Chapter 1

Existing Environmental Conditions in the Study Area

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1.1 General Environmental Conditions

1.1.1 Geography

The study area occupies a part of North Sulawesi Province, and consists of Manado municipality, Bitung municipality, Minahasa regency, and a part of Bolaang Mongondow regency. The study area is located North between 0° 23′ and 2° 55′ and East between 124° 04′ and 125° 20′ extending about 200 km long from north-south and about 60 km wide from east-west. The coastline of the area is about 960 km long, and the study area is 7,800 km^2. Table 1.1 is estimated by GIS database.

Minahasa regency and a part of Bolaang Mongondow regency is dominated by hilly and mountainous areas with relatively fertile volcanic soils in the center and western areas. Stretches of coastal plains are relatively narrow fringe found anywhere in the study area. Manado municipality is located along the northwest coast of North Sulawesi peninsula and facing Sulawesi Sea. On the east and south sides of the city are hills and two rivers: Tondano-Jengki River and Malalayang-Bahu River running into Manado Bay. Manado municipality has 4 islands: Bunaken, Manado Tua, Mantehage, and Nain, which are parts of National Park of Bunaken. Bitung municipality locates along the northeast coast of North Sulawesi peninsula and facing Maluku sea. Bitung municipality has very limited land space due to two mountains, Batuangus and Dusaudara (twin mountains), which are located in its midst. Bitung Selatan district is an island (Lembeh island) and has also limited land along the coast with very hilly topography.

Table 1.1 Shoreline and Coastal Water Area of the Study Area

Parameters	Areas	Manado	Bitung	Minahasa	Bolaang Mongondow	Total Study Area
Length of Coastline (km)	Main land	29.7	46.3	411.3	226.9	714.2
	Islands	36.4	96.9	184.4	23.8	341.5
	Total	66.1	143.2	595.7	250.7	1,055.7
Coastal Water Area (km^2)	4 miles from shoreline	317.5	439.8	2,419.3	1,044.3	4,220.9
	12 miles from shoreline	820.2	1,314.7	5,842.2	3,263.2	11,240.3

Source: JICA Study Team

Note: Data of Bolaang Mongondow covers only the Study Area

1.1.2 Topography

The inland of the study area is generally mountainous or hilly because it was formed geo-morphologically by the occurrence of volcanic eruption. Plains in limited scale are distributed among the mountains as basins or along the coastline facing the Celebes Sea. Because of the mountainous topography and strip shape of Sulawesi Island, rivers generally are rather short and the current is rapid.

Concerning topography of the seabed, the sea around the study area is generally deep, compared with the Sunda and Sahul continental shelves. In the study area, some different topographic characteristics can be found between Molucca Sea and Celebes Sea. In the Molucca Sea, the water deepens gradually from the shore with inclination of 3-5%. On the other hand, the Celebes Sea generally deepens a short distance from the shore with inclination of 20%, although the seawater in some areas, for example around Raprap, deepens gradually. Two small shelves are found in the study area. The first is in the area between the shore and the islands of Mantehage, Bunaken, and Manado Tua, and the second is between Likupang and the islands of Talise and Bangka. Especially in the latter area, shallow seawaters with depths of 10-30 m are distributed.

1.1.3 Climate

The climate of the study area can be divided into two periods of rainy season and dry season as follows:

Rainy season : November to April

Dry season : August to October

Cool northwesterly wind brings moisture from South China Sea from November to April. During this season, sea conditions get rough. In dry season, on the other hand, dry southwesterly winds blow in the study area. Sea conditions are relatively calm.

There are 19 meteorological stations in the study area in 2001. All these stations measure rainfall. On the other hand, 6 stations (Manado: 1 station, Bitung: 1 station, Minahasa: 4 stations) measure temperature, humidity and wind. In Bolaang Mongondow, no station measures these parameters excluding rainfall. The climate conditions of the meteorological stations in the study area are shown in Figure 1.1. Temperature, humidity, rainfall and wind of the study area are as follows:

(1) Temperature and Humidity

In the coastal lowlands, the yearly average of temperature is 26-27℃, while in the highlands, such as around Tondano Lake, the average temperature is lower, around 22°C. The temperature is relatively higher from June until October, coinciding to the dry season, than the other months, although the difference of the temperature between months is usually less than 1 °C.

The humidity is relatively high throughout the year, between 70 - 90%, in the whole study area. Coinciding to the amount of the rainfall, the humidity is higher in the rainy months.

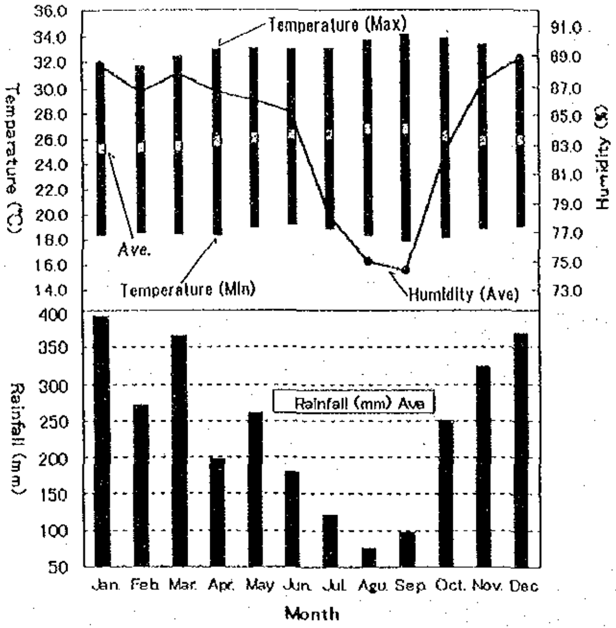
(2) Rainfall

In the study area, generally rainfall of the east coast faced to Molucca Sea is less than 2,000 mm/year, while that of the west coast faced to Celebes Sea is increased up to around 2,300 mm/year, e.g. at Poigar and even up to 3,000 mm/year, e.g. at Manado. In highlands, such as around Tondano Lake, the amount of rainfall is around 1,700 mm/year.

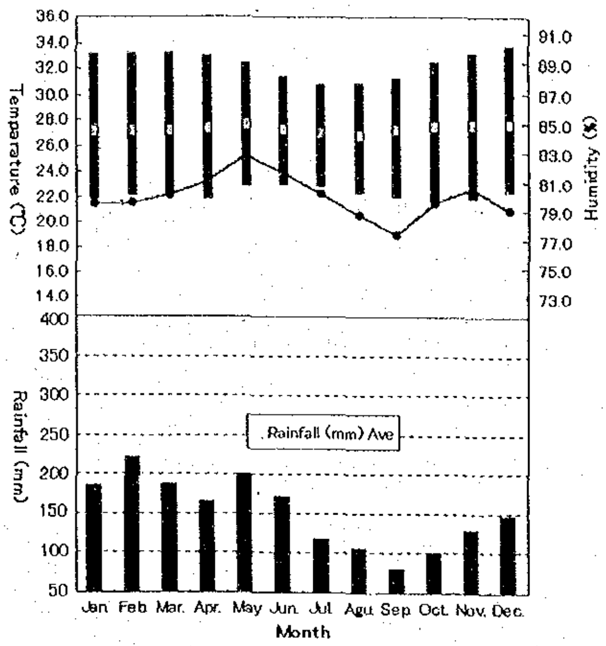
Through the whole study area, the rainfall is less from July until September, sometimes less than 100 mm/month. On the contrary it increases from October to May, sometimes over 300 mm/month in the west coast, and over 200 mm/month in the east coast.

(3) Wind

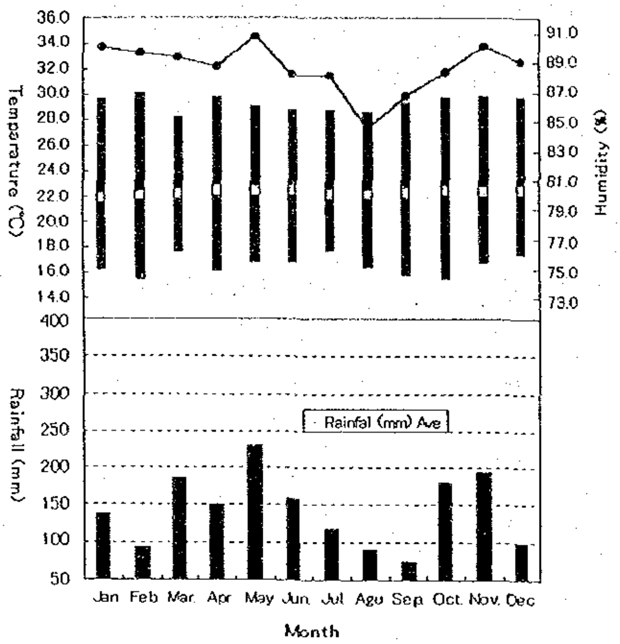
In the study area, the yearly average of wind speed is 0.7-1.1 m/sec. The dominant direction of wind is generally south from May to October, and north from November to April. Usually the wind speed is higher in the months when the south wind is dominant.



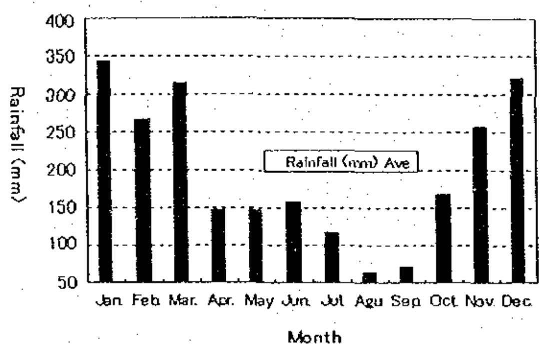
Kayuwatu Station (Manado Municipality) 1990-1999



Bitung Timur Station (Bitung Municipality) 1990-1999



Tondano Station (Minahasa District) 1991-1999



Poigar Station (Bolaan Mongondow District) 1990-1999

Note: Data of temperature, humidity and wind are not available

Figure 1.1 Monthly Average Climate in the Study Area

Source : Meteorological and Geophysical Agency

1.2 Marine Environment

1.2.1 Shoreline Forms

The study area is largely a volcanic island with a very irregular coastline and a narrow littoral shelf. The geological situation of North Sulawesi has important implications for its coasts and coral reefs. The shoreline forms of the study area are composed of coral reef, rocky shore, sandy beach, mud, mangrove and artificial structure. Sandy beach consists of light color (white) beach and dark color (black) beach. The light color sand may have originated from coral and/or eroded light-colored coastal deposits. On the other hand, dark sand may be derived from basaltic materials. Figure 1.2 shows the location of shoreline forms in the study area. Meanwhile, the shoreline length in front of shore by form is shown in Table 1.2

Table 1.2 Shoreline Composition of the Study Area

Category	Length (km)	Proportion (%)
Sandy beach	456	43
Light sandy beach	(283)	(27)
Dark sandy beach	(173)	(16)
Mud	31	3
Rocky shore	216	20
Mangrove	316	30
Artificial structure	37	4
Total	1,056	100

Source : JICA Study Team

The main structure of shoreline forms has several patterns. The main base shore of the study area is composed of coral reef, sandy beach and mangrove forest. These three main base shores accompany other shore types. The major patterns are as shown in Table 1.3. The shore pattern, which is "Sandy beach – Coral reef," can be seen on the west coast of the study area. The shoreline of Lembeh Island and around the coast of North Sulawesi peninsula, and spotted area of southern west coast are "Rocky shore – Coral reef." In "Mangrove forest – Mud– Coral," coral reefs are developed widely.

The coastlines of the cities of Manado and Bitung are dominated by artificial structures. In Manado there is considerable landfill going on, on top of what used to be coral reef. Much of the artificial structure along the coast of Manado is related to coastal defense whereas Bitung is dominated by port facilities.

Table 1.3 Major Shoreline Patterns of the Study Area

Base Shore Type	Shoreline to offshore
Coral reef	sandy beach – coral reef rocky shore – coral reef rocky shore – sandy beach – coral reef mangrove forest – mud – coral reef
Sandy beach	sandy beach
Mangrove forest	mangrove forest - mud

Source : JICA Study Team

The narrow submarine shelf bears many small islands, especially on the south side of the main island. Island clusters located off Manado and Likupang and the solitary large islands of Lembeh and Bentenan are particularly salient. Clusters of smaller islands occur along the south side at Bentenan, Ratatotok area, and there are scattered islands along the coast farther west. The spectacular Manado Tua with its very narrow shelf is an extinct volcano that last erupted in the Eocene. Lembeh is a large high island separated from the Bitung area of peninsular North Sulawesi by the narrow Lembeh Strait. Much of the coast of Lembeh is clifted, with the north end mostly cliff, turning to cliffs and bluffs alternating with sandy beaches farther south. Some of the cliffs appear to be raised reef, others are volcanic and at least two in the vicinity of Kungkungan (Cape Baturirir and Pulau Sarena Besar) are raised deposits of foramniferan chalk. All of the islands sit on the marginal shelf of the main peninsula.

