. Even though officially forbidden by law and despite the dangers to the fishers themselves, home-made bombs remain popular fishing gear in Indonesia. The law enforcement is rarely implemented effectively.

Pollution contributes on coral reefs destruction. Pollution come from unsustainable land-based human

**Table 3.** The status coral reefs in Indonesia (%) [36]

Region	No. of locations	Excellent*	Good*	Fair*	Poor*
West	243	5.76	20.99	33.33	39.92
Central	210	6.19	31.43	45.24	17.14
East	195	9.23	29.23	33.08	28.46
Indonesia	648	6.69	26.59	37.56	29.16

\*Excellent:75-100% living coral cover. Good:50-74% living coral cover. Fair:25-49% living coral cover. Poor:0-24% living coral cover.

activities such as deforestation, poorly regulated agriculture, and urban and industrial development resulting in the release of excess amounts of sediments and nutrients [46]. Land-based pollution on Indonesian reefs comes from three primary sources: agricultural runoff (including increased sedimentation from deforestation and aquacultural runoff), human sewage and industrial waste. Stresses from land-based sources of pollution are associated with 40-70% reductions in coral species diversity at all depths, with greater impact at 10 m depth than at 3 m depth [13]. The decreased diversity on reefs subject to land-based pollution implies a dramatic, rapid decrease in Indonesian fisheries resources [13]. Many studies conducted in Banten, Java Sea, South Sulawesi and Ambon show that pollution combined patterns of coral growth rates, coral cover and bioerosion. Reefs subject to land-based pollution show 30-50% reduced diversity at 3 m, and 40-60% reduced diversity at 10m depth relative to unpolluted comparison reefs in each region [13,15,17].

Coastal development such as building of ports, airports, settlements, industry, shipping and tourism will impact the coral reef ecosystems [21,22,46]. They will produce physical damage on coral reef ecosystems. Mechanical damage to coral reefs is generally associated with up to 50% reduced coral species diversity in shallow water (3 m), with relatively minor effects at 10 m depth [11]. The reduced diversity in 3 m is approximately equivalent to the reductions associated with natural mechanical damage such as storms or growth on an unstable bottom, but these natural forms of mechanical damage also reduce diversity at 10m [13]. Reefs which affected by these mechanical damages can be recovered in two ways. Firstly, if they are protected from any further damage, otherwise if some undamaged reefs inhabits in the area [27,33].

Coral-mining have significantly modified the reef ecosystem and will cause serious long-term consequences. Most of people in Indonesia do not know about coral reefs ecosystem. They assumed coral reefs as general stone which can be utilized. It causes an excessive use that will threat the resources which impact ecosystem. Over-fishing and over-exploitation of coral reefs fisheries and coral rock and sand resources occur because of excessive use. People also catch reef fish as ornamental fish for aquarium. These bring high prices and have resulted in destructive fishing practices that destroy the reefs, as well as their inhabitants.

Tourism represents threats to coral reefs. Types of tourism and resorts vary widely. Tourism is seen as potentially a major determinant on the reefs condition. They can damage reefs in any ways. In Indonesia, the attraction of high species diversity of corals and fish, easy accessibility and low prices contribute to making the archipelago an attractive destination for marine tourism. Undoubtedly the industry is having some impact on the coral reefs [39]. Large increases in marine tourism around the world have raised questions about environmental effect of snorkeling and a diving activity. Divers and snorkelers may negatively affect the surrounding area of coral reefs. They break corals and other organisms by touching them by hand, body and equipment. Studies have shown significant reduction on coral coverage and growth on tropical reefs [18-20, 23,24,30,31,33].

### Natural disturbances

Unpredictable natural phenomenon like cyclones, volcanic eruptions, earthquakes and tsunamis and predators also contributes on coral reefs ecosystem in Indonesia. The Indonesian archipelago lies between two main tropical cyclone. Some of the eastern Indian Ocean cyclones generate in Indonesian waters. The impact of these storms has not been documented previously and therefore little is known about their impact on the coral reefs community, yet they may have adequate strength to damage reefs. In Flores Island has been affected by two cyclones in the last 30 years, i.e. Sally in December 1971 and Lena in January 1993 [39]. Such storms are not considered to have long-term effects on coral reefs unless there are other chronic impacts which may stop regeneration [39].

