Table 3.8. Some products from mangroves in Indonesia. (continued)

A. Plant Products		
Category	**Products**	**Examples of species used**
	medicine	*Drymoglossum piloselloides, Drynaria rigidula*
	mosquito repellent	*Osbornia octodonta, Quassia indica*
	buttons	*Nypa fruticans*
Food, beverage and medicine	sugar	*Nypa fruticans*
	alcohol	*Nypa fruticans*
	cooking oil	*Terminalia catappa* seeds
	fermented drink	*Rhizophora stylosa*
	sweetmeat (from propagule)	*Bruguiera cylindrica, B. gymnorrhiza*
	vegetable (from propagule, fruit, leaves)	*Stenochlaena palustris* (leaf), *Avicennia, fruit of Inocarpus fagifer*
	cigarette paper	epidermis of *Nypa leaf*
	tobacco substitute	*Loxogramma involuta*
B. Animal Products		
Miscellaneous	fish	*Lates calcarifer, Chanos chanos*
	crustacea	*Penaeus* spp., *Scylla serrata*
	shells/clams	Cockle shell, Green mussel, scallop
	honey and candle	*Apis dorsata*
	birds	especially water fowls
	mammals	especially *Sus scrofa*
	reptiles	*Varanus salvator, Crocodylus porosus*
	others	*Rana* spp.

Adapted from Saenger et al. (1983) with additional information from Knox and Miyabara (1984) and Fong (1984) *in* Noer et al. 2000.

of coral reef in 324 locations. Although not all sites of the two studies are exactly the same, an indication of the condition of coral reef can be obtained as follows: 6% in very good or satisfactory condition (live coral cover more than 75%); 23% good (coral cover 50-75%); 30% moderate (coral cover 25-50%) and 41% bad or damaged (coral cover less than 25%) (Steffen, pers. comm. 2002). In 1994 Wilkinson predicted some of Indonesia's coral reef will disappear in the next 10-20 years (critical condition) and others will disappear within 20-40 years (threatened).

A survey conducted between 1990 and 1998 showed that coral reef condition is better in the eastern than the western part of Indonesia. In some areas such as the Thousand Islands, Taka Bonerate, Bali, Lombok, and Morotai damage to coral reef is considered very serious. In Morotai the level of damaged coral reef amounted to 92,86% (PKSPL-IPB and Puslit Oceanologi 2000).

Excessive and destructive fishing threatens respectively 64% and 53% coral reef in Indonesia. Coastal area development and sedimentation threatens 20% of the coral reef (Burke et al. 2002). Coral reef is also influenced by the impact of land based pollution. The diversity of corals suffering from pollution is reduced by 30-50% at 3 m depth and 40-60% at 10 m compared to corals in good condition (Edinger et al. *in* Burke et al. 2002).

In 1997-1998, the ENSO (*El Nino Southern Oscillation*) phenomenon, popularly known as El Nino, led to coral reef bleaching[5], especially in the western part of Indonesia. This was recorded in the eastern part of Sumatra, Java, Bali and Lombok. In The Thou-

5 *Bleaching* is the disassociation of symbiosis between invertebrates living on reefs with symbiotic algae (*Zooxantella*). Bleaching causes animal tissue to loose its colour. The process may be caused by reduced density of symbiotic algae and/or the loss of photosynthesis pigment concentration in the cells (Coral Bleaching expert consultation, Manila 1997).

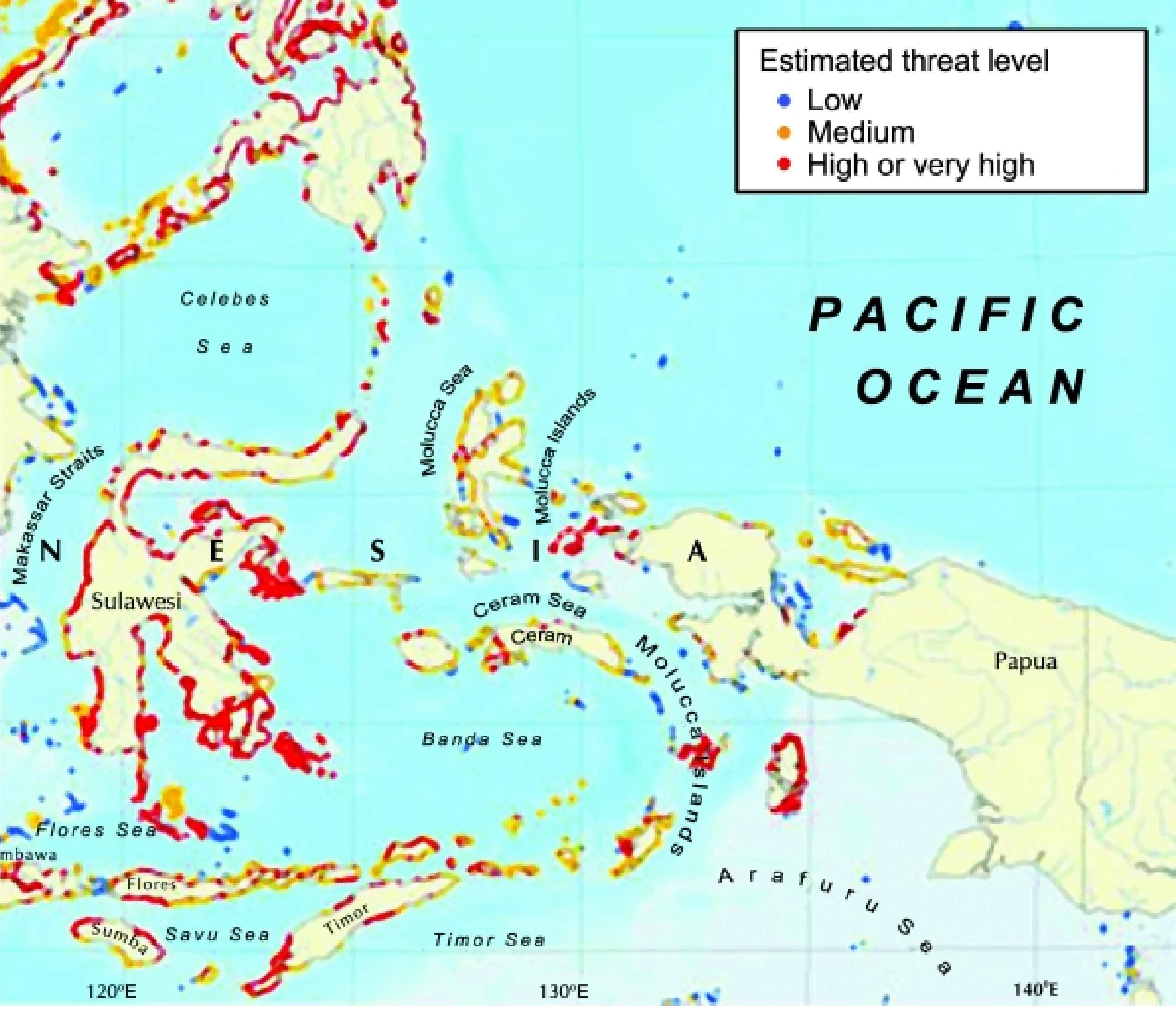
Figure 3.10. Reefs at risk in western and eastern Indonesia.