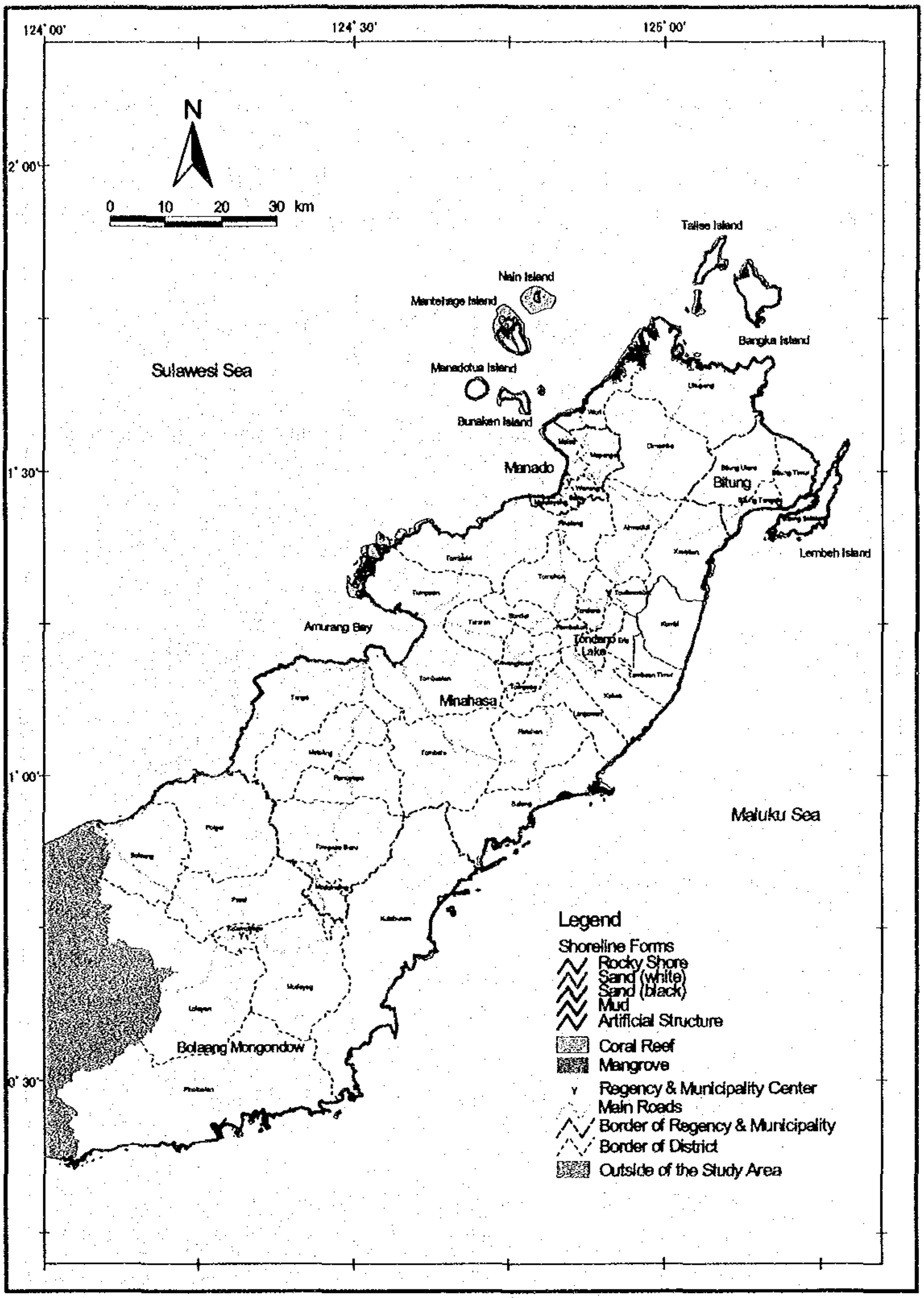


Figure 1.2 Location of Shoreline Forms

Source : JICA Study Team

1.2.2 Physical Oceanography

(1) Currents

Around Sulawesi Island, current conditions depend on wind conditions and shoreline forms. During northwesterly monsoon from November to April, the currents stream counter clockwise around Sulawesi Island (see Figure 1.3). One the other hand, from May to November, current conditions are complicated. In the northern coast of North Sulawesi, the northeastward current is dominant throughout the year.

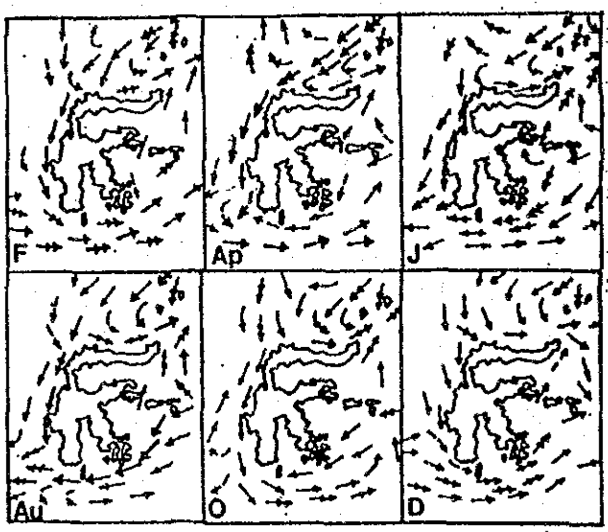


Figure 1.3 Current Pattern around North Sulawesi
Source : The Ecology of Sulawesi, Gadjah Mada University Press, 1988
Note : Surface currents. F – February, Ap – April, J – June, Au, August, O- October D – December.. *After Wyrtki 1961*

(2) Tides

There are three tidal types in Indonesia such as diurnal tide, semi-diurnal tide and mixed tide type which depend on not only position of the sun and the moon but also geographic conditions. Three tidal types can be seen in the following:

- diurnal tidal type : the Java Sea;
- semi-diurnal type : around West Sumatra; and
- mixed tide type : the eastern archipelago.

The tides around Sulawesi Island are categorized as the mixed prevailing semi-diurnal type in which two high and two low tides occur, but with difference in height (Ecology of Sulawesi, Gadjah Mada University Press, 1988).

1.2.3 Water Quality

It is difficult to assess water quality of the study area because of limited information. However, polluted coastal water could be found, especially near urban areas, such Manado Bay and Lembeh Strait. There are lots of pollution sources in the hinterland of these areas such as houses, factories, markets and others. Most of these pollution sources discharge organic materials including nitrogen and phosphate. Although it is possible that organic matters lead to red tide occurrence, there have been no reported cases. Oil spillage, which may be discharged from the land and vessels, is found especially in Lembeh Strait.

In inland, there are also water pollution sources. During rainy season, intensive agricultural activities can generate soil erosion. This eroded soil flows into the coast, and sediment settles on the sea bottom including coral reefs.

There are gold mining sites in the study area. There is a large-scale gold mining site (PT. Newmont Minahasa Raya) located in Ratatotok. This large-scale mining company adopted the cyanide method of refining gold. On the other hand, there are 11 small-scale mining sites in the study area as shown in Figure 1.4. They use amalgam method, which uses mercury for refining process. It is expected that discharged mercury has accumulated into organisms such as benthos and fishes. Gold refining process generates tailings with crushed ore content. Scientific data on mercury contamination in the study area is limited. The Study Team found that only Yayasan Bina Cipta Tech had conducted mercury test for water in November 2000, coral and mollusk in December 2000.

Total mercury of water samples at sampling sites ranges from 0.00005 to 0.00013 ppm which are under WHO standards (see Table 1.4.). The survey result on analysis of mercury biological accumulation is shown in Table 1.5. According to the result, concentration of mercury in all samples of bivalve and coral in Tongkaina coast did not exceed the 0.5 mg/kg safe level for mercury established by World Health Organization. It can be said that sampling points were far way from pollution sources so that actual contamination could not be identified.

These results of water, coral and mollusk sampling showed that their mercury content is still at safe levels according to WHO standards. However, these surveys covered a limited area (northern North Sulawesi peninsula) and frequency, so that mercury contamination should be surveyed extensively and regularly.

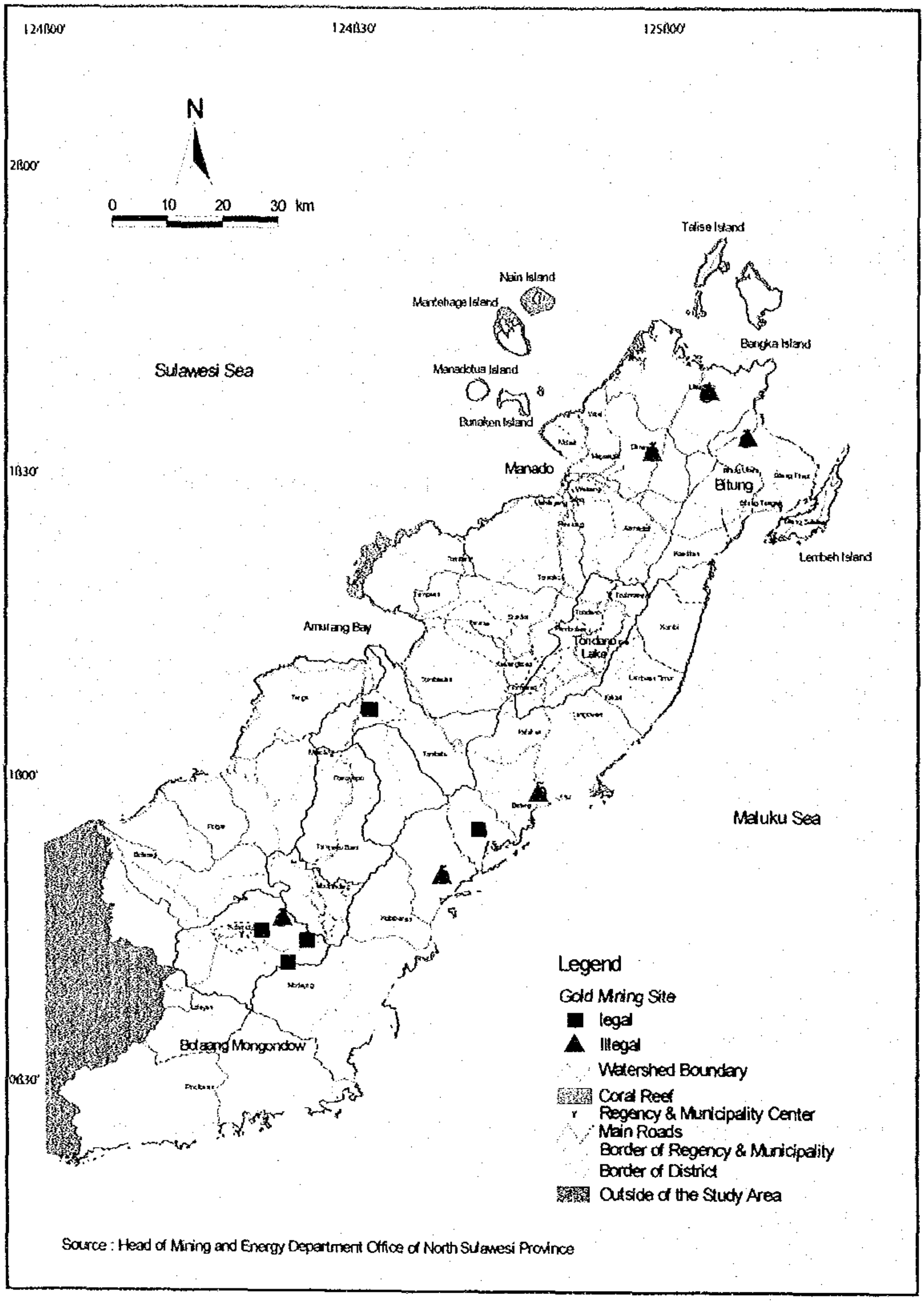


Figure 1.4 Goldmining Sites
Source : JICA Study Team

Table 1.4 Result of Mercury Test for Water

Number	Sampling Location	Total Hg (ppm)	Indonesian Standards WHO Standards
1	Kumahukur Spring	0.00013	
3	Pancuran IX Instalation	0.00010	
4	Sea Spring	0.00009	
5a	Malalayang Spring	0.00009	
5s	Malalayang River	0.00010	
6	Koka Spring	0.00013	0.001
8	Paal II Instalation	0.00007	
9	Perumnas Slow Sand Filter	0.00010	
10	Paniki Drill Well	0.00010	
11	Kilu Water Treatment Instalation	0.00005	
13	Tondano River (Kairagi)	0.00005	

Note: Sampling date: Novermber 2000

Table 1.5 Result of Mercury Test for Coral and Mollusk

Genus	Hg Content (mg/kg)
Isognmon (Bivalve)	0.303
Tridance (Bivalve)	0.345
Montipora (Hard coral)	0.288
Acropora (Hard coral)	0.297

Note: Sampling data: December 2000

1.2.4 Coral Reef

(1) Distribution and Conditions

In the study area, most of the reefs are fringing reefs close to shore. There are comparatively wide coral reefs in the northern west coast, and the coast between Tanawangko Bay and Amurang Bay, and islands in the northern part of the study area: Nain, Mantehage, Manado Tua, and Bunaken. On the other hand, coral reefs on the east coast have not developed well. The slope of coral reefs is a steep, often negative slope, especially along the north coast. The slope on the south side is generally more gradual. In areas of substantial freshwater drainage coral reefs are either poorly developed or absent (e.g. Inobunto on the north and Nuanga to Ratatotok on the south).

The status of coral reefs in the study area was assessed using coral cover as a proxy for coral community well being. Coral cover estimates were assigned to a four-category system based on live coral ratio commonly used in Indonesia. Coral reef conditions are classified into "Poor" = 0 to 25% cover; "Fair" = 26 to 50% cover; "Good" = 51 to 75% cover; and "Excellent" = 76 to 100% cover. This classification is very common in the Southeast Asian countries. Although this is a gross simplification of a complex situation, these ratios provide a standard for comparison of reefs in the study area with those in other parts of Indonesia. A coral reef distribution map based on aerial photographs is shown in Figure 1.5, and cover ratio of classified coral conditions is shown in Table 1.6.

Total coral reef area of the study area is 221.6 km^2. A large portion (88% of total coral reef or 195.8 km^2) of coral reef is classified as "Poor," (live coral ratio: 0 – 25%) including areas covered with seagrass and algae. "Excellent" condition is shared at only 0.2% of total coral reef in the study area or 0.4 km^2. Excellent conditions are spotted on the northern part of Manado Bay, in the southern part of Lembeh island and the south side of Putusputus islands. Most of "Good" condition (live coral ratio: 51% – 75%) coral reef is also spotted with 1.8% of total coral reef area or 4.0 km^2 in islands in the northern part of the study area such as Banga, Talise, Nain, Mantehage and Bunaken.