The Indonesian archipelago is a tectonically active region and contains many islands with active volcanoes (Sumatara, Jawa, Bali, Lombok). Coral reefs have recolonisation and resilience ability to respond to the eruption of lava. When eruption of Api Mountain happened in the Banda Islands, within 5 years corals had recolonised the lava. It was proof by occurrence of 124 recorded species and over 60% live coral cover [39].

Geologically the Indonesian archipelago is relatively young, formed by the interaction of three major tectonic plates, the Australian-Indian Plate to the south, the Pacific Plate to the east and the Eurasian Plate to the North. Thus, Indonesia is one of the most earthquake

**Table 4.** The recent data of major tsunami happened in Indonesia [39]

Date	Location
December 1992	Flores northern shore reaching 26 m at Riagrak, 7.3 m at P. Babi and 4 m at Maumere Bay
June, 1994	Banyuwangi, south-east Java, reaching 4 m
February, 1996	Biak
December, 2004	Aceh

region in the world. The Indonesian region experiences 10% of the world's earthquakes including many of magnitude 8 and greater, which could cause the tsunami as well [39]. The immediate effects on Indonesian reefs have not been described as for example after the earthquake in Madang, New Guinea in 1970 [39].

As a result of its geological and tectonic condition, the Indonesian archipelago is one of the most tsunami affected regions in the world. Since the devastating 1883 tsunami that was generated by eruption of Krakatau, more than 35 tsunamis have been reported in Indonesia (Table 4) [38]. Tsunami occur in December, 2004 in Aceh Province, on the northern tip of Sumatera Island caused serious impact on coastal ecosystems, such as mangrove, sea grass, and coral reefs [10]. Impact of the latest tsunami happened in July, 2006, in Pangandaran coastal on coral reefs have not assessed yet.

Coral predators are known to have significant impact on coral reefs. Crown of Thorns Starfish (COTS) is the major coral predator in Indonesia. They have rarely been reported in large proportions before the 1990s. Notable aggregations had been noted in Seribu Island in the Java Sea, large numbers of juveniles reported in Ambon in 1973, and damage from the starfish in the 1980s in northern West Papua [39].

Predator outbreaks like COTS are increasingly reported around areas of human activities [39]. Two main hypotheses an advanced: the plagues may be initiated and certainly exacerbated by either over-fishing of key starfish predators; and/or increases in nutrient runoff from the land favours the planktonic stages of the starfish [46]. Indonesia has experienced COTS outbreaks around North Sulawesi (Bunaken National Park and adjacent waters) in 2003 [39]. In Permuteran Bay, Bali Island, there is conspicuous damage on both natural and artificial reefs from COTS and *Drupella*, which are approaching plague densities but are not conspicuously aggregated [46].

After the 1998 rise in sea-surface temperature (SST) caused massive coral mortality throughout the Indian

Ocean Approximately half of the reefs in the Indian Ocean and around South Asia were reported to have lost most of their living corals [18,19]. However, coral cover in Indonesia is also greatly reduced because of climate change [6,9]. Corals were bleached most of the western Indian Ocean in the warm season of 1998 and coral mortality occurred over an extended period from March to July 1998 [18,19]. Moderate to severe damage was reported on Indonesia's coral reefs after the 1998 bleaching event and recovery has been variable [46]. From 1999-2004 there is evidence of coral recovery in Cambodia, Indonesia, Philippines, Thailand and Vietnam after extensive coral bleaching mortality, mostly in the northern parts of Southeast Asia [46]. In Indonesia, recovery has been slow in Sumatra and Lombok, but rapid in the Seribu Islands adjacent to Jakarta where coral cover is 40% on some reefs [6]. Coral reefs in Bali, Tulamben and Seraya c show minimal bleaching and many corals are in excellent condition except for physical damage caused by dynamite explosions and localized anchor damage [46].