sand islands, 90-95% coral reef died (Suharsono *in* Burke 2002). This shows that climate change, most probably caused by global warming, has an impact on the biodiversity of coral reef.

Mangrove area was reduced from 5.2 million hectares in 1982, to 3.2 million hectares in 1987 and further to 2.4 million hectares in a 1993 due to intensive conversion for cultivation activities (Dahuri et al. 2001). Mangrove degradation is caused by land conversion for brackish water fishery/shrimp farm (*tambak*), agriculture, port, industrial complex, and in addition a large part of the mangroves are also logged to obtain raw materials for the pulp and paper industry.

Some marine fishery areas already have symptoms of overfishing.The north coast of Java, Malacca and Bali straits are the centers of fish catching; some 85% of Indonesia's fisherfolk operate in these regions. The marine fishery resources are also threatened by the use of environmentally destructive fishing technique and equipment such as explosives, poison and trawls. The level of damage caused by trawls can sometimes be higher than the damage caused by waves. For instance, a 20 m wide trawl to catch shrimp can erode sea bottom of up to 1 km^2 in one hour.

The level of coastal pollution in Indonesia is estimated to be relatively high, especially in highly populated areas with intensive industrial or agriculture activities, as well as in areas where marine traffic is heavy (such as in Jakarta Bay, Malacca Straits, Semarang, Surabaya, Lhokseumawe, and Balikpapan). For



Source: Burke et. al. 2002.

example, the concentration of Hg (mercury) in the waters of the Jakarta Bay is recorded at between 0.005-0.029 ppm in 1982 (LON-LIPI 1983), yet the environmental threshold level for Hg is 0.003 ppm (Decree of MoE No. 02/ 1988). The Jakarta Bay is also polluted with *E. coli* originiating from domestic waste. Recent data on this is not yet available, however, given the rapid industrial development in Indonesia, it is estimated that the Jakarta Bay as well as other coastal areas are facing increasing pollution threat.

WETLANDS ECOSYSTEM

According to the Ramsar Convention, wetlands area "swamp, brackish, peat areas, or other natural or human made water bodies that are flooded with fresh, brackish or salt water, including marine waters whose depth is not more than six meters during low tide". Wetlands also include "the edges or river watershed or coastal areas near wetlands, and with islands or marine waters whose depth is not more than six meters during low tide, and are located in wetlands" (Keppres No. 48/1991).

There are two types of wetlands, natural and artificial. According to Ramsar Convention, natural wetlands consist of mangrove, peat swamp, freshwater swamp, seagrass, coral reef and lakes. In this document, the discussion on wetlands is limited to those that are inland; whereas discussion on coral reef, mangrove and seagrass is presented in the section **Coastal, Marine and Small Island Ecosystems,** although figures on wetlands refer to all types of wetlands.

Based on secondary data survey by AWB (1987), Indonesia has the largest area of wetlands in Asia, about 42.6 million hectares.

(Doc. State Electricity Company)

Figure 3.11. Dams, an example of human made wetland ecosystem.

Data in 2002 indicates reduction in area, i.e. 33.8 million hectares; 25 million hectares are natural wetlands and 8.8 million hectares artificial wetlands (Table 3.9).

Table 3.9. Estimation of wetlands area in Indonesia, 2002.

WETLAND TYPE	AREA(Ha)
NATURAL	
• Mangrove	2,450,185
• Peat lands	16,973,000
• Fresh water swamps	5,185,500
• Others	386,000
	24,994,685
MAN MADE	8,853,129
TOTAL	33,847,814

Source: Wetlands-IP 2002.

Wetlands in Indonesia have a high level of biodiversity. This habitat harbors diverse flora from bacteria, fungi, algae, water plants to trees in swamplands. There is a total of 1423 wetlands plant species in Indonesia consisting of rattan, rubber, resin, spices and fruit plants as well as timber of high economic value such as swamp meranti (*Shorea* spp.), ebony (*Dyospyros* spp.), gelam (*Melaleuca* spp.) and ramin (*Gonystylus bencanus*). More than 80% wetlands flora are found in Sumatra.

The fauna population is also diverse, consisting of protozoa, mollusc, crustaceans, insects, fish, amphibians, reptile to mammals and many species of waders. Freshwater fishery in Indonesia is characterised by species richness and a relatively high level of endemism. The World Bank (1998) recorded 1300 freshwater species (with endemic species respectively 30 species in Sumatra, 149 species in Kalimantan, 12 species in Java, and 52 species in Sulawesi (Kottelat et al. 1993).

Indonesia has gazetted two areas as Ramsar sites because of their international importance. They are Berbak NP in Jambi and Danau Sentarum Wildlife Sanctuary in West Kalimantan. In addition, there are many other important wetlands areas in each bioregion. A list of important wetlands areas in each bioregion together with a description on the flora and fauna is provided in Appendix 3.