Table 1.6 Cover Ratio of Live Coral in the Study Area

Classification	Poor	Fair	Good	Excellent	Total
Live coral ratio (%)	0 – 25 %	26 – 50 %	51 – 75 %	76 – 100 %	
Cover Area (km^2)	195.8	21.4	4.0	0.4	221.6
Cover ratio (%)	88.3	9.7	1.8	0.2	100.00

Source : JICA Study Team

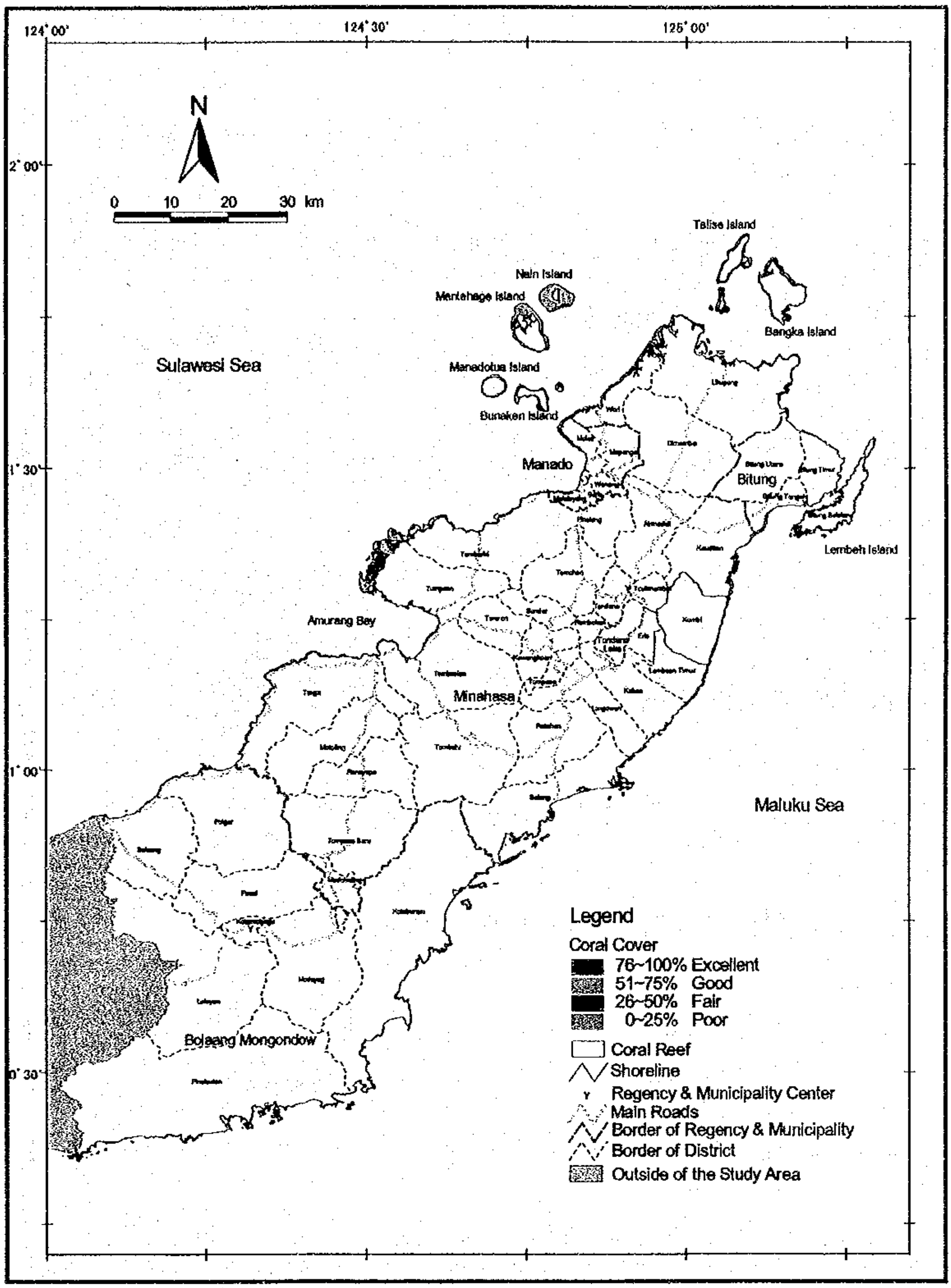


Figure 1.5 Coral Reef Distribution
Source : JICA Study Team

1.2.5 Seagrass / Algae

Much of the coast has well developed seagrass beds with a predictable zonation pattern. Total area of seagrass bed and algae is 94.5 km^2 and 4.9 km^2 respectively. Seagrass beds can be seen on most of shore in the study area. Large size of seagrass beds is distributed in islands in the northern part of the study area including Nain island, Mantehage island, and the coast between Tanawangko Bay and Amurang Bay, and around the border between Dimembe district and Likupang district, because these areas are located on wide coral reefs.

The densest beds of seagrass are *Enhalus acoroides* and *Thalassia hemprichii*. *Enhalus acoroides* can have very long leaf blades and is abundant close to shore and mangroves. According to Whitten et al. (1987) this species is indicative of quiet, warm, turbid water with a high organic load. *Thalassia hemprichii*, the most abundant seagrass in the study area, replaced *Enhalus acoroides* at 10 to 20 m from shore. It occurred in pure stands or mixed with other seagrasses such as *Enhalus acoroides* towards land and other species such as *Syringodium isoetifolum* and *Halophila ovalis* towards the sea. Towards the sea the density of all types of seagrass progressively declined to very low density in the outer backreef. *Thallassodendron ciliatum* is a large species found on the outer backreef, usually just behind the reef crest but sometimes in the surf zone. Normally it grows in small clumps making a narrow, patchy zone. It is common on the north side of the peninsula where the backreef is wide (e.g., Mantehage, Arakan).

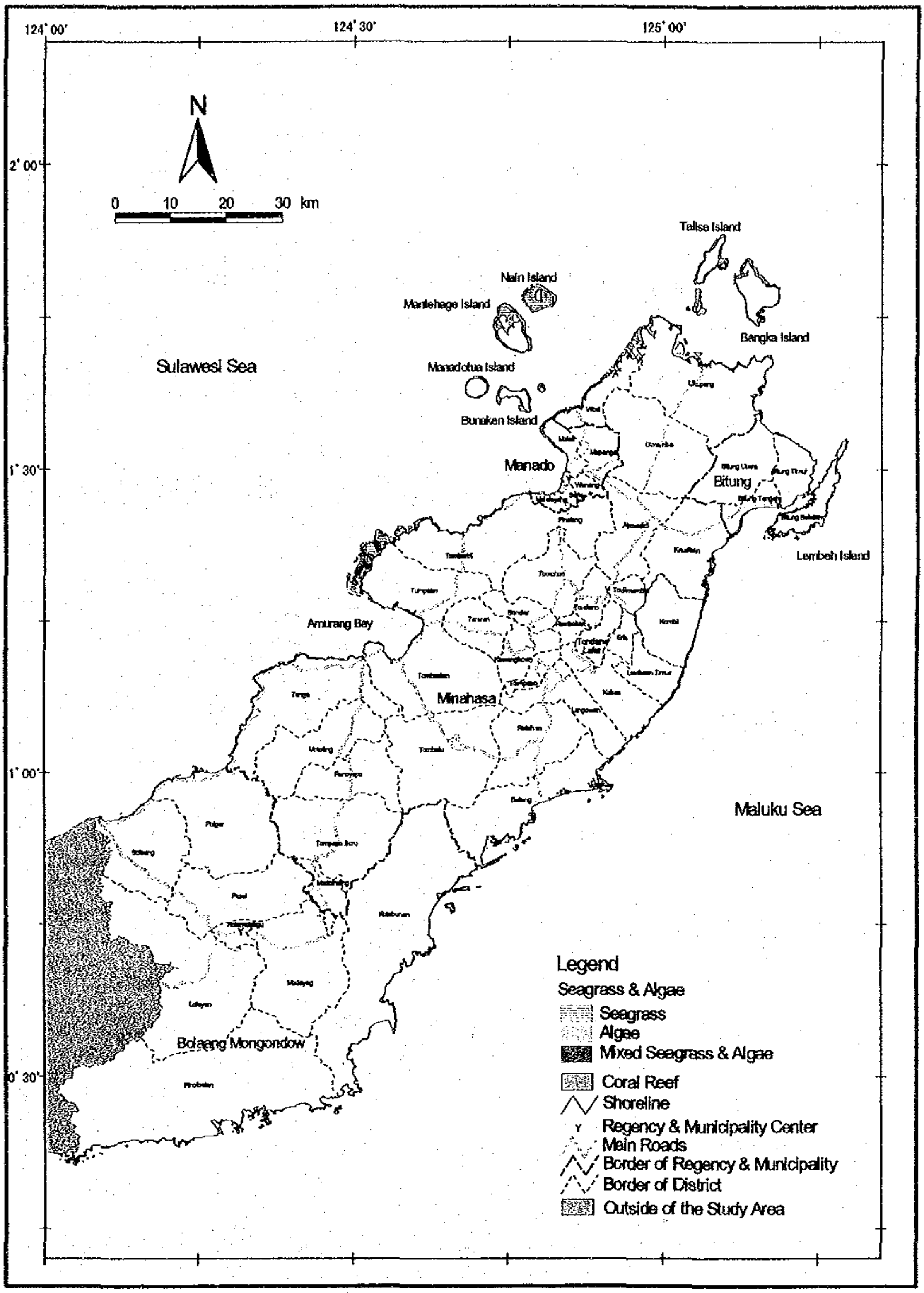


Figure 1.6 Seagrass and Algae Distribution

Source : JICA Study Team

1.2.6 Fishes

There are over 7,000 species of tropical fishes that live on or near coral reefs. In Bunaken National Park, there are at least 2,000 species of reef fishes (*Bunaken National Park Natural History Book*, NRM/EPIQ, 1999).

The Study Team conducted a coral reef fishes visual census in 1999 in the Study Area. The survey areas are shown in Figure 1.7. *Chaetodontidae* can be used for indicator species because *Chaetodontidae* is grouped as coral polyp eater, so that there is a relationship between distribution of *Chaetodontidae* and coral reef distribution. In other words, composition and number of species from the *Chaetodontidae* family indicate healthy conditions of coral reefs. Species belonging to the *Chaetodontidae* family were identified in the survey areas as follows:

Table 1.7 Number of Species from the Chaetodontidae Family in the Survey Area

Family of fishes	Manado Tua	Bunaken	Lembeh	Tanjung Tiwan	Likupang	Wori	Manado	Rap-rap	Siladen	Mantehage	Nain	Bangka	Total
Chaetodon	12	14	9	3	7	11	3	11	11	8	8	9	106
Chelmon	0	0	0	0	0	0	0	0	0	0	0	0	0
Coradion	0	0	0	0	0	0	0	0	0	0	0	0	0
Forcipiger	1	0	1	0	0	0	0	2	1	1	0	0	6
Hemitaurichthys	1	1	1	0	0	1	0	1	1	1	1	1	10
Heniochus	1	2	2	2	1	3	2	3	1	3	2	2	24
Total	15	17	13	5	8	15	5	17	14	13	11	12	146

Source : JICA Study Team

A comparatively higher number of species of coral is identified in the coral reef areas of Bunaken, Rap-rap, Manado Tua, Wori, and Siladen, especially Bunaken National Park and other protected areas, than in other areas. On the other hand, smaller number of species is identified in Tanjung Tiwang and Manado. Coral reefs are developed and conserved in the comparatively rich divested areas. In the smaller number of species, reef flat is narrow and poor. It is found that size of fishes is comparatively small compared with other areas by quality observation, especially commercial fishes such as snapper, emperor, travally and wrass. One of the possible causes of miniaturization of fish size is fishing pressure. Fish miniaturization is not found in areas where there are no dominant fishing grounds. In Bunaken National Park, which is a protected area, fishes are conserved and protected against destructive fishing practices.

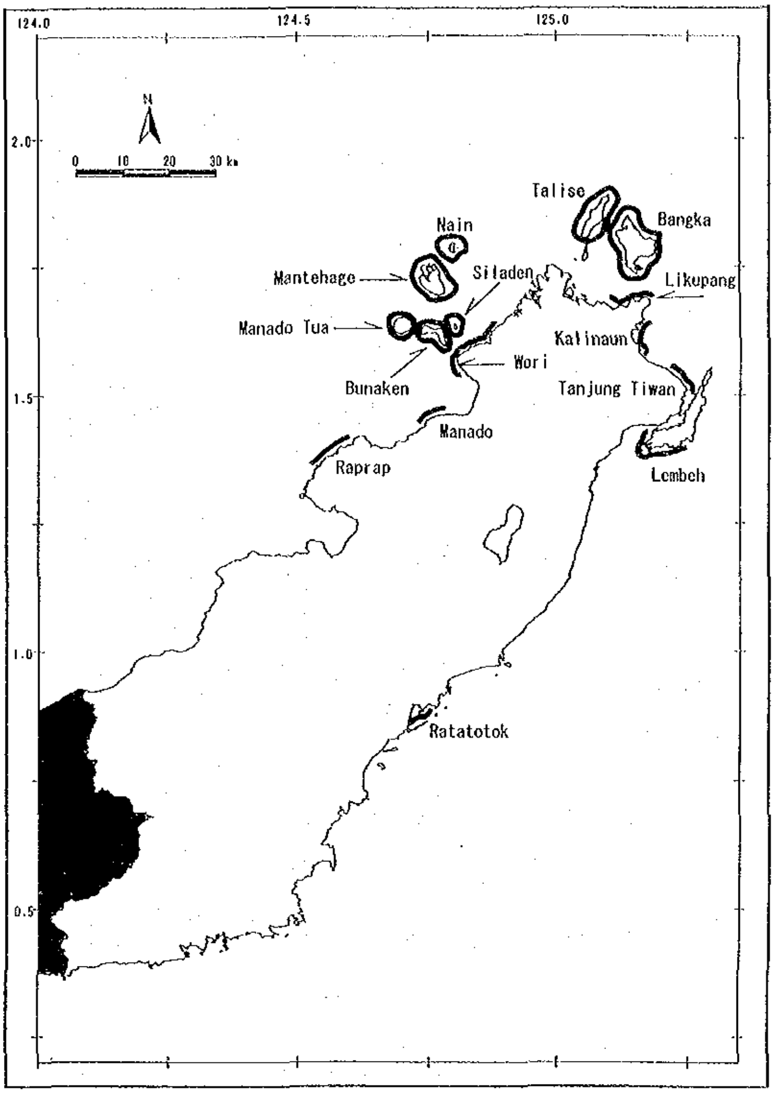


Figure 1.7 Location of Coral Reef Fishes Visual Census
Source : JICA Study Team

1.2.7 Mangrove Forest

Mangrove forest is one of the important components of coastal ecosystem. Mangrove forest acts, as the basis of its ecosystem, as spawning ground for various marine biota and protection of shorelines from erosion.

a) Distribution, Structure and Species of Mangrove Forest

Mangroves can be found along most of the shorelines of the study area, although their area is generally small and in strips. A large area of mangroves exists in a few places, such as the northern part of the study area including Likupang, Arakan, and Mantehage Island. The distributions of mangroves are shown in Figure 1.8.