### The impact of anthropogenic and natural disturbances

In an assessment of the major human-induced stresses to coral reefs Wilkinson (2004) highlighted population pressure in Indonesia in the highest threat level, closely followed by sediment loading [46]. Away from major population centers destructive fishing practices are the greatest threat [12], but these too are the result of population pressure and associated economic need.

Threats to Indonesia's coral reefs resources can be divided into two main impacts: acute impacts and chronic impacts [7]. Acute impacts cause dramatic damage in a short period of time. Examples include destructive fishing practices, such as blast fishing, as well as other forms of mechanical damage, like anchor damage, ship groundings, cyclones or crown of thorn starfish (*Acanthaster*) outbreaks. Acute impact cause significant damage. The impacts but do not persist. The reef usu-

**Table 5.** The recent reports of Crown of Thorns Starfish (COTS) outbreaks in Indonesia [39]

Date	Location
Early 1990s	Aggregation of over 1000 in northern P. Saparua east of Ambon
1992-1993	Sixty five individuals on a 100 m intersect, P. Walae
February 1996	Massive outbreak but limited to P. Panteh in the Banggai Islands
1996	COTS scars in P. Barrang Lompo reefs
1997	Sompini Bay, Bentenan Island and Puntan Island, North Sulawesi
1997	Lasolo, Wakatobi National Park, several COTS noted
1997-1998	Massive numbers cleared from local reefs on Bentenan and Tumbak Islands
1998	Outbreak noted, eastern Malenge Island
2003	North Sulawesi (Wilkinson 2004)

ally will recover if protected from further physical attacks [27]. Chronic stresses, on the other hand, alter the physical or biological environment on a long term basis, and cause long term damage to coral reefs. Examples of chronic stresses in Indonesia include sewage pollution, increased sedimentation, eutrophication, and industrial pollution [39]. Non-point source pollution, such as sewage and agricultural/aquacultural runoff, is an increasingly important type of stressor in Indonesia [5,22]. Reefs will not normally recover from chronic stresses until the stressor is removed, that is, the pollution is cleaned up [14]. Stresses from land-based sources of pollution are associated with 40-70% reductions in coral species diversity at all depths, with greater impact at 10 m depth than at 3 m depth [12]. Disturbances can also be classified according to the type of effect they have on the physical and biological environment within which corals live, whether they affect the environment directly or indirectly (Table 6).

### Marine protected area (MPA) in Indonesia

A few years ago there is no particular coral reefs management in Indonesia. In 1992 Ministry for Environment (LH) of Indonesia began to conduct program called 'Program Laut Lestari' (Sea Sustainable Program). Since 1994 there is a monitoring program

coral reefs in Indonesia coordinated under COREMAP (Coral reefs Rehabilitation and Management Program). In the 1999 government of President Abdurrahman Wahid made a new Ministry of Maritime Exploration and Fisheries specifically concerned with the definition and development of marine and coastal resources, particularly fisheries. This is the first Maritime and Fisheries Ministry in Indonesia [8].

Designation and management of Marine Protected Areas (MPA) in Indonesia was authorized by Ministerial declaration in 1990 [16]. Management and responsibility for marine areas has been in the hands of the Department of Forestry, specifically The Directorate General of Forest Protection and Nature Conservation (PHPA). Four different types of MPAs in Indonesia are recognised: (1) National Parks (*Taman Nasional*), (2) Strict Nature Reserves (*Cagar Alam*), (3) Wildlife Reserves (*Suaka Margasatwa*), (4) Nature Protection Park (*Taman Wisata Alam*) [16].

There are 646 marine protected areas in Southeast Asia, but only 14 percent is effectively managed [4]. The immediate target of the Indonesian government is to establish 10,000,000 ha of marine conservation areas, distributed over 85 reserves throughout the country and to increase this over 30,000,000 ha by the year 2000 [39]. In 2000, Indonesia had just 51 marine protected areas that included coral reefs, covering an estimated

**Table 6.** Disturbance and recovery of coral assemblages [7]

Effect on the physical and biological environment	Duration of disturbances	
	Short: acute	Long: chronic
Direct	A single disturbance that directly alters the environment temporarily	Continuing disturbances that directly and continually alter the environment
Indirect	A single disturbance, for example, a disease outbreak or a storm that has no direct effect on the environment	Continuing disturbances for example long lasting disease or a series of storms that have no direct effects on the environment

6.2 million ha [4].