Benefits and value of wetlands ecosystem

Wetlands have life supporting functions since they regulate water cycle (provide ground water, prevent drought and flood), regulate nutrients cycle and contain rich biodiversity. Therefore they also have high economic value, for instance as water resources, fish resources (more than two third of fish catch in the world is associated with coastal and wetlands areas in the hinterlands); agriculture, by maintaining water supply and nutrient retention in flooded lands; timber production, energy source from peat and industrial materials; genetic resources; transportation; and various recreation and tourism benefits. The economic value of Indonesia's wetlands has not been fully

Table 3.10. Fish production and estimates of direct benefits in Lake Sentarum.

Commodity	Annual Production Estimate		Net estimate of direct benefits per year (US$)
Lake and river fishery	3,200	tons	817,000
Fishery	522,000	kg Toman	
Catch	60,000	kg Jelawat	700,000
Subsistent fishery	4,000	tons	88,000
Ornamental fishery	2.4	million tons Ulang uli fish	130,000
T o t a l			**1,735,000**

Source: adapted from various sources and reports on Lake Sentarum.

calculated. However, several examples can provide an idea about their significance. Table 3.10, for instance, illustrates the economic value of Lake Sentarum, one of the important wetlands site in Indonesia. Box 3.1. describes several examples of economic benefits of wetlands.

One of the most significant potentials of wetlands is its role in caught as well as cultivated fishery. For example, West Sumatra is one of the major fish production centres, with yields of up to 84,614 tons per year: 78,156 tons from ponds, 1460 tons from floating cages, and 4998 tons from wet rice fields cultivation (Statistics of Fishery 1997). Another example is fish production from the waters of Central Kalimantan which amounts to 42,090 tons, consisting of 17, 880 tons from the rivers, 17, 346 tons from swamps and 6,864 tons from lakes (Statistics of Fishery 1996).

(Doc. BirdLife-Indonesia)

Figure 3.12. The poorly regulated spatial planning causes ineffective functions of many rivers in Indonesia.

Wetlands also have social and cultural significance. As part of the human cultural heritage, wetlands are closely associated with the beliefs of certain communities, are sources of inspiration on beauty, provide protection for wildlife and are the basis for important local traditions. All these functions and values can only be maintained if the ecological processes in wetlands can continue. Unfortunately, wetlands are categorised as one of the most threatened ecosystems in the world, mostly because of reclamation, conversion, pollution and excessive exploitation. One example is the water crisis as described in Box 3.2.

Resource depletion and degradation

Wetlands have faced depletion during the past few years as described above. In addition, physical and biological damage has occurred, particularly in rivers, lakes and swamps, due to imbalanced exploitation of resources, pollution, habitat conversion and natural factors such as natural disasters.

Wetlands depletion occurred in many highly population areas. For instance, in Java the problem is complex since dams, lakes, rivers and swamps are drained for other purposes such as settlement and industrial areas. The floods which occurred in early 2002 in Jakarta was partly due to the drainage of 831.63 ha of swamplands by PIK (Pantai Indah Kapuk) in the Sedyatmo toll road (see Box 3.2.); a rainfall of 30 cm is enough to cause flooding of an area of 2,494,890 m^2. In addition, the rapid depletion of ground water has surpassed the refilling capacity of aquifer, leading the lowering of ground surface of 4-9 mm/year (Kompas 24 April 2000).

The use of dams and lakes for fish cultivation using floating nets (*karamba*) has often not considered the capacity of these waters to absorb and decompose waste. This has led to

Box 3.1
SOME ECONOMIC BENEFITS OF WETLANDS

Swamps and other freshwater ecosystems in Kalimantan are important sources of fish for local communities and the main suppliers of dried fish to Java. South Kalimantan is the main supplier of dried fish, aside from East and Central Kalimantan; the production is about 2000 tons.

The value of reptile (snake, giant lizard, crocodile) skins export from Kalimantan is relatively high. In 1988 a trader from Banjarmasin (the capital of South Kalimantan) exported at least 54,000 pieces of monitor lizard (*Varanus salvator*) skins, which is usually collected in South and Central Kalimantan. At US$ 5/piece in the local catching site, this commodity generates about US$ 270,000 for the local economy (Djasmani and Rifani 1988 *in* MacKinnon, et al. 2000).

The eggs of Beluku or Tungtong (*Calliagur borneensis*) soft shelled turtle are caught and sold as food, the local duck alabio (*Anas platyrhunchos borneo*), reared by communities in swamp areas can provide an income 20 times higher compared to duck farmers in Java and Bali who earn US$ 200 per capita, on the same land size.

Swamp plants such as water spinach, hermit's waterlily or velvet leaf are used and sold as vegetables and provide additional income for local communities.

Source: Voudal 1987, de Beer and McDermott 1989 *in* McKinnon, K. et al. 2000.

Figure 3.13. Deforestation often leads to a prolonged draught.

environmental degradation as reflected from the upwelling phenomenon from time to time, in which there were mass killing of fishes, both cultivated and native species.

Accumulated organic waste from cultivation activities accelerates eutrophication in some water bodies, as in the case of the Cirata Dam in West Java. Eutrophication, caused by high pollution, leads to rapid growth of water weeds, followed by shallowing of the waters. This is happened in several areas such as the Way Jepara and Way Rarem dams in Lampung. Sumatra has many volcanic lakes, which are still active, and therefore upwelling occurs at certain times which increases the sulphur gas content in waters. Such a condition is unfavorable for fishes, particularly cultivated fish.

The opening up of one million hectares peatswamp through the Conversion of Peat Swamp (PLG) project in Central Kalimantan causes one of the most serious ecological damages to wetlands. This projects was aimed at converting peat swamp forest into wet rice fields, but the project ended in environmental disaster (see Box 4.6 in Chapter 4).

Population growth and the expansion of settlements on river banks cause the narrowing of river channels. As a result, floods increase in scale and frequency, as has happened in the case of Ciliwung, Cisadane, Angke, Pesanggarahan, Cipinang and Sunter rivers in Jakarta. There is an effort to normalise river flow, but experiences in other countries show that this is not a solution, but creates another problem. Normalisation aggravates floods, particularly in downstream of the middle part which may be relatively located at lower altitudes. It would also cause serious ecological damage.

The fauna in wetlands are also being depleted due to overharvesting. For instance, the green turtle (*Chelonia mydas*), protected by law since 1990, is in reality still traded freely in

Box 3.2
THE WATER CRISIS

The increasing scale of water crisis and floods in Jakarta is closely linked with reduction in water catchment areas due to road and building construction. In the 1970s one third of Jakarta or 22,000 ha, were swamps, fish ponds and wet rice fields which functioned as water catchment. In 1990, only 467 ha is left.