Totally, in Indonesia, there are 91 species of mangrove plants, and 37 of them are tree species (Kartawinata *et al*, 1979. *Status Pengetahuan Hutan Bakau di Indonesia. Prosiding Seminar Ekosistem Hutan Mangrove,* 1978: 21-39.). In Sulawesi Island, 35 tree species can be found in the mangrove forests. Main genera of mangrove tree species which live in the study area are *Avicennia* sp, *Rhizophora* sp, *Sonneratia* sp and *Bruguiera* sp (Whitten, *et al*, 1987. *The Ecology of Sulawesi*). Depending on the tide, salinity and mud thickness, the mangrove consists ideally of three main zones as follows:

The outer zone	:	dominated by *Avicennia* and *Sonneratia*, and its forest is around 1 meter high
The middle zone	:	dominated by *Rhizophora*, and it is around 3-4 meters high
The inner zone	:	dominated by *Bruguiera*, and it is around 5-10 meters high

This zonation and size of forests are normally found where a wide mangrove forest exists in the above-mentioned areas.

According to the research conducted in some parts of the study area (*Palenewen, et al 1996. Inventarisasi Potensi Ekosistem Mangrove Bagian Barat Pantai Selatan Minahasa danal Rangka Penyusunan Rencana Rehabilitasi Pantai*), in Tumpaan, Tombasian and Tenga Districts, five species of mangrove trees, such as *S. alba J.E. Sm., A. alba, R, apiculata Bl., A. officinalis and B. conjugata Merr.* were found. Among these species, *R. apiculata and B. conjugata* have become very rare.

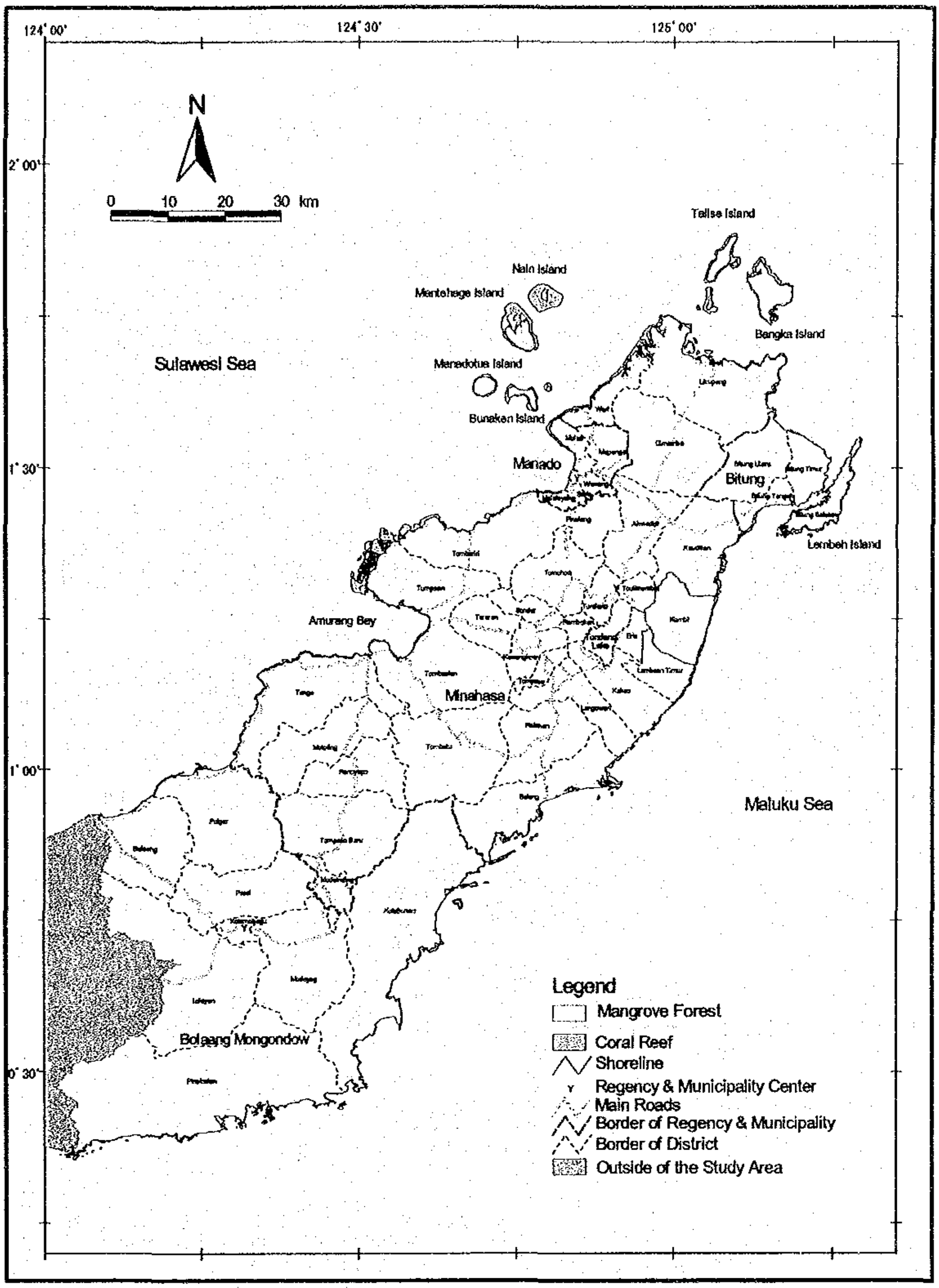


Figure 1.8 Mangrove Forest Distribution
Source : JICA Study Team

1.2.8 Marine Endangered Species

In the study area, several endangered species have been found such as dugong, sea turtles, and coelacanth as follows:

(1) Dugong (scientific name: *Dugong dugon*)

Dugong dugon were formerly found throughout Indonesia and neighboring seas. They remain relatively abundant in Northern Australia, the Torres Straits and Papua New Guinea. They are severely reduced in west and central Indonesia and locally extinct in some areas. The only significant population remaining in North Sulawesi resides in the southern main peninsular portion of Bunaken National Marine Park where they are under considerable pressure from humans. There is no data available on the status of their population.

(2) Sea Turtle

Sea turtles lay eggs on sandy beaches. Sandy beaches of North Sulawesi are used as nesting sites of sea turtles. The following four sea turtles can be found in North Sulawesi.

- green turtle (Chelonia mydas)
- hawksbill turtle (Eretochelys imbricata)
- loggerhead turtle (Caretta caretta)
- leatherback turtle (Dermochelys coriacea))

Several sightings of sea turtles in North Sulawesi have been reported as shown in Table 1.8.

Table 1.8 Sightings of Sea Turtles in North Sulawesi

	Green Turtle		Hawksbill Turtle		Leatherback	
	nest	hunt	nest	hunt	nest	Hunt
Sangihe Island	-	+	-	-	-	-
Tanjung Flesko	+	-	-	-	-	-
Tangkok Batuangus	+	+	?	-	+	+
Karkaralang Island	+	-	-	-	-	-
Nenusa Island	+	-	-	-	-	-
Bunaken Island	-	+	+	+	-	+
Popaya & Mas Island	+	-	-	-	-	-

Source: Ecology of Sulawesi, Gadjah Mada University Press, 1988

(3) Coelacanth

Coelacanth is an ancient group of large, lobe-finned fish. It was believed that Coelacanths were extinct since 70 million years ago. Surprisingly, a Coelacanth was caught in South Africa in 1938. This was followed by another catch in Manado in 1997, the first time that a Coelacanth was found outside South Africa. Then another Coelacanth was caught in

Manado in 1998. Coelacanth was included in the list of protected fishes by the Convention of International Trade in Endangered Species (CITES).

1.2.9 Marine Natural Disaster

The degree of coastal erosion in the study area is too complex an issue to assess conclusively. The area is geologically young so substantial terrestrial erosion is expected to carry material to the coast producing coastal accretion. Waves and currents are expected to erode this material subject to mitigation by coral reefs, seagrass meadows, mangroves and coastal mixed vegetation. The narrowness of the coastal shelf limits the effectiveness of these mitigating factors and the dynamic nature of coastal areas ensures that coastal erosion will always be apparent in one location or another. Without baseline and monitoring data, it is difficult to decide if an area that superficially appears to be eroding is experiencing coastal erosion or coastal accretion by downstream transport of terriginous materials. For lack of other evidence, erosion is inferred from such clues as erosion scarps, fallen and falling trees (e.g., east of Inobotu), and the presence of coastal defense structures (e.g., prevalent along the west side of Manado Bay). There is no baseline data and no information about trends so interpretation of these observations is difficult. In general, the falling trees are coconut palms and there is no vegetated buffer zone between them and the sea. No doubt the coast was thickly wooded in the past and this zone has been removed, either replaced by coconut plantations or eroded from the sea side or both. The presence of coastal defense structures implies that erosion is or has been a problem but the nature and cause of the problem is not clear. For example, the structures could have been built to protect land fill areas. In almost all cases, it is clear that at the present time a vegetated coastal buffer zone is absent and, in many cases, there is either no fringing reef or the reef has been degraded reducing its effectiveness as a coastal defense mechanism. In conclusion, it seems that the effectiveness of the various factors mitigating coastal erosion has been reduced and this, in conjunction with signs of coastal erosion and the presence of coastal defense structures, implies that coastal erosion is a problem in many locations. Assessing the nature and seriousness of particular problems will require further investigation.

Although the Meteorological & Geophysical Agency and Central Geological & Oceanographic Management Office (PPGC), Bandung, compile natural disaster record, none was found of any occurrence of tsunami, high waves (heavy waves) and high tides in the study area.

1.2.10 Coastal Environmental Impacts

Coastal environmental impact can be divided into direct impacts and indirect impacts on coral reefs. Direct impact on coral reefs includes some natural phenomena and human activities such as destructive fishing, coral mining, solid waste dumping and collecting ornamental fishes.

As natural phenomena, climate record shows that high temperatures and extensive bleaching struck the Indo-Pacific in 1983 but none was reported in North Sulawesi at that time. In November 1998, a relatively minor reef bleaching killed many of the branching corals on the reef top of Bunaken.

Reported crown-of-thorns starfish (*Acanthaster planci*) outbreaks in the study area have been confined to the south side ranging from Bentenan to Ratatotok. Although large numbers have been reported removed during the crown-of-thorns removal operations at Bentenan and Ratatotok, density estimates are not available. It seems that compared to other forms of reef degradation, crown-of-thorns starfish outbreaks are a minor concern and are possibly derived from other forms of disturbance.

On the other hand, indirect impacts, in other words land-based activities, also have an effect on coral reefs especially soil erosion. These land-based activities are discussed later in section 1.3.8.

(1) Destructive Fishing

Destructive fishing is common and severely impacts on coral reefs in the study area. It has been evidenced that large areas of coral reefs are destroyed by dynamite fishing and coral mining, although it is difficult to determine from old marks on coral reefs if dynamite fishing specifically had caused this damage. Map 1.2 shows damaged coral reef areas, possibly by dynamite fishing, with comparatively fresh marks. Such damaged areas can be seen in the west coast of the study area, especially in the south of Tumpaan.

a) Dynamite fishing

According to the coastal community survey conducted in the study area, the community recognizes that one of the biggest threats to coral reefs is still dynamite fishing. Although there is no scientific periodic data or reports over the years, reefs were destroyed significantly in the 70s and 80s according to information gathered from community people. In the study area, dynamite fishing was introduced during the WW II and this practice has continuously destroyed coral reefs until today. Dynamite-using fishermen in a village tend to go to neighboring coral reef areas rather than destroy their own village coastal area. In the study area, there is a village called Ranoiyapo where coral reefs have been completely destroyed and now the dynamite-using fishermen in the village take trips to neighboring villages and use this destructive method of fishing on a daily basis, sometimes multiple times in a day.

It is difficult to obtain the perception of fishermen engaged in dynamite fishing. From observation, the need of these fishermen seems not to be economic emergency relief, but more of greediness to catch more fish quickly and easily. To solve the problem of dynamite fishing, there is a need to consider the interwoven aspects of management issues. First of all, dynamite fishing is not only done by the community members in one village but by those from outside as well. However, the absence of a right to use and to protect one's own coastal area makes it difficult to find a solution to this problem. There is also a need to find out the real motive of fishermen engaged in dynamite fishing and to counsel them. Unless these fishermen undergo a change in motives and behavior, even the enforcement power of the police would not be able to solve this problem from its root cause.

Monitoring activities for dynamite fishing by the police authorities and community members are almost non-existent. Community people do not think that it is their responsibility to be on the look out for illegal activities in their area; they believe that this is a responsibility of the local government.

b) Poison fishing

It is not an easy task to find out the situation of poison fishing in the study area, because this fishing method is not visible like dynamite fishing or coral mining. Based on a survey conducted by the Study Team, in a village called Manado Tua II, women are using poison from a root of a tree for poison fishing in the coral reef area. In another village, a fisherman uses a chemical (*Potas*: potassium cyanide) for poison fishing. He explained that he puts poison in a small fish and feeds a bigger fish in deeper water. It is not known whether his story is true, but what he described might be one of the fishing methods used in the area. The village people uses poison fishing to catch fish efficiently and economically, so that an in-depth study on their knowledge, practice, and perception of fishing is necessary to devise the appropriate measures to stop this practice.

c) Harmful fishing

Besides the two most harmful fishing methods, dynamite fishing and poison fishing, there are other fishing gears (techniques come with gear) which can be potentially harmful to coral reefs in the study area. In a survey of 24 coastal communities, these potentially harmful fishing gear identified are Trap made of bamboo (Bubu), Gill net, Encircling net (Darape), Drift gill net (Pakapaka), Seine net (Tagaho), and spear gun (Jubi). Basically these nets can be harmful because they are used with techniques where fishermen stand on corals and slap the water to frighten fishes, or the net is staked into the coral and pieces of coral are used as weights.