Lack of effectiveness can be illustrated by the fact that of all the Marine Protected Areas in Indonesia, only in Komodo and Bunaken have destructive fishing practices almost been eliminated (Hopley & Suharsono 2000). There is a clear danger that the designation of marine protected area without sufficient data and management plan will lead to future conflict. The major constrain for MPAs in Indonesia are lack of facilities for management, lack of funds, political and legal support to enforce regulation and lack of trained personnel who can appreciate the scientific principles [16].

## Discussion

Anthropogenic and natural disturbances affect coral reef ecosystems in Indonesia. It is difficult to measure whether anthropogenic or natural disturbances give the highly significant influence on coral reefs degradation in Indonesia. The important thing is we may conclude that both of them give major effect on coral reefs ecosystem in Indonesia. The anthropogenic impact (destructive fishing, pollution, mining and harvesting live fish and coral, tourism, costal development) and continually rising human population are having significant impact on Indonesia's reefs. Under natural condition coral reefs in Indonesia also threatened by unpredictable phenomenon like tropical cyclones, volcanic eruptions, earthquakes, tsunami and predator. The actual impact of anthropogenic and natural disturbances on coral reef ecosystems and their functions is difficult to measure, because sometimes they occur in the same time.

Incorporation effects between various anthropogenic and natural disturbances significantly resilience process and resulted in coral reef degradation [2]. Coral reefs are very sensitive to natural disturbances which associated with anthropogenic disturbances. It is essential to recognize that coral reef ecosystems also contain many kind of organisms. These organisms (fish, invertebrates and others organisms that lives in coral ecosystem) are also highly sensitive to both excess nutrient input and pollutants associated with anthropogenic activities. This phenomenon has significant conservation and management implication. However it is essential to apply the most appropriate management options. It is important but difficult to conserve such valuable coral reefs, sea grass bed, mangrove forest and others

coastal ecosystems. To conserve and protect any one of these components all of them must be managed together.

The principal problem, challenges and constrains of coral reefs management in Indonesia are lack of integration among all the components, lack of conservation ethic, political and economical constraint, social and cultural constraint (low levels of awareness and low levels of education), lack of information system and research. Based on that condition we have to find type of coral reefs management that appropriate applied in Indonesia. I propose two type of management that can be applied in coral reefs ecosystem in Indonesia are community based management and integrated coastal zone management.

Community-based management is recommended by almost all reviews of Indonesia's coastal and marine conservation [1,16]. Empowered communities are more effective in controlling destructive fishing and other activities caused by other users as well as themselves [16]. Coastal resources management needs much more than regulation. Their management should be rooted in local communities and thus should be designed to empower local communities to conserve their own resources [39]. An important lesson about the coastal management in Indonesia is about their traditional culture to conserve their natural resources, like traditional 'Sasi' in Mollucas. Sasi is the spatial and temporal closure of fields, forests, reefs and fishing grounds, is a conspicuous feature of many Moluccan. For many years 'Sasi' give significant influence to conserve coral reefs in Maluku Island [37]. Traditional management such as *Sasi* should be incorporated into coastal and marine care at the village level [6].

Coral reefs management in Indonesia has no co-ordination both vertical (National, Provincial and Local levels) and horizontal between agencies. (Status of coral reefs in Indonesia) Many of the problems facing Indonesia's coral reefs result from what is happening on the adjacent land [16]. It means if we want to manage them properly we have to involve all components (government, private sector, local society, fishers and other stakeholders). The integrity should be done in horizontal and vertical level. Horizontal integrity involves: (1) Stake holders integrity, integration between government, scientist, private sector, local society fishers is needed in order to avoid conflict of interest among them (2) Multidisciplinary integrity, integration among fields



of study will provide important tools for more holistic assessments of best practices in marine management and restoration. On the other hand vertical integration is needed as well. There should be a vertical integration among central level, provincial level and district (regency) or city level to conduct coral reefs management in Indonesia.

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