The 327.70 ha Angke-Kapuk area, part of which has been converted into Pantai Indah Kapuk (PIK) housing estate, is the estuaries of several rivers such as the Angke river and Cengkareng Drain (Atmawidaja and Romimohtarto 1998). Some 28.43 ha of mangroves still exist Muara Angke Nature Reserve while other parts have become non-intensive small scale *tambaks* (fishponds). The nature reserve, protected forest and traditional tambak function as regulator during high tide. But when some parts of the swamp were reclaimed for industrial, settlement and golf course complex, floods occur every year and water fill up the Sedyatmo toll road leading to the International Airport. This happens because the buffer zone can no longer absorb or store the water once its functions were converted.

Another example of the water crisis is in Samarinda, the capital of East Kalimantan. The inhabitants of the city face freshwater scarcity. In the past, sea water would seep in up to the upstream area of the Mahakam river and into the city water sources during the prolonged dry season that sometimes occur for 10 or 11 months. This happened once in a few years. Since 1991, however, sea water had seeped into the wells of the upper part of Samarinda, despite the fact that the dry season was only six months. This situation is affecting agriculture, industry and public health. It is suspected that the situation is due to the reduction in water flow from the lakes and rivers in the larger Mahakam river systems, brought about by clear felling of the forest in the watershed areas upstream (BAPPEDA KALTIM, pers. comm.).

Bali, Penyu bay at Cilacap, Pangandaran and other tourism areas. Studies by Syamsiah (2002, unpublished) showed that in Cilacap during June 2001, 53 sea turtles were caught by fisherfolks. They then sold the turtles freely to souvenir traders at the Penyu Bay, Cilacap.

(Doc. Ministry of Forestry)

Figure 3.14. Settlements along riverbanks put higher pressures for rivers to provide their ecological services.

AGRO-ECOSYSTEM

Biodiversity is imperative for agriculture, to increase production but particularly for food security. Therefore agrobiodiversity is the main building blocks to fulfil basic human needs. Agrobiodiversity management is partly conducted through a system known as **agro-ecosystem.** In this document, **agro-ecosystem** is to be understood as an **ecological and socio-economic system** which include livestock and plants as well as humans who manage them, to produce food, fibre and other agricultural products (Wood and Lenne 1999). Thus, agro-ecosystems only include **a part of the agrobiodiversity**, since the agrobiodiversity concept encompasses more than just cultivated plants and animals.

According to Qualset et al. (1995) agrobiodiversity includes all cultivated plants and animals, their wild relatives, and various species involved in their life processes such as pollinators, symbionts, pests, diseases and competitors. Thus food producing species that are harvested directly from their natural habitat are not part of the agro-ecosystem. Various types of agro-ecosystem has developed in Indonesia, ranging from traditional ones such as shifting cultivation, to the monoculture system such as cultivation of high yielding rice variety. In general traditional agro-ecosystems harbor many cultivated species, which are planted simultaneously at the same time or in rotation.

Plant cultivation began around 10,000 years ago. During that period, natural selection occurs to adapt to the various climate types, diseases, pests, weeds, and then human induced selection process, particularly for certain traits in plants and livestock (Frankel et al. 1995). Agriculture practices of local communities make it possible for selected plants and animals to disperse far from their places of origin. Dispersal of cultivated plant species is accelerated by through collection activities by humans. Based on the diversity of economic plants, Vavilov, the Russian botanist, developed the theory of origin of cultivated plants. Indochina-Indonesia is one of the 12 centres of origin (Zeven and Zhukosky 1975).

Some economic plant species with global importance, whose centre of distribution is the Indochina-Indonesia area, are banana (*Musa balbisiana* and *M. acuminata*), coconut (*Cocos nucifera*) and sugar cane (*Saccharum officinarum*). This region is also important in terms of diversity of bamboo, tropical fruits such as rambutan and durian, taro and ginger families. In addition, the region is also the center of distribution for rattan and commercial timber species such as ironwood, shorea, meranti, etc. Cultivation of indigenous species in this region is limited, covering only clove, nutmeg and cinnamon, as compared to species from outside the region such as rubber, coffee and cocoa.

An important aspect of the agro-ecosystem is medicinal plants, both cultivated and wild[6] . Data on the number of medicinal plants varies. Heyne recorded about 1070 species of medicinal plants in Indonesia. Eisai (1995) reported there are 2500 plant species which potentially contain medicinal properties in Indonesia's forests while Zuhud et al. (2001) identified 1845 species with medicinal potentials in the forests of Indonesia (Bermawie 2002).


(Doc. Ministry of Forestry)

Figure 3.15. Agroforestry is one of the land use systems that support both economic activity of rural population as well as preserving fauna and flora diversity.

Not much information is available on the animal genetic resources in Indonesia, since research and inventory is still on-going. But, the livestock genetic resources is reflected from their diversity. For instance, Indonesia has several cow races, such as Madura, Bali and the coastal cow of West Sumatra. Similarly with carabou, consisting of mud carabou, spotted carabou as well as local varieties of sheep, chicken, fish and duck in various area of Indonesia (Zuhud and Putro 2000).

Genetic diversity of cultivation plant and animals are assets for developing plant varieties and animal races within the framework of national food security. Genetic resources is also a long-term capital for food, medicine, dye stuff, cosmetics industries as well as for industrial raw materials.

Cultivated plant genetic resources are collected in the form of field gene banks in various research agencies of MoA, MoF, LIPI, some universities, MoH, private agribusiness companies, as well as by NGOs and communities, as a group or individually. Some of the computerised genetic collections for food, vegetable, fruit, ornamental, medicinal and industrial plants are presented in Appendix 4.

[6] Medicinal plants are generally not included in the agro-biodiversity. However, given that they are very important biological resources in Indonesia, the IBSAP document provides a brief discussion on medicinal plants and the associated problems in this section.

It should be noted that although Indonesia is known as one of the centres for economic plant distribution, not many Indonesian indigenous species have been cultivated. In fact, the diversity within those species has been little studied. Yet knowledge on the diversity within a species is very important for breeding purposes.