However, careful study will need to be done on where and how the fishermen here use those fishing gears and techniques, and what the magnitude of damage is in order to draw up appropriate measures for both coral reefs and fishermen.

(2) Coral mining

One of the biggest threats to coral reefs in the study area is coral mining. Coral mining is more visible than other problems, so that it gives an impression of a serious problem. Observation was made of piles of corals in all villages that were visited. Although there is no written information on coral mining practice over time, historically it is well known that for the construction of Trans Sulawesi (from Manado to Makassar highway, the total amount of coral rocks used is unknown) corals were used for foundation of the road. Coral rocks are still used for foundation of roads, houses, and sometimes for jetties in villages. Also, coral rocks are commercially valuable for production of septic tanks of toilets; especially coral rocks are sold in cities where there is higher demand for toilets. According to the survey, the price of coral is Rp. 30,000 per 1 cubic meter, an amount attractive for those fishermen living in poverty.

The Study Team conducted a questionnaire survey on coral rocks used for the septic tank of household toilets in Manado City to estimate the total amount of corals mined. In designing the survey method used in this study, the following factors were taken into consideration:

- Difference of toilet system in households, especially the period before and after 1979 when coral mining was prohibited;
- How coral is used in the household toilet system of middle and high income families and of low income families, considering that coral is expensive; and
- Population density may cause some differences in the usage of corals in the toilet system of a household.

Based on the factors mentioned above, this survey was designed to cover toilets that are built in different periods of time, built by different levels of family income, and located in various levels of population density. To fulfill these requirements, the following method was adopted.

Respondents for this survey were selected in a two-stage process. First, 16 *kelurahans* were selected, and then from every chosen *kelurahan* 40 to 50 households were selected to be surveyed. The sampling method used is as follows.

- All *Kelurahans* in Manado were divided into three categories, according to their population density.
  - Low density (less than 50 persons/ha)
  - Medium density (between 50 to 200 persons/ha)
  - High density (more than 200 persons/ha)

- From 27 low-populated *kelurahans*, 6 *kelurahans* were chosen randomly. From 23 medium-populated *kelurahans*, 6 *kelurahans* were chosen randomly. Finally, from 18 high-populated *kelurahans*, 4 *kelurahans* were chosen randomly.

Corals used in Households

As a result of survey, it is estimated that 142,500 m^3 or 48 ha of coral reef have been mined and used for the septic tanks of the households in Manado municipality up to the present. Survey data and calculation steps are as follows:

• No. of HH interviewed	722 HH (households)
• No. of HH with valid responses	699 HH (100.0 %)
• No. of HH with toilets	681 HH (97.4 %)
• No. of HH with septic tanks	675 HH (95.6 %)
• No. of HH using coral rocks in septic tanks	496 HH (71.8 %)...(a)
• No. of septic tanks with corals/HH	1.2 units/HH........(b)
• Average no. of septic tanks with coral rocks/HH	86.8 %..... (c) (=a x b)
• No. of HH in Manado municipality in 1999	109,498 HH..........(d)
• No. of septic tanks with coral rocks	95,000 HH...(e) (=c x d)
• Average volume of coral rocks/septic tank unit	1.5 m^3..................(f)
• Total volume of corals	142,500 m^3..(g) (=e x f)
• Conversion to coral reef area	47.5 ha(142,500 m^3/30 cm)

Corals used in buildings

Above estimation is not inclusive of the corals for septic tanks of the other buildings such as hotels, restaurants, commercial shops, offices, industrial factories, public facilities, etc. According to the "Master Plan for Human Waste and Wastewater Disposal for City of Manado," the number of building units are mentioned as listed below :

• Hotel and restaurants	152 units
• Service	3,128 units (bank, doctor, finance, contractor)

- Governmental offices 207 units
- Commercial shops 1,420 units
- Industrial factories 1,975 units
- Public facilities 1,166 units (religious, educational, medical)
- Total building units 8,048 units

The volume of corals used for the septic tanks of buildings other than households can be roughly estimated under the assumption that those buildings also have septic tanks with corals similar to the conditions of the households as follows:

- Total building units 10,000 units (increased)
- No. of buildings with septic tanks used corals 7,000 units (70 % of above)
- Volume of corals/building 3 m^3 (more than that of house)
- Total volume of corals 21,000 m^3
- Conversion to coral reef area 7.0 ha (21,000 m^3 / 30 cm)

Total amount of Corals in Manado

It is estimated that around 163,500 m^3 or 54.5 ha of coral reef area have been destroyed and used as absorbent material for septic tanks within the Manado municipality area since the 1950s until the present time.

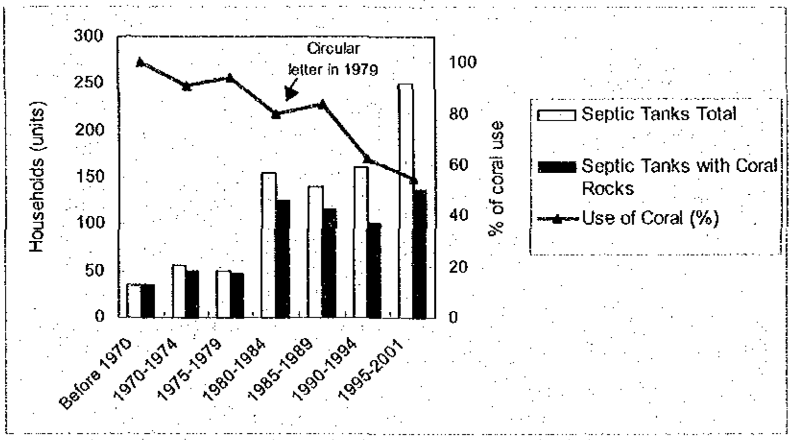
Table 1.9 and Figure 1.9 show the historical trend of the use of septic tanks and those with corals in Manado municipality. It is noted that:

- Until 1979, corals were frequently used (more than 90% of septic tanks);
- There was sharp increase after 1980 in both number of septic tanks and those with corals and reached a peak during 1985 – 1989;
- After 1980, the frequency of use of corals decreased (62.5% in 1995 - 1999); and
- The rates of coral use for septic tanks became lower than before; however, more than 50% of the people still continued to use coral for their toilets.

Table 1.9 Number of Septic Tanks with Corals by Time Period

Year	Septic Tanks		Use of Coral (%)
	Total	with Corals	
Before 1970	35	35	100.0
1970-1974	55	50	90.9
1975-1979	49	46	93.9
1980-1984	155	124	80.0
1985-1989	139	116	83.5
1990-1994	161	100	62.1
After 1994	251	136	54.2
Total	845	607	71.8

Source: Questionnaire survey by the Study Team



Source: Questionnaire survey by the Study Team

Figure 1.9 Number of Septic Tanks with Corals in Individual Toilets

(3) Water pollution by discharged water

There is no off-site treatment plants for human waste and wastewater in Manado and also Bitung Municipalities. Accordingly the used water runs to the following two ways;

- The most of the human waste water is treated by septic tank and infiltrated to the underground or overflow to the drains, and finally the water is carried by surface and underground water into the sea; and
- Wastewater run through drains or rivers into the sea.

The Department of Public Works made "Master Plan for Human Waste and Wastewater for City of Manado" financed IBRD in 1995. The Master Plan proposed to construct treatment facilities the off-site and on-site treatment systems.

- -Off-site system :12.5 % of the built-up area
- (461 inhabitants/ha in 2018)

- -On-site system :87.5 % of the built-up area
  (205 inhabitants/ha in 2018)

The most of the coastal area in Manado are high-density area and thus covered by the area of off-site system. The plan proposed to commence this project from 1996, however the project is not yet started until now. The implementation of the project will be difficult in the near future, if we consider this kind of project has been executed only in part of Jakarta and Bali urban area.

In Bitung municipality, the Lembeh Strait is threatened by the discharged human waste and wastewater from not only residential areas, but also port and industrial areas along the shoreline of the strait. However there is no master plan for the management of human waste and wastewater in the Bitung Municipality. .

Table 1.10 shows the estimation of the amount of consumption of clean water and total Biological Oxygen Demand:BOD generated in 2000 to 2015 in two municipalities.

Table 1.10 Total BOD generated in the municipalities

	year	2000	2005	2010	2015
Manado	Population	366,695	414,910	472,846	534,982
	Consumption of clean water per capita *2)	230 l/day	240 l/day	250 l/day	270 l/day
	Total BOD generated *1)	15.0 tons/day	17.0 tons/day	21.5 tons/day	24.3 tons/day
Bitung	Population	141,306	160,656	182,211	206,156
	Consumption of clean water per capita *2)	230 l/day	240 l/day	250 l/day	270 l/day
	Total BOD generated *1)	5.8 tons/day	6.6 tons/day	8.3 tons/day	9.4 tons/day

Note;
*1) assumption is made based on 45 g/day/capita in 2000 - 2005 and 50 g/day/capita in 2010 – 2015 (according to the criteria used in the Master Plan for Human Waste and Wastewater Disposal for the City of Manado, 1995)
*2) according to the criteria used in the Master Plan for Human Waste and Wastewater Disposal for the City of Manado, 1995 with minor modification by the JICA Study Team.

The existing total BOD generated is calculated as 13.6 tons/day in Manado and 5.8 tons/day in Bitung in 2000, and the BOD in 2015 will be increase to 25.9 tons/day in Manado municipality and 7.6tons/day in Bitung municipality. If the appropriate management system of the wastewater will not carried, the quality of the sea water will be degraded and give serious damage to the coral reefs and other marine life, because BOD causes enrichment of sea water and leads to water pollution.

(4) Solid waste dumping

The problem of solid waste is two. One is that solid waste physically tangled on corals and the other problem is water pollution by wastewater leachate. At the present time, it is commonly seen that solid waste are disposed into rivers and flow into ocean or that solid waste are directly disposed into ocean and some float on the water, some reach to other side of coastal area, or some go under water and tangle on corals. Those solid waste cause destruction of coastal eco-system and also cause unfavorable view of coastal area.

The existing TPA (final deposal site) in Sumompo in Manado is still in operations since 1971 by controlling landfill. However, the site will be fully utilized up to the capacity soon, and due to the other reasons, the Manado Municipality has decided preparing the new TPA site in Teling Atas, with an area of 3 ha. The Bitung Municipality has decided to prepare new TPA (Final Deposit Site) site in Aertembaga, about 10 km from the shoreline, with an area of 7 ha.

There are no responsible organizations for cleaning service in coastal water areas, except harbor water areas, which are to be managed by the port authorities in both municipalities. The cleaning service of beach and river are responsible of the City Cleaning Service Office of the municipalities, and they collect the waste at TPS near the beach and river regularly. However the TPS are installed mostly in the populated areas, and no TPS or very few trash boxes in the coastal and beach areas, such as Boulevard. The solidwaste management in the Bunaken National Park is one of the key issues to be solved. The situation of Bitung municipality is very similar to one in Manado

According to the cleaning service department of the municipality, they collects around half of the generated solid waste in Manado at present. If this collection rate will not change in the future, about 800 m^3/day of the generated waste will be left out of management of municipal service. It also means that the same amount of solid waste as produced in 2000 will potentially become a pollution load to the environment in the year 2015.

Table 1.11 Total Solid waste generated in the municipalities

year	2000	2005	2010	2015
Manado	220 tons/day or 880 m^3/day	270 tons/day or 1,079 m^3/day	331 tons/day or 1,324 m^3/day	401 tons/day or 1,605 m^3/day
Bitung	85 tons/day or 339 m^3/day	104 tons/day or 418 m^3/day	128 tons/day or 510 m^3/day	155 tons/day or 618 m^3/day.

Notes; assumption is made based on 600 g/day/capita in 2000, 650 g in 2005, 700 g in 2010 and 750 g in 2015, and 250 kg = 1 m^3 (according to the criteria used in the Master Plan and Feasibility Study on Wastewater and Solid Waste Management for the City of Ujung Pandang, 1996)

Source; JICA Study Team

Garbage dumping on beaches and shore is noted as a big problem in most of the villages surveyed. According to the survey, 368 respondents out of 493 answered that they dumped garbage on beaches and waterways. In larger cities such as Manado, Bitung, and Likupang, the harbors are full of solid waste and human waste. Those houses built along shore simply dump both liquid and solid waste directly on shore. This practice is generating negative impacts not only on coral reefs but also on living environment, including public health problems. Solid waste dumping is remarkable in Nain community where a large concentration of population in the last 7 to 8 years has been attracted by the seaweed culture business in the area. In the study area, disposal of human waste is so inadequate everywhere that water resource and coastal water are becoming polluted.

However, there are some villages which have better practice in terms of waste dumping. In Motto community, for example, which is located in the northeast tip of Lembeh Island, the Study Team was impressed by how clean the place was, from its beaches and shore to the edge of the village. The community is one of the IDT communities and is physically isolated from other communities. The access to other villages is not easy sometimes due to big waves. Despite its economic condition and isolation in terms of information, the community engages in the clean-up of the village and beach every Friday and people decorate their homes with many flowers.

Many assumptions can be set to explain the differences in terms of cleanliness of villages. However, the most important thing is that social condition is not necessarily parallel to economic condition in villages, and a village can have a clean environment if they work together to attain this.

(5) Collecting ornamental fishes

Ornamental fishing is seen in the south east coast of Minahasa regency in the study area. In a survey of 24 coastal communities, it was found that a small-scale, ornamental fish company run by a family exists in Tumbak. This company collects ornamental fish not only from Tumbak area but also from other coral reef areas nearby. The company collects and sends 2,000 ornamental fishes for each shipment, twice or even sometimes three times a week, to Bali, Jakarta and Surabaya via Makassar. When ornamental fishes are transported, each one of them is put in a small plastic bag with oxygen gas. Ninety percent (90%) of fishes collected are well enough to be transported, and of this percentage about 90%~95% reach their destination in good condition.

According to the survey, this company collects *"Angel Maria"* which is most expensive fish and the price is about Rp.100,000 per fish, *"Angel Piama"* at Rp.500, *Napoleon, letter six.Bangay,* and others. Naturally the company exploits *Angel Maria* " the most.

The problem area of ornamental fishing is the exploitation of fishes and also the destructive way of catching them in coral reefs. In order to collect ornamental fishes, fishermen sometimes break corals or cover corals with fishing net and strike them hard. Although there is no study done yet on the situation of ornamental fishes in the study area, the Study Team sees a great possibility that ornamental fishes would be depleted. Ornamental fishing should be included as one of the coastal resources to be managed by the community.

1.3 Terrestrial Environment

It is important for the management of coral reef and other marine natural resources to understand terrestrial environmental conditions, because human activities on land affect the coast. Especially, the impact of sedimentation of eroded soil on the coral reef would be very critical. In this section, the terrestrial environmental condition related to coral reef management is explained.

1.3.1 Topography

In the study area, although some coastal plains such as Manado area are found, they are generally in small scale. Almost all of the coastal and inner areas facing Sulawesi Sea have hilly or undulated topographic characteristics. In this area, comparatively large rivers such as Tondano River, Ranoiapo River, and Mongondow River run and flow into the Sulawesi Sea.

On the other hand, in the coastal area facing Maluku Sea, from Kema to Pinolosean, steeper slopes toward the shore and very strip plains along the beaches are seen. In this area, many short and small streams are found on the slope.

Inland, highlands and basins are distributed. The highest mountain in the study area is Mt. Klabat (1,990m). High mountains range in the westpart from Tondano Lake and around Mooat Lake. Typical basins are distributed around the Tondano Lake and Kotamobagu. Around the basins, mountains and hills whose altitude is above 1,000m are distributed.

In the study area, there is a small portion of flat area (smaller than 8 %) constituting 14% of the total study area. Steep slope which is more than 8% accounts for 56% of the study area. Charactarisitcs of slope by municipality and regency are almost the same.

Table 1.12 Classification of Slope Conditions

Slope	Manado		Bitung		Minahasa		Bolaang Mongondow		Total (km^2)	
	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%
0 - 3%	113.4	6.8	29.4	9.4	714.3	16.0	234.3	8.2	1,091.3	14.0
3< - 8%	26.4	15.8	87.3	28.0	1,767.0	39.5	450.9	15.8	2,331.6	30.0
8< - 15%	10.9	6.5	96.2	30.8	1,143.2	25.6	762.4	26.8	2,012.7	25.8
15< - 25%	8.5	5.1	71.6	23.0	701.6	15.7	944.5	33.2	1,726.2	22.1
25< - 40%	5.5	3.3	20.3	6.5	122.9	2.7	399.6	14.0	548.3	7.0
40< %	1.9	1.1	7.5	2.4	21.5	0.5	55.7	2.0	86.6	1.1
Total(km^2)	166.7	100	312.2	100	4,470.6	100	2,847.3	100	7,796.8	100

Source : JICA Study Team

1.3.2 Soil

(1) General Condition of the Soil

The characteristics of soils are strongly related to the parent material. Based on the dominance of the parent material formations, the study area can be divided into two parts, northeastern part and southwestern part. The border between them is Amurang-Belang line. In the northeastern part, the parent materials are dominated by newly volcanic rocks and Tondano Tuff. The newly formed volcanic rocks are mainly dominated by lapili and volcanic ash characterized by basalt and andesite, and the Tondano Tuff is characterized by andesite. In the study area, the soils of the northeastern part are generally fertile.

On the southwestern part, from the Amurang-Belang Line to Kotamobagu area, the dominant parent materials are volcanic rock formation mainly dominated by breccia, agromerate and lava characterized by basalt. Compared with the northeastern part, the southwestern soils are generally less fertile, because of its older volcanic origin. Regarding the western part from Kotamobagu, the parent materials gradually become acidic because of decreasing volcanic rock materials, and the soil becomes less fertile.

(2) Description of the Soil Distributed in the Study Area

On the soil map, the soils found in the study area are classified by sub-order level as shown in Figure 1.10. The soils, however, are explained according to a more common order. Based on the USDA Soil Taxonomy, seven soil orders are found in the study area. They are Inceptisols, Entisols, Mollisols, Andsols, Ultisols, Alfisols and Oxisols.

(3) Possibility of Soil Erosion

Occurrence of soil erosion is related to several factors, such as land vegetation cover, topographic condition, rainfall, and soil characteristics. Severe soil erosion generally occurs in areas where the land vegetation cover is low, the slope is steep, and rain intensity and soil permeability are high. Also, the erosion from areas close to coasts may more strongly affect the marine environment. Concerning the sources of soil erosion, two types are considered: one is the point source, such as the road slope erosion, the landslide and riverbank erosion; the other is the non-point source, such as agricultural farm area and forest area.

As a result of the study, it is clarified that there are few point sources which cause severe soil erosion, although attention should be always paid to some activities such as construction projects near coasts.

Concerning the non-point sources, soil loss from agricultural farms and forests is estimated by USLE (Universal Soil Loss Equation), which is authorized by the Department of Forestry and Plantation (Decree of Director General of Reforestation and Land Rehabilitation, No.04/Kpts/V/1998) as a method of soil loss estimation.

a) Estimation of Soil Loss by USLE

USLE is expressed as follows:

$$A = R\ K\ LS\ C\ P$$

Where, A: computed soil loss per unit area per year (tons/ha/year)

R: rainfall and runoff factor

K: soil erodibility factor

LS: topographic factor

C: cover and management factor

P: support practice factor

-R factor:

R factor is estimated based on the data from meteorological stations and rainfall distribution map (Department of Water Resources). The factor in the area is calculated using the Lenvain formula shown below.

$$Rm = 2.21 \times (Rain)^{1.36}$$

Where, Rm: monthly rainfall erosivity

Rain: monthly rainfall in cm

-K factor:

The value of K factor depends on the characteristics of soils. The factor is determined referring to existing soil map, which is Soil Map Sulawesi (1:1,000,000) issued by the Center for Soil and Agro-climate Research (1993).

-LS factor

LS factor is determined by gradient and length of slope. Slope gradient is measured by counting the number of contour lines in each unit on the topographical map of 1:50,000 scale. Slope length is fixed at 40 meters in all cases in this estimation. The formula to calculate the LS factor is shown below.

Slope $<$ 22%

$$LS = \sqrt{(L \times (1.38 + 0.965\, s + 0.138\, s^2)/100)}$$

Where, L: slope length (40 m)

S: steepness (%)

Slope $>$ 22%

$$LS = (L/2.21)^m \times C \times \cos(S)^{1.503} \times (0.5 \times \sin(S)^{1.249} + \sin(S)^{2.249})$$

Where, L: slope length (40 m)

S: steepness (º)

C: 34.7046

m: 0.5

-C factor

C factor is determined in each legend of the map of vegetation and land use, based on the recommended value with some modification from the result of field observation. The recommended value was referred to the Decree of Director General of

Reforestation and Land Rehabilitation, No04/Kpts/V/1998. The value used in this estimation is shown in the table below.

-P factor

P factor is determined for some legend of the map of vegetation and land use, based on the recommendation value with some modification from the result of field observation. The recommended value was referred to the Decree of Director General of Reforestation and Land Rehabilitation, No04/Kpts/V/1998.

The value used in this estimation is shown in the table below.

Table 1.13 Values of C and P Factors

Land Use or Vegetation	C-factor	P-factor
Dense Forest	0.001	1
Open Forest or Shrub Land	0.005	1
Mangrove	0.001	0.4
Coconut Palm, or Mixed Coconut Palm and Tree Crops	0.027	0.5
Mixed Coconut Palm Plantation and Extensive Agricultural Farm	0.04	0.448
Clove Plantation	0.27	0.5
Tree Crops Excluding Coconut Palm and Clove	0.1	0.5
Intensive Dry Agricultural Farm	0.45	0.15
Extensive Agricultural Farm (Forest or Bush Fallow)	0.12	0.8
Extensive Agricultural Farm (Grass Fallow)	0.17	0.15
Open Wet Paddy Field	0.09	0.04
Mixed Wet Paddy Field and Coconut Palm Tree	0.01	0.04
Fish or Shrimp Pond	0.02	0.04
Swamp	0.01	1
Bare Land	0.5	1
Water Body	0.005	1
Settlement and Others	0.18	0.15

Note: The value is determined based on the recommended value in the Decree of Director General of Reforestation and Land Rehabilitation, No04/Kpts/V/1998, with some modification based on the result of field survey.

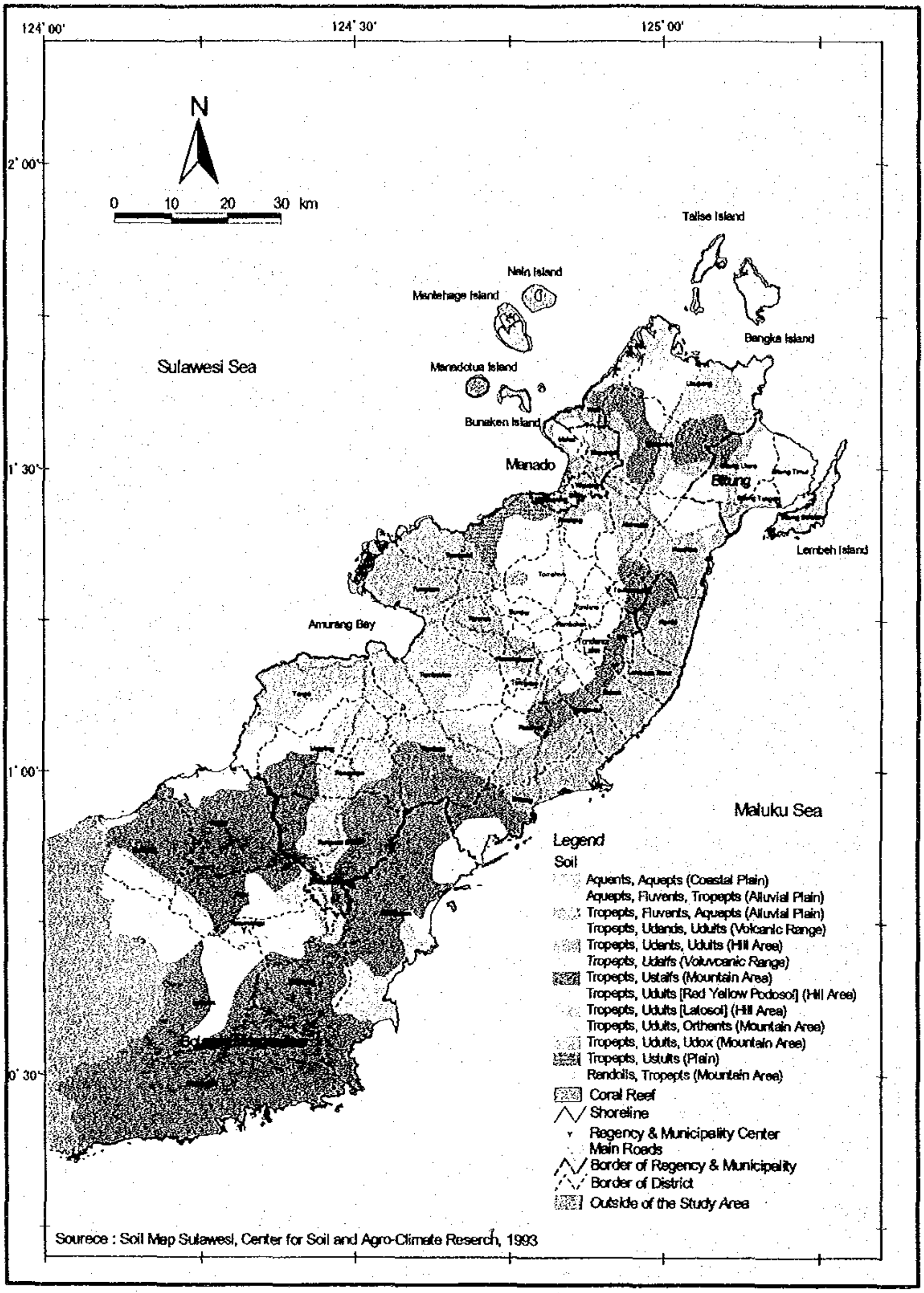


Figure 1.10 Soil Classification

Source : JICA Study Team

b) Result of Soil Loss Estimation

According to the result of estimation of soil erosion shown in Figure 1.11, it is understood that the soil erosion in the middle and lower part of Lomagin River is relatively serious. This is attributed to the Extensive Agricultural Farms (Forest or Bush Fallow) on steep slopes broadly distributed in the areas. The other critical areas are the clove planted land around Tondano Lake, and lands of Extensive Agricultural Farm (Glass Fallow) located between Kema and Bentenan and also between Tanawanko and Inovonto. In these land uses, it is possible that the land cover would decrease depending on the economic condition, as explained also in section 1.3.4.

Usually the clove plantation is found relatively far from the coastal areas. However, as mentioned above, there are Extensive Agricultural Farms found near coasts and on steep slopes. Especially for these land uses, special attention should be paid.