Most of the food plants that comprise the agro-ecosystems in Indonesia are "immigrants". Corn, sweet potato, cassava, potato, soya bean, peanut, chilli and highland vegetables were introduced to Indonesia hundreds of year ago. Some of these have adapted well to their growing environment. Given the large range of ecosystems in Indonesia, some immigrant plant species indicate a large diversity within species as well, for instance in the case of sweet potato, cassava and chilli.

Biodiversity forms, patterns and levels in the agro-ecosystems all over Indonesia have not been well documented. But there are individual reports from various areas on the diversity of system, species and genetic resources in agroforestry and community agricultural systems. For example the Dayak Pasir community in East Kalimantan plant 10-17 rice varieties simultaneously, while the Dayak community in the upstream area of Bahau river plants 58 local rice varieties. The agroforests in Maninjau, Sumatra usually have more than 300 plants, 30 of which are fruit species. The communities in West and Central Kalimantan developed the *tembawang* agroforest system, in which they plant fruit trees together with resin producing trees, timber, palm, liana, rattan and herbs in a single patch of land, adopting the forest like structure. One tembawang plot can harbor up to 45 fruit species (de Foresta et al. 2000).

Benefits and value of agro-ecosystem

Agro-ecosystem is the backbone of agriculture development in Indonesia. The biodiversity in agro-ecosystems have economic value for food crops agriculture, estate plantation and fishery. GDP of the agriculture sector continues to increase from Rp. 57, 028 billion (1998) to Rp. 60,020 billion (2000) or approximately 15% of the national GDP. The agricultural sector involves 21.4 million households in Indonesia (BPS 2001 *in* KLH 2002).

The biodiversity of medicinal plants also has social and economic benefits which have not been fully harnessed. From the 89% of the population that sought to overcome health problems, 45.1% conduct self-medication using traditional medicine preparation, 26.9% use formal health services and 16.7% use both methods (Sumoharyono *in* Bermawie 2002). In 1996, there were 600 household level and large-scale traditional medicine industries which rely on medicinal plants. This figure increased to 810 in 2001. The volume of trade in traditional medicine increased from 686 tons (1996) to 1200 tons in 2000 (Pramono 2001). But Indonesia is not yet capable to harness the maximum economic benefits provided by its medicinal plant diversity.

The value Indonesia's traditional medicine trade was only Rp. 124 billion in 1992. It increased to Rp. 1 trillion in 1999/2000 (Sumaryono 2002). However, total herbal medicine trade in the world was US$ 19.8 billion in 1998 (Dennin *in* Bermawie 2002). From that amount, about US$ 1 billion was Chinese traditional medicine (Pramono 2001). China and Korea could secure high socio-economic benefits from their trade in traditional medicine. In 2002, China earned US$ 3 billion, while Korea US$ 1 billion from traditional medicine trade. However, according to Sampurno (Head of Food and Drugs Supervisory Body), Indonesia's traditional medicine business is rapidly increasing in the last three years. In 2002, the market value estimated at Rp. 1.3 trillion or ten percent of the total national pharmaceutical trade (Bisnis Indonesia 12 August 2002 *in* Warta Balitro No. 44/2002).

While the germplasm collections have not been given monetary value, statistics show that the value of spices and medicinal plant export in 1998 was US$ 426 million, excluding their industrial products (Bermawie 2001). The collections are very valuable for breeding crops in the country, and can be "sold" or "lent" to international seed companies for their agriculture business.

Agro-ecosystem also has socio-cultural values. Each region can be developed into an agro-ecosystem according to the local knowledge, culture and environment. For instance, those found in dry land areas usually integrates many plant species. In the *pekarangan* (home garden) system, communities integrate annual and perennial plants. The high level of biodiversity ensures the fulfilment of various needs such as food, medicine, cash, fuel wood, and building materials, beauty and shade. Thus, agro-ecosystems not only provide food but also cultural needs such as bettlenut, flowers for

(Doc. State Electricity Company)

Figure 3.16. Land conversion is common to make way for rice fields expansion.

offerings and ceremonies, as well as raw materials for handicrafts.

Resource depletion and degradation

Comprehensive inventory and documentation on agro-ecosystem depletion and degradation is not available. However, there are indicative information that can provide a picture on the level of degradation and depletion.

Farmland reduction occurs in highly populated areas such as Java, Madura, Bali and Sumatra. Rapid population growth on these islands, combined with infrastructure development, has led to the conversion of agricultural lands into settlements, industrial complex and roads. Although there is a government regulation to limit agricultural land conversion, particularly wet rice fields, such a process continues. It is estimated that 30,000 ha of agricultural lands, a large part of which is wet rice fields, are converted each year into non-agricultural uses (Kompas 10 October 2001 *in* KLH 2002).

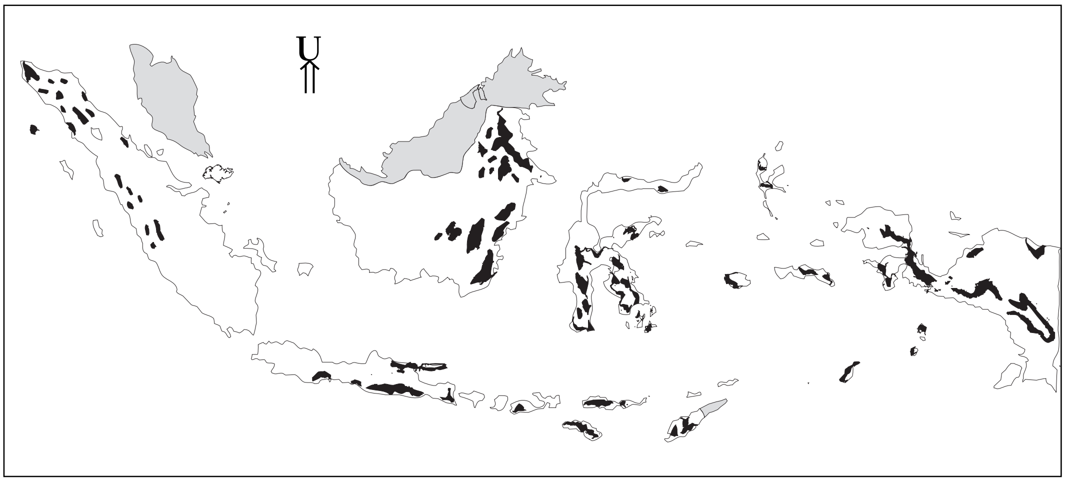
At the species level, depletion occurs particularly among tree species that make up the home gardens. A 1974 survey in Java, Madura and Bali showed the depletion of fruit trees that were less preferred such as mundu (*Diospyros edulis*), kepel (*Stelechocarpus burahol*) and others (Sastrapradja 1974). The depletion of these fruit species is drastic in the Bogor-Jakarta area, especially after the toll road and new settlements were built.

Before the 1970s, the Bogor-Jakarta region was a settlement area with *pekarangan* agroforest, where fruit trees were the main components. Kemang (*Mangifera caesia*), rambutan (*Nephellium lappaceum*) and durian (*Durio zibethinus*) were the most common trees planted. Kemang, whose flowers adorned the area in September, is no longer seen in the area, although rambutan and durian are still relatively abundant.

Genetic erosion in agrobiodiversity has not been systematically documented. However, in general it can be said that such an erosion occurs at an alarming rate (Sastrapradja and Rifai 1989). The Green Revolution, launched in Indonesia since 1969, especially on islands that applied the *Panca Usaha Tani* (Five Agriculture Tenets), has led to erosion in local rice varieties. In the early 1990s, some 70% atau 8-9 million hectares of wet rice fields are planted with one rice variety, the IR64, in a monoculture system. The uniform phenotype and genotype of rice plant weakens genetic viability towards new pests and diseases. This became evident when leaf blight disease, tungro virus and brown hopper infected rice fields in 1998-1999 and destroyed fields planted with IR64. In addition to pests, the use of high yielding varieties in a monoculture system also replaced local varieties, thus narrowing the genetic base of agricultural crops, not just rice.

Before local rice varieties were replaced by high yielding varieties, IRRI had collected and preserved them together with Indonesian authorities. But, since the gene bank conservation system in Indonesia is not well developed, the duplicates kept in Indonesia no longer have germination capability. If necessary, the samples can be accessed by Indonesia's MoA from IRRI.

Another indication of genetic erosion in agricultural crops is the continued reduction of germplasm accession in various research centers. For example, the Biotechnology and Crop Genetic Resources Research Center had at one point collected 10,000 accession of rice germplasm, but in 2002, there were only 3500 collections. Greenbean germplasm collection was 2300 in 1983, but only 1100 accession in 2002. Industrial plant collections in Cimanggu, Bogor, which was developed since 1943, has been so much reduced that only 6% of perennial plants and 25% of annual plants are left (Deptan 2002).



Source: KMNLH 1999.

Figure 3.17. Distribution of karst in Indonesia.

Another problem in the management of agro-ecosystem is the impact of new species introduction on local species and agricultural environment. In the new environment, the introduced species can breed faster and dominate over native species. Also, the new species might bring other unknown associated species that can become pest or weed. The following examples illustrate the problem of invasive species:

a. *Leucaena leucocephala* for regreening and shades for cacao and coffee, followed by explosion of plant hopper pest.
b. *Chrysanthemum* sp. followed by leaf borer (*Liriomyza huidobrensis*) which damaged hundreds of hectares of potato crops in Java, Sumatra and Sulawesi during the 1990s.
c. Water hyacinth (*Eichornia crassipes*), introduced as ornamental plan, expanded very quickly and is now a major weed in many Indonesian waters.

KARST ECOSYSTEM

Karst is a unique landscape formed by slow erosion of rocks, usually limestone and dolomite. In Indonesia, limestone or its metamorphose from, i.e. marble or meta-limestone, is more common (KMNLH 1999).

Limestone area in Indonesia is about 15.4 million hectares. Some sites have developed into karst ecosystem. The following description on karst is mostly extracted from KMNLH (1999), unless otherwise specified.

Limestone is found in all big and small islands in Indonesia (Papua, Kalimantan, Sumatra, Sulawesi, Java, Madura, Bali, Halmahera, Lombok, Sumbawa, Flores, and Timor) and some smaller islands such as Nusa Penida, Sumba, Muna, Togian, Biak and Misool. Figure 3.17 presents the distribution of carbonate rocks in Indonesia. However not all limestone areas develop into karst.

Studies on karst are very limited in Indonesia, thus not all karst areas are known well. For instance, information on the karst areas of Sumatra is relatively little, despite the fact that the island is one of the centers of limestone areas. One important karst area is Lhok Nga in Aceh whose forests have potentials to produce timber, rattan and durian.

The biodiversity in karst ecosystem, whether at the surface or in the caves, is very specific and limited, consisting of species that can survive in an environment highly alkaline (due to the calcium carbonate content), resistent towards permanent dry conditions, without light and most of the times the oxygen content is low. Therefore the plant and animal species in this area is also specific or may only be found in karst and limestone caves (Vermeulen and Whitten 1999).

Due to its uniqe ecosystem, karst has a high endemism level. Some cave species reported during the last decade have astounded the world such as cave crab (*Cancrocaeca xenomorpha*, Ng 1991) and blind scorpion (*Chaerilus sabinae*, Loureneo 1995) from Southeast Asia which were found in Maros, South Sulawesi. The LIPI research team in Maros (Suhardjono 2001) reported two new bat species, two mouse species, one new smallest tree-shrew species, two blind fish species, suspected to be new, one new bee species, and several Arthropode species suspected to be new. Although much has been reported, studies to reveal the life processes in this ecosystem are still needed, since only a small part of the natural resources of karst and caves in Indonesia has been explored.

Benefits and value of the karst ecosystem

In Java, important karst areas are Gombong Selatan and Mount Sewu. In East Kalimantan, karst areas are found in the Mangkalihat Mountains. In Central Kalimantan, karst areas are found, among others, in Haje and Menunting mountains in Muara Teweh. These caves are known as important swiftlet nest producers. In South Kalimantan, karst areas are found in Meratus mountains, dispersed intermittently from Batu Apu mountain to Batu Haje mountain, stretching 200 km.