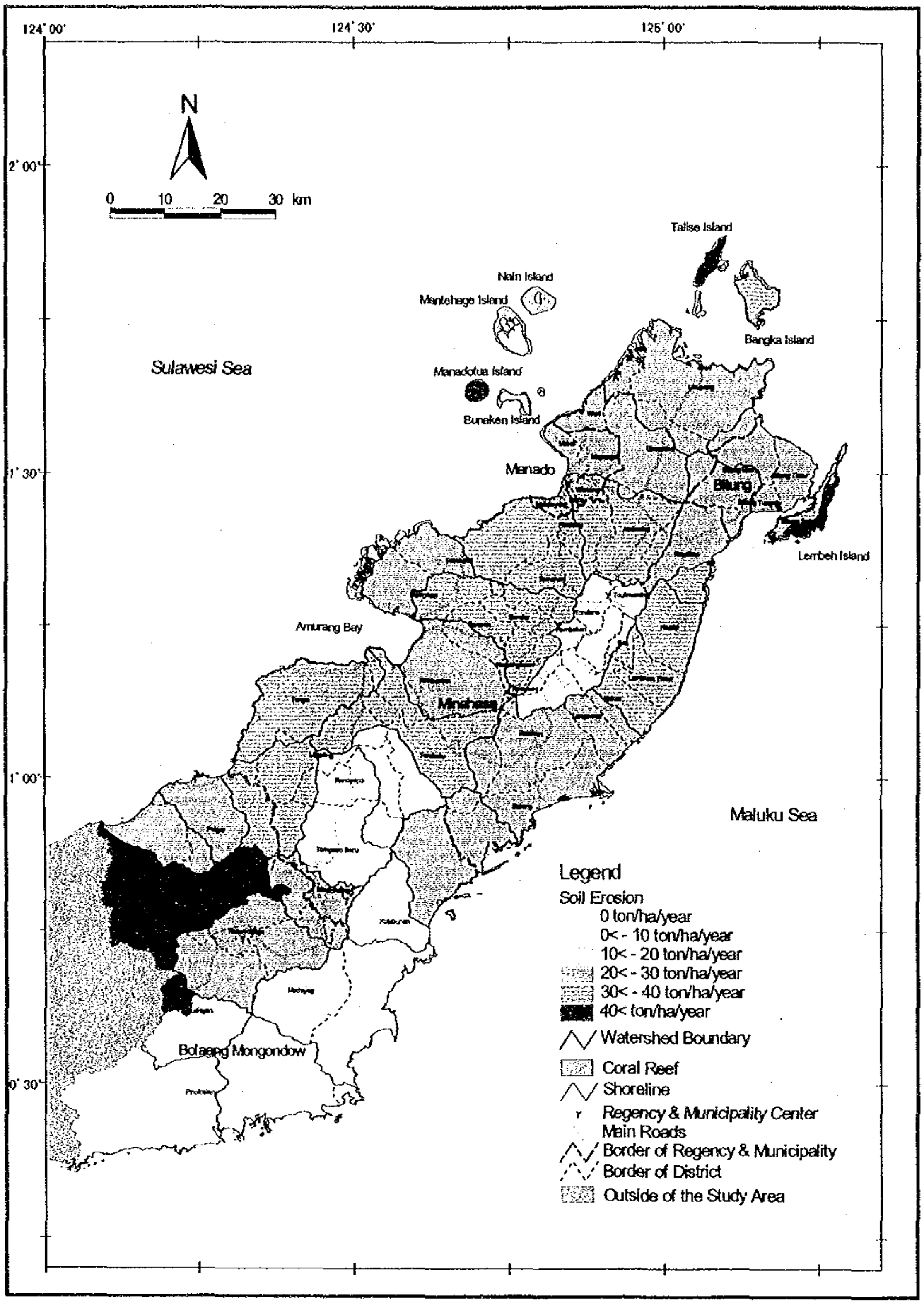


Figure 1.11 Estimated Amount of Soil Erosion in Each Watershed

Source : JICA Study Team

1.3.3 Landscape

The study area can be divided into two parts from the viewpoint of landscape characteristics, namely, the plantation dominant area and the forest dominant area. The border between these two parts is the Tenga - Belang line. In the northeastern part from the border, plantations of coconut and clove are main component of landscape, while in the southwestern part, forest is dominantly distributed (See Figure 1.12).

(1) Northeastern Part of the Study Area

In the northeastern part, plantations of coconut and clove are dominantly distributed, although there are other kinds of land use, such as wet paddy field, upland farm and urban area. The landscape from the high-altitude areas down to lowlands is described next.

High mountains with altitude over 1,500m a.s.l., for example Mt. Klabat (1,990m), Mt. Sopuan (1,809m) and Mt. Lokon (1,579m), dot the area. The higher part of the mountains is usually occupied by natural and dense forest, and plantations of clove and coconut distribute in their middle and lower part.

Highlands with altitude above 400 m a.s.l. are distributed around Tondano Lake. Although a large area of wet paddy fields is adjacent to the north and southwestern coast of the lake and vegetable farms around Tomohon are found, plantations of clove, an adaptable crop in high altitude area, are largely distributed.

In the eastern part from the highland, a belt of steep slope from highland to the coast is found between Kema and Minanga. Clove plantations in the upper part of the slope and the coconut palm plantations in the lower part are distributed. Some alang-alang (*imperata* sp.) grasslands are also found in the lower part of the slope. The other areas of the northeastern part have hilly or undulating topographic characteristics, although some high mountains mentioned above are found. Coconut plantation is dominant there. The plains are distributed in a few areas and in limited scale around Manado and Amurang.

(2) Southwestern Part of the Study Area

The southwestern part has a mountainous characteristic and the area is dominantly covered by forests. Around the Mooat Lake, mountains over 1,500m high are distributed. Those mountains are covered mainly by forests. In the highlands around the Mooat Lake, a large area of vegetable farms is found. The basin of Kotamobagu is an extensive flat area where a large area of wet paddy fields and coffee plantations are distributed.

From the mountainous areas, relatively long rivers, such as Ranoiapo River, Poigar River and Mongondow River, run down to the west coast and flow to the Celebes Sea. There are plains in limited scale along the coast faced to the Celebes Sea, for example, around Inovonto and Poigar. In these areas, the lands are used as wet paddy fields and settlement areas. On the other hand, along the east coast faced to the Molucca Sea, plains are very limited and coconut palm plantations are mainly found.

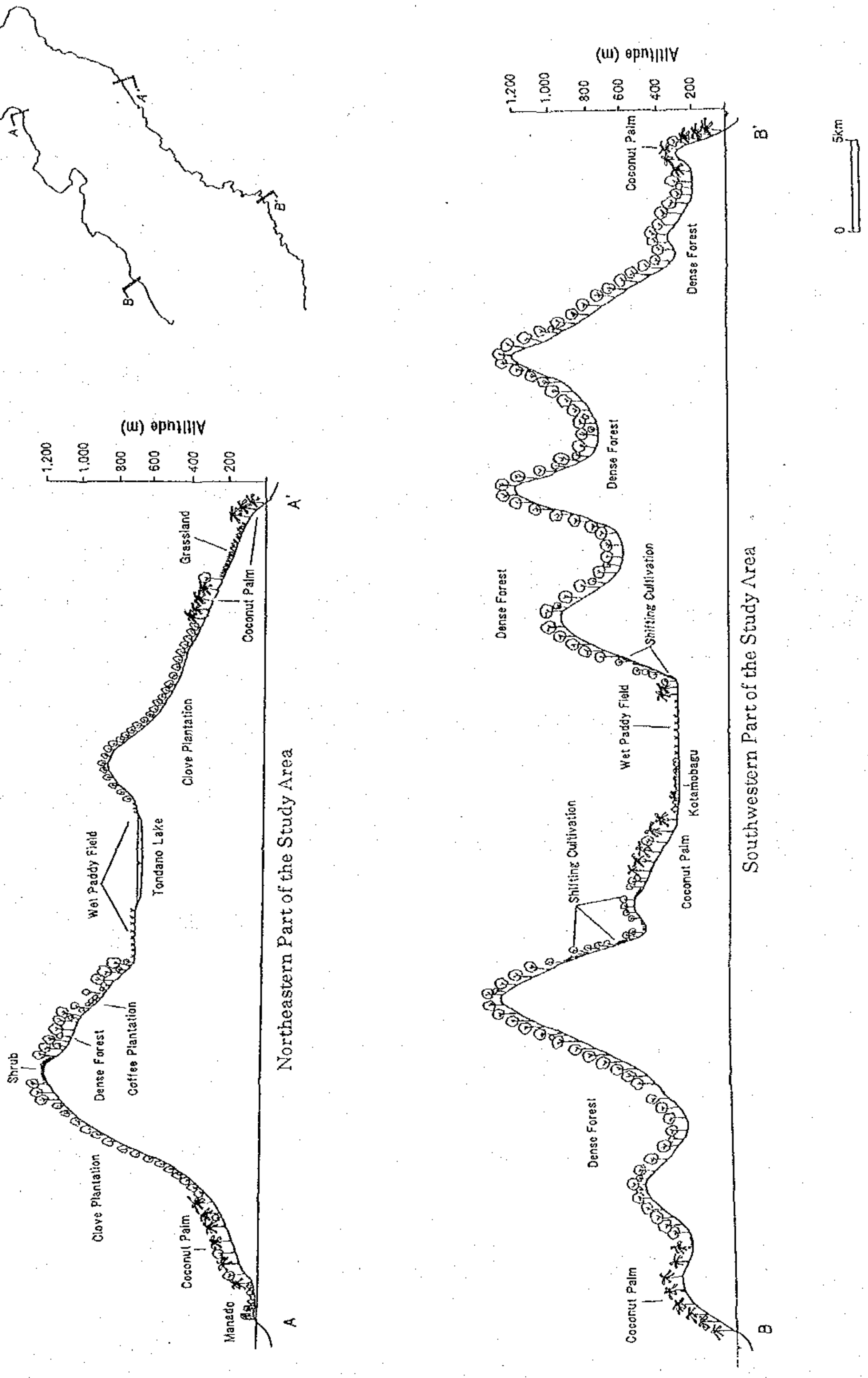


Figure 1.12 Outline of Landscape in the Study Area
Source : JICA Study Team

1.3.4 Land Use

A map of vegetation and land use was prepared in this study, with the method of interpretation of aerial photographs (scale 1:50,000) taken by the Study Team in July and August 2000, and field survey to check the land use and vegetation of unclear areas on aerial photographs.

The classification of vegetation and land use, referring to the existing classifications done by the Land Resources Evaluation and Planning Projects (LREPP: Department of Forestry and Estate Crops), and by the National Land Agency (BPN), was done in this study from the viewpoint of coastal reef management. Especially land cover, which is strongly related to soil erosion, was main criterion for the classification. The vegetation and land uses found in the study area are classified into 17 types as shown in Table 1. 14.

As a result of the study on vegetation and land use, in the study area, dominant vegetation and land use found are "dense forest" and land use with coconut palm, which fall under No. 4 and No. 5. The dense forests (No.1) are distributed in the southwestern part of the study area, while a large area of coconut palm (No. 4 and No. 5) is found in the northeastern part.

Table 1. 14 Classification of Land Use and Vegetation in the Study Area

No.	Legend	Area (km^2)	Ratio (%)
1	Dense Forest	2,399	30.6
2	Open Forest or Shrub Land	44	0.6
3	Mangrove	77	1.0
4	Coconut Palm, or Mixed Coconut Palm and Tree Crops	2,073	26.4
5	Mixed Coconut Palm Plantation and Extensive Agricultural Farm	1,234	15.7
6	Clove Plantation	590	7.5
7	Tree Crops Excluding Coconut Palm and Clove	33	0.4
8	Intensive Dry Agricultural Farm	140	1.8
9	Extensive Agricultural Farm (Forest or Bush Fallow)	335	4.3
10	Extensive Agricultural Farm (Grass Fallow)	212	2.7
11	Open Wet Paddy Field	318	4.1
12	Mixed Wet Paddy Field and Coconut Palm Tree	88	1.1
13	Fish or Shrimp Pond	3	0.0
14	Natural Swamp	3	0.0
15	Bare Land	13	0.2
16	Water Body	58	0.7
17	Settlement and Others	229	2.9

Source : JICA Study Team

Clove Plantation (No. 6) consists mainly of clove trees. The bud of the clove is utilized as spices put to cigarette and food preparation and as some kind of medicine. Almost all plantations are owned by individual farmers as well as urban dwellers. In lowlands whose altitude is less than 400m a.s.l., there are clove trees planted under the coconut palm plantation. In that case, it is classified to No.4 "Coconut Palm and Mixed Coconut Palm and Tree Crops".

During the 1970s and 1980s when the price of clove was good, the production of clove was very high. A lot of new plantations were made possible through the clearing of forests, and for proper management, undergrowth between clove trees was cleared. Because of the low vegetation cover, it is estimated that amount of soil erosion was quite big in that period. After the clove price went down, management of clove plantations did not do so well. In the study year, the undergrowth is vigorously grown in almost all of plantations and severe soil erosion is not observed.

Extensive Agricultural Farm (Forest or Bush Fallow - No. 9), Shifting cultivation with forest or bush fallow is widely seen in the southwestern part of the study area, where a large area of forest exists. A portion of forest fallowed for 3-10 years is cut and burned by local farmers in many case at the starting period of rainy season. After the clearing of forest, the farmers hoe the soil to get rid of weeds, and plant paddy, maize, peanut, etc. The products are utilized for self-consumption and for selling in small scale to towns and urban areas. Since the farming is done on the steep slopes and an area of bare land appears after the hoeing, the amount of eroded soil would drastically increase there.

Extensive Agricultural Farm (Grass Fallow - No. 10), Alang-alang (*imperata* sp.) grasslands are normally seen on the slopes near coastal areas. Especially, larger areas of alang-alang grass are distributed on the slopes adjacent to the east coast (between Kema and Bentenan), the west coast (between Tanawanko and Inovonto), around Rikupang and Pulau Bangka. The local farmers sometimes cut open the grassland using a bush knife and set it to fire, and then they plant maize, peanut and paddy. Although the land is covered by grass, its vegetation cover is normally low and the possibility of soil erosion would be much more higher than if the areas were covered with forest and perennial crop plants.

According to interviews with local people near Kema, the use of the grasslands is related with economic conditions. For example, in 1999 they planted maize broadly preparing farms on a 300-ha grassland, but in the study year only a few farmers cultivated there because of the disappearance of the demand of maize in market. Since the grasslands are generally near to coast and land cover by grass is low, careful attention for soil erosion and its effect to coastal environment should be paid.

There are two types of **Fish or Shrimp Pond** (No. 13). One is constructed in coastal areas, usually back of the mangrove forests. In the ponds owned by usually urban dwellers, *Chanos chanos* (ikan bandong) and shrimp are mainly cultivated for the purpose of selling them to urban markets. In the study area, a few of this kind of pond are seen, and they are dotted around Likupang, Bitung and Belang. The other type of pond is found in inlands, for example Tatelu where water in good quality is abundant. In the ponds, mainly *Cyprinus carpio* (ikan umas) and *Tylapia mussambicus* (ikan mujail) are cultivated by local people.

Some small portions of **Natural Swamp (No. 14)** are seen in coastal areas. It is just mud lands or sometimes covered by some grass on the halomorphic soil. There is generally no human activity in the swamp and it provides habitats for aquatic livings and birds.