Karst develops very well in Sulawesi, especially South Sulawesi. The Maros karst, with an area of about 400 km^2, is a famous tourist and research area. The Waingapu Karst in West Sumba is an important source of water. This ecosystem also has high potentials in Papua, which is rich in limestone areas that have developed into karst. Some examples are the Wamena-Trikora karst, Biak with unique cave corridors, Misool island with it archaeological value.

Important karst areas that need to be conserved include Sewu mountain, Karang Bolong, in South Gombong, Maros in South Sulawesi and the karst in Papua.

Karst has significant and unique value, such as source of limestone for cement and stone industries. However, limestone exploitation for cement often threatens the karst ecosystem itself. Karsts also have high economic value as sources of ground water. Almost one third of the world's population depend on the karst areas for ground water (Watson et al. 1997). This ecosystem also has scientific value for geological, geomorphological, paleontological, hydrological studies as well as other scientific research. The karst in mount Sewu and Papua are important study areas.

Some caves have historical, prehistorical and cultural values, such as the Leang-leang cave in Maros. Several other caves are still used for rituals and religious ceremonies. Karst is a natural purifier for polluted ground water, which are washed by the limestone pores. Thus karst is a life-supporting ecosystem for the survival of organisms in its surroundings. The value of karst as tourist area has not been fully harnessed in Indonesia, despite the fact that the country has many beautiful caves not found anywhere else in the world. For example, the caves in Maros, explored by a joint Indonesia-French team, are reported to be the longest and to have the best decoration in Southeast Asia (Expedition Thai-Maros 85; Expedition Thai-Maros 86; ASC 1989). The most spectacular example is the "*tropical cone-karst*" in lowland areas (Sunartadirdja and Lehmann 1960) which is found only in Indonesia.

Resource depletion and degradation

Like other ecosystems, karst also faces degradation, although there is no comprehensive data on the scale and location. For instance, intensive mining in some karst areas such as in Kecamatan Semanu, Rongkop, Tepus and Pojong has reduced biodiversity, caused sedimentation and degraded soil fertility, as well as changed the landscape. Forest clearing in the karst of Kidul Mountain has increased the carbon dioxide content in the soil and reduced evaporation. Some karst areas exploited for tourism are also beginning to face degradation. For example, "statue making" in the Jatijajar Cave has changed the original appearance of the cave.

Karsts are vulnerable ecosystems because of their low environmental carrying capacity. Therefore this ecosystem is sensitive to environmental changes brought about by mining, logging, road building and tourism activities. There is a great concern that karst ecosystems are being damaged before comprehensive studies are conducted to reveal its potentials.

STATE OF SPECIES AND GENETIC DIVERSITY

As mentioned before, Indonesia has high species diversity. However the level of species extinction and threat is also high. Records on species threat and extinction are difficult to obtain unlike data on ecosystem degradation. One of the reasons for this is the fact that it is difficult to ascertain whether a species is already extinct. The Bali tiger (*Panthera tigris balica*) has been declared extinct since 1940. The Red Data List of 1980s states that the Java tiger (*Panthera tigris sondaica*) is extinct, although some national agencies, including the MoF, have not officially declared it as such.

Despite such difficulty, it is estimated that one species becomes extinct per day (KMNLH 1997) in Indonesia. Another source estimates that in the future, Indonesia will lose one to 50 species every year (Dephut nd). In addition, the inventory by international agencies such as IUCN, can be used as indicator on threats towards species. In 1988 126 bird species, 63 mammal species, 21 reptile species and 65 other animal species were declared on the brink of extinction (BAPPENAS 1993). Four years later, the Red Data List IUCN indicate that 772 flora and fauna species were threatened with extinction, consisting of 147 mammal species, 114 birds, 28 reptiles, 68 fishes, three molluscs, 28 other fauna species, 384 flora species. A more detailed list on the status of some plant and animal groups under threat is given in Appendix 5.

Furthermore, ramin (*Gonystylus bancanus*) is now included in the Appendix III of CITES (not banned from international trade yet, but member countries must have permits to and monitor the trade in such species). The range of distribution of ebony (*Diospyros celebica*), ulin (*Eusideroxylon zwageri*), sandalwood (*Santalum album*) is also narrowing. So is the case with many Dipterocarps species. According to Newman et al. (1999) Kalimantan is known to harbor the highest number of Dipterocarp species in Indonesia (267 species), but only a few species have actually been used commercially. Other species may have become extinct before being harvested because logging trees of this family member often damage other non-commercial species, especially since natural regeneration of Dipterocarps trees is known to be difficult and takes a long time.

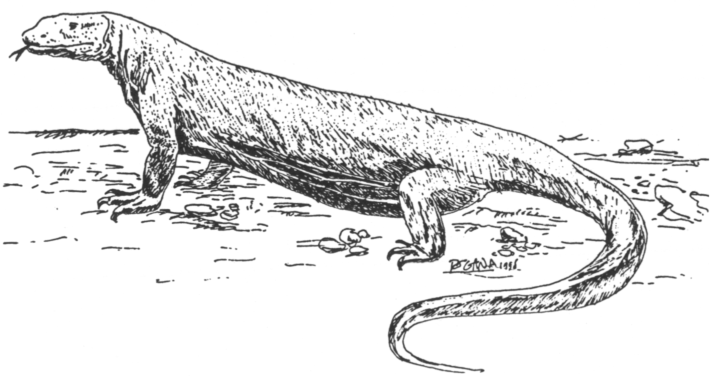
About 240 plant species have been declared rare, many of which are relatives of cultivated plants. At least 52 orchid species (Orchidaceae) are declared rare, as well as 11 rattan species, nine bamboo species, nine betel palm species, six durian species, four nutmeg species, and three mango species (Mogea et al. 2001). Also 44 medicinal plant species have become rare, the list of which is provided in Appendix 6.

Several fish species are also threatened with extinction. For instance, the chinese herrings (*Clupea toli*) which dominated the eastern coast of Sumatra and flying fishes (*Cypselurus* spp.) in the southern coast of Sulawesi. Other threatened fish species are batak (*Neolissochilus* sp.) the pride of Toba lake often used in indigenous ceremonies, bilih (*Mystacoleucus padangensis*) which is endemic in Singkarak Lake, botia (*Botia macraranthus*), the ornamental fish unique to Batanghari river, which used to be consumed by local community but have now become rare.