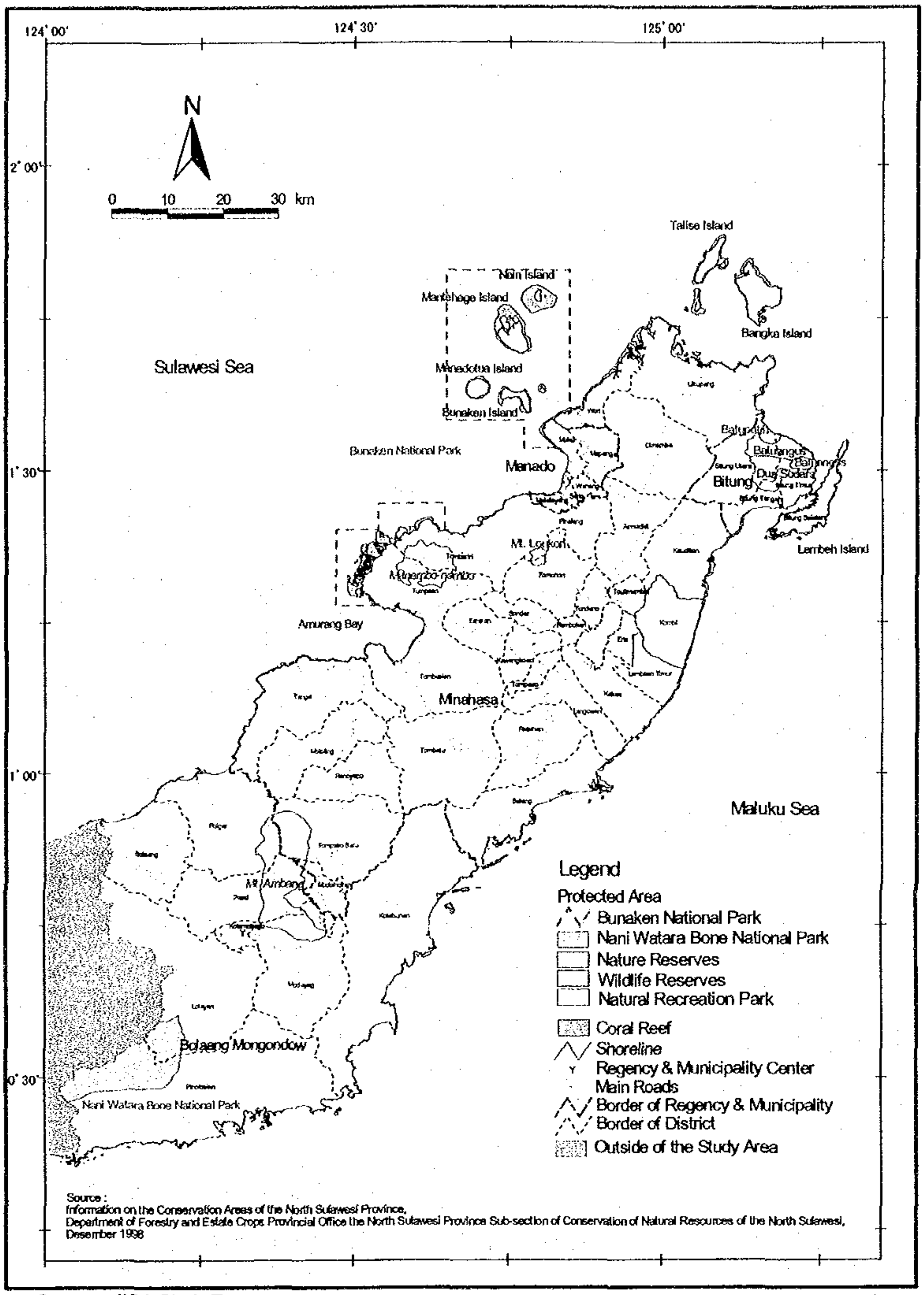
The land use of **Settlement and Others (No. 17)** includes urban areas as well as small villages. The larger areas of this type are urban areas of Manado, Bitung and Kotamobagu. In the Minahasa district, excluding Manado and Bitung, many towns and villages are concentrated around Tondano Lake, where lands are fertile. On the contrary, in Bolaang Mongondow district, the population and number of settlement are relatively small.

1.3.5 Terrestrial Flora and Fauna

(1) General Conditions of Flora and Fauna

Sulawesi is an island where Asian and Australasian floral and faunal components were mixed more than two million years ago. Since then, the island has been totally isolated from the main land. The isolation has created a lot of unique flora and fauna characterized by high proportion of endemic species. Almost all of those flora and fauna live in the natural forests whose distributions are explained in sections 1.3.3 and 1.3.4. The natural forest in the study area consists of 3 or 4 layers of crown vertically. The highest layer sometimes reaches more than 20 m tall, and the typical tree species in lowland forests are *Livistona* spp., *Nephelium* spp., and *Sandoricum* spp, although the diversity of the tree species is quite high.

A large area of the natural forests is now designated as protected forests, national parks, nature reserves, hunting parks, and recreation parks. The purpose of each protected area follows: natural park for nature preservation, scientific study, education, tourism and recreation use; nature reserve for preservation for valuable wildlife and ecosystems; hunting park for hunting game; recreation park for nature tourism and recreation use; and protected forest for conservation of water catchment area and control of soil erosion and flooding. However, some protected areas are already disturbed. For example, in the study area, there are 24 protected forests with the total area of 105,793 ha, while 31,273 ha of the total area are in bad condition, becoming shrubs and man-made mixed gardens. The distribution of the protected areas located near coasts is shown in Figure 1.13.



Source : JICA Study Team

Figure 1.13 Protected Area

(2) Flora

In Sulawesi Island, approximately 5,000 plant species have been found, and North Sulawesi is recognized as an area with richer flora existence, although there are a few forest areas in Minahasa district. One of the factors of its richness is geo-historical background as explained above, while the complex topographic condition is also an important factor. In the study area, there are several kinds of habitat depending on the altitude. In the mountain forests, where temperature is relatively low, and on the contrary, humidity is relatively high; the number of tree and creeper species is relatively small, but that of moss and lichen is many. In the lowland forests, the species of higher tree, such as *Diospyros* spp. and *Terminalia* spp. and large climbers increase. In the lower areas, the mangrove forests explained in section 1.2.7 are distributed.

(3) Fauna

A total of 515 mammal species are found in Indonesia, while 127 species (25%) of them can be found in Sulawesi, and 79 species (62 %) are endemic species. In the study area, Tangkoko-Batuangus Nature Reserve and Dua-Sudara Wildlife Reserve are areas where almost all of macro fauna living in North Sulawesi can be found. In the reserves, the threatened species, such as *Macaca nigra*, *Bubalus depressicornis*, *Phalanger ursinus*, *P. celebensis*, *Macrocephalon maleo*, *Macrogalidia musschenbroekii*, *Cynopterus blackyotis*, *S. celebensis* and *Varanus salvator* are observed.

In the coastal areas with mudflats, the bio-productivity there is generally high. The areas provide a favorable habitat for aquatic animals, such as shorebirds. However, in the study area, since there are few large mudflats, the small number of shorebirds, such as broad-billed sandpiper (*Limicola falcinellus*) and gray-tailed tattler (*Tringa breviceps*), are found in the limited areas of mudflat.

1.3.6 Terrestrial Endangered Species

The conditions of the world's threatened species are monitored by the International Union for the Conservation of Nature and Natural Resources (IUCN), which prepare an IUCN Red List. The categories of threatened species are: Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN) and Vulnerable (VU). Rare or endemic species fall into Vulnerable species (VU).

Since Indonesia signed the CITES Convention in 1975, the country has continued trying to protect the threatened flora and fauna within all its ecosystem. For a detailed list of currently protected flora and fauna, reference can be made to the attachment of Government Regulation, No: 7/1999, dated 27 January 1999. In the study area, several endangered species, such as *Anoa depressicornis* (EN), *Anoa quarlesi* (EN), *Babyrousa babyrussa* (V), *Macrogalidia musschenbroeki* (R), *Macrocephalon maleo* (V), *Nectariniidae* (Pr), *Phalanger* spp. (R), *Livistona* spp. (Pr), *Pigafatta filaris* (Pr), *Nephentes spp.* (Pr) and *Vanda celebica* (R) are found, in the nature and wildlife reserves and in the forests distributed in the southwestern part of the study area.

1.3.7 Terrestrial Natural Disasters

The types of natural disasters which may cause some effects on the coral reef in the study area are considered to be floods, coastal erosions, coastal sedimentations and volcanic eruptions.

Floods sometimes occur in the study area. The affected areas are 6,794 ha in Manado municipality, 1,003 ha in Minahasa district, and 6,794 ha in Bolaang Mongondow district (CIDA 1999, North Sulawesi Water Management Plan). The coastal erosion may affect the living environment of coastal villages, as well as the ecosystem of coastlines. In the study area, the coastal erosion is reported in Kapitu, Borgo, Arakan, Wawontulap, Amurang, Kema, Likupang and Bitung (CIDA 1999, North Sulawesi Water Management Plan). If eroded soil from coasts and inlands accumulated in estuaries, it might cause flooding in the areas near river mouth, and may affect the coral reef ecosystem. In the study area, although relatively large areas of load sedimentation are observed near Kotabuan, severe sedimentation that may cause a disaster is not seen. Sometimes the lava and ash from volcanic eruption affect coral reef. In the study area, around 14 active volcanoes including a submarine volcano can be found. Evidence of the influence of lava on coral reef can be recognized in Bata Agus mountain. Today, traces of lava which flowed into the sea and affected coral reef are found.

Table 1.15 below gives a record of disasters that had occurred in the study area.

Table 1.15 Record of Natural Disaster in the Study Area

Name of Station / Disaster	Manado	Minahasa South	Kotamobagu
Flood	**- 4 January 1996** in and around Sario, Volume of rainfall : 174.2 mm **- 29 Nopember 2000** in Central Manado, Volume of rainfall : 116.0 mm	**- 29 Nopember 2000** in Motoling sub-district and Amurang District. Intensities of rainfall above normal.	No record
Strong Wind	**- 18 Juni 1993** Strong wind (gale) in Tondano Area, V: 34-40 Knot. **- 21 November 1998** Strong wind squall in Manado Area, V : 30-34 Knot **- 4 Desember 1998** Light noisy wind (near gale) in Tomohon and around, V : 28-33 knot **- 28 Juli 1999** Strong gale in Winangun (Manado) Area, V = 40-50 knot **- 7 Nopember 1999** Near gale in Manado Area V : 25-30 Knot **- 12 Nopember 1999** Near gale in Manado Area, V : 25-30 Knot **- 30 Nopember 2000 and 01 Desember 2000** Strong gale in Tumumpa (Manado) Area, V : 41-47 knot **- 3 Desember 2000** *Gale in Tondano Area, V : 40 Knot.*	No record	No record
Earthquake	**- 13 December 1858** Damage in Manado, Tikala **- 14 May 1932** Epi: 0.5 N – 126.0 E, M 8.3 RS 592 shattered houses, 115 people injured, 6 people dead. Affected were Langowan, Tondano, Waluyama, Remboken, Koya, Likupang, and all along the coast between Amurang and Tumpaan were landslides in steep slope. **- 22 February 1980** Epi : 1.5 N-124.65 E, M:5.6 RS, H : 33 Km Several buildings and houses cracked **- 17 Augustus 1988** *Epi : 1.56 N – 124.78 E, M =4.9 RS, H :36.2 Km.* Felt in Manado VII-VIII, Reported multistoried buildings along 17 Augustus road cracked such as Regional Office of Directorate General of Tax, Provincial Development Planning Board, Regional Office of Religion, Finance Investigator Body Office, Central Post Office, Military Court, Bersehati Market etc.	**- 13 December 1858** **- 14 May 1932** Epi : 0.5 N – 126.00 E Reported 115 people injured, 5 people dead, 592 collapsed houses **- 11 June 1992** Epi : 1.10 N – 124.10 E M: 5.8 RS, H: 50 km There were cracked buildings, a part of ground was rent. Reported in Tanamon village were thundering and ground rent, 43 buildings were heavily damaged and 460 houses had moderate and light damage	**- 11 June 1992** Epi : 1.10 N – 124.10 E M : 5.8 RS Depth of 50 km. There were cracked buildings
Volcanic Activity	No record	**Soputan Mountain** **- 14 Januari 1996.** Ashfall and thundering **- 13 Mei 2000** Heavy black fog erupted, High 1 km above the top. **- 14 Agustus 2000** *Heavy fog erupted High* 2.5 km above the top.	No record

Source : Badan Meteorologi dan Geofisica - Balai Wilayah IV - Stasiun Geofisika Manado, Maret 2001

Note : Epi = Epicenter, N = North Latitude, E = East Longitude, M = Magnitude, RS = Richter Scale, H = Depth, V = Velocity

1.3.8 Environmental Impacts Caused by Land Based Activities

The impact of sedimentation of eroded soils on the coral reef is very critical for the reef's survival. From the viewpoint of terrestrial environment, soil erosion is an important factor in the preparation of a proper coral reef management plan.

The study area is characteristically mountainous, and the distance from some inlands to shores is generally short. Throughout the whole study area, land cover by plants is generally moderate or high, although some areas have low plant cover. In the northeastern part of the study area, land use with coconut palm or clove is dominant with moderate land cover, while in the southwestern part, dense forests are largely distributed with high vegetation cover. If soil erosion occurs, topographically the eroded soil runs down rapidly and flows into seas directly; therefore, proper management of land use to control soil erosion is very important. Critical areas showing evidence of serious soil erosion, such as areas of large landslide and incidence of riverbank erosion of a large scale, could not be found in the study area.

However, several high potential areas for soil erosion, because of their steepness and low land cover, are observed. In those areas, serious soil erosion may occur, such as in the extensive agriculture farm in alang-alang grasslands, which has low grass vegetation cover and uses an extensive method of farming. Also, usually the alang-alang grasslands are located on the steep slopes and near coasts. The eroded soil may run off on the slope and directly flow into the seas in a relatively short period of time. Map 4 shows the estimated amount of soil erosion in each watershed.

Some considerations for land use management in the critical areas for soil erosion, such as in the extensive agricultural farms in alang-alang grasslands, are deemed necessary.