The erosion of genetic diversity, particularly in the wild species, is not well documented. Logically, if ecosystems and species are threatened, it will inevitably lead to genetic erosion. The discussion on genetic erosion in agro-ecosystem might well apply to wild species. Since not all of the genetic erosion occurring among wild species is known, while it is certain that erosion does happen, Indonesia probably has lost many of its "pearls" without knowing their value and their uses.

CULTURAL DIVERSITY AND TRADITIONAL WISDOM

As discussed in Chapter 2, Indonesia also has a high cultural diversity. For instance, Papua is home to 250 ethnic groups with a diverse culture, language and tradition that governs relationship among groups and with nature (KLH 1997). For traditional communities, biodiversity is important not only as a source of food and medicine, but also as an element that shapes their cultural identity. Tribes in Papua respect certain sweet potato varieties as part of their traditional ceremony to mark the birth of a child or to propose marriage to a woman. The Bajau community believes that they are related to sea turtles and thus they do not hunt turtles. Communities on Komodo island also believe they are related to the komodo dragons.



(Doc. BirdLife-Indonesia)

Figure 3.18. The Komodo dragon is an endemic reptile and the largest lizard in the world that can be found in the Komodo National Park.

The daily interaction between traditional communities and biodiversity has given rise to a dynamic knowledge system which is useful for biodiversity conservation. The taboo system in the Baduy community, for example, prevents them to clear forests excessively. The agriculture system that they have developed has also been instrumental in conserving rice genetic resources; it also tends to reduce pests and diseases thus is more ecologically sustainable compared to the modern monoculture agricultural system.

Similarly, there are 127 different terms for various rice strains used in about 400 tribal languages in Indonesia. The community in the western part of Madura (an island near East Java), for instance, can identify 12 snake fruit or salak (*Zalacca edulis)* cultivars while botanists can only identify nine cultivars (Rifai 1994). Box 3.3 presents an example of traditional wisdom in biodiversity management.

Information on traditional wisdom in biodiversity management is still scarce. Recently, the MoE attempted to document traditional wisdom in environmental management, including biodiversity management, by compiling about 300 articles on this issue.

Traditional wisdom and knowledge system is also under threat and is degrading. For example, the Dayak communities in Kalimantan is experiencing cultural changes. In the past, the old members of the community rely on natural signs (the voice of the birds, the position of the moon, the presence of certain animals) to govern their activities; today such belief is considered as superstition. Similarly, the ancestors of the Dayak community believe that other living beings can help humans in living their lives, and therefore these other organisms are considered sacred; today other living beings are considered a threat (Limin 1999). Such cultural degradation is reflected from the fact that Dayak community now cannot contain land fires and has also shortened the fallow period of their lands (the period to provide a rest to the soil after several planting seasons). The Dayak community in Kalimantan practice the shifting cultivation, a technique adapted to the forests of Kalimantan, as long as it follows traditional patterns. A study on the practices of shifting cultivation among the Dayak Iban community in West Kalimantan, in the early 1990s indicates that the fallow period has been shortened from 10-15 years in the 1970s to 8-10 years. This is due to economic demands and reduction in land allocated for cultivation (Semedi and Riyanto 1996).

Another example is the utilisation of coastal resources among the indegenous community of Sungai Pisang in West Sumatra. The traditional values in natural resources management, in the form of myths and beliefs, together with the *adat* council to regulate the practices, are now changing. This is partly because the family ties among the fisherfolk communities are no longer as tight as before, the changes in government system from the traditional nagari into the formal *kelurahan* and the higher economic demands of the household (Yunaldi nd).

One of the most important aspects is the shift in the enforcement of adat laws in relation to natural resources managemment. Once an area is developed, the community structure and practices will change. For example, the entry of new settlers, whether through government sponsorhip or new economic activities (mining, logging, industry), will make community structure and resource utilisation pattern more diverse and complex. As a result it becomes difficult to enforce adat laws, especially when natural resources utilisation regulation also shift from the hands of adat communities to the government. This has led to many conflicts in the concept and implementation of adat laws *vis a vis* government regulations on natural resources utilisation. In turn, this has led to erosion in the sense of belonging, in which local and adat communities would gradually leave the sustainable resource utilisation pattern and shift to exploitation.

Cultural degradation also brings about degradation of traditional knowledge system. This is unfortunate as traditional knowledge is one of the important keys for sustainable biodiversity utilisation.

To realise sustainable development, the factors and underlying causes of damage to biodiversity and cultural diversity must be identified and dealt with. One of the important aspects is human behavior when undertaking economic activities. Also, the existing biodiversity management practices need to be reviewed, while the current and future conditions need to be considered as all of these will influence sustainable biodiversity management. These will be discussed in Chapter 4.

Box 3.3

TRADITIONAL WISDOM IN MARINE BIODIVERSITY MANAGEMENT

In the eastern part of Indonesia, traditional communities have developed the *sasi* system. In general, sasi is restriction to enter, harvest or do any activity in a designated area for a given period of time. The sasi system regulates utilisation of natural (forest and marine) resources by indigenous as well as imigrant communities. The system is based on adat and religious regulations, and has a penalty system as well as supervisory body consisting of village government, religious leaders and other village elite. There are many kinds of sasi such as sea cucumber, bia-lola and batu laga sasi in Kei and Nolloth islands, lompa sasi in Haruku, and marine area sasi in the northern coast of Papua. In Haruku, the lompa fish may only be caught using net and should not be caught as long as other fishes are still available. In Kei, bia-lola may only be caught if the size has reached 6 cm.

The start of sasi or harvesting period is determined after observing certain natural signs known by the local community. If sasi regulations are violated, the violaters will face penalities, caught and convicted by the adat council. The penalty can be in the form of social punishment such as being excommunicated, or in the form of fines and confistication of properties. Social punishment is metted out to stop violators from repeating their acts and to warn other community members to refrain from commiting similar violations. Like any other traditional wisdom, the practice of sasi is also eroding.

Source: summarized from Muhtaman et al. 1999 and Purwoko et al. 2001.

In addition to producing hydroelectricity, the Cirata Dam will be developed as a tourism area with facilities to ensure economic, education and cultural activities.