社会開発調査部報告書

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JAPAN INTERNATIONAL COOPERATION AGENCY

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

MINISTRY OF PUBLIC WORKS, THE REPUBLIC OF INDONESIA

THE STUDY ON FLOOD CONTROL FOR AMBON AND PASAHARI AREA IN THE REPUBLIC OF INDONESIA

FINAL REPORT

SUPPORTING REPORT

NOVEMBER 1977

YACHIYO ENGINEERING CO., LTD.

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Exchange Rate

Master Plan and Conceptual Plan :
1US$=¥115=Rp.2,300 (as of November 1, 1996)

Priority Project :
1US$=¥120=Rp.2,928 (as of September 1, 1997)

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SOCIO-ECONOMY AND LAND USE

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IN THE REPUBLIC OF INDONESIA
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CHAPTER 1 SOCIO-ECONOMY

1.1 Current Economic Conditions

1.1.1 General Economic Trend

Ambon City is the capital and the trade center of Maluku Province, accounting for 11% of the total provincial population and 25% of the provincial Gross Domestic Product (GDP) in 1994. Ambon City is dominant in the telecommunications sector (61%), water & electricity sectors (57%), transportation sector (54%), financial sector (50%), and in governmental services (47%), while the share in agricultural (16%) and manufacturing and mining (11%) sectors is relatively low. The annual growth rates of regional GDP for Maluku Province and Ambon City from 1983 to 1994 were 7.6% and 7.5% in real terms, respectively. The growth of the regional GDP of Maluku Province and Ambon City is shown in Figure-A.1.1 and the breakdown of GDP of Ambon City is given in Table-A.1.1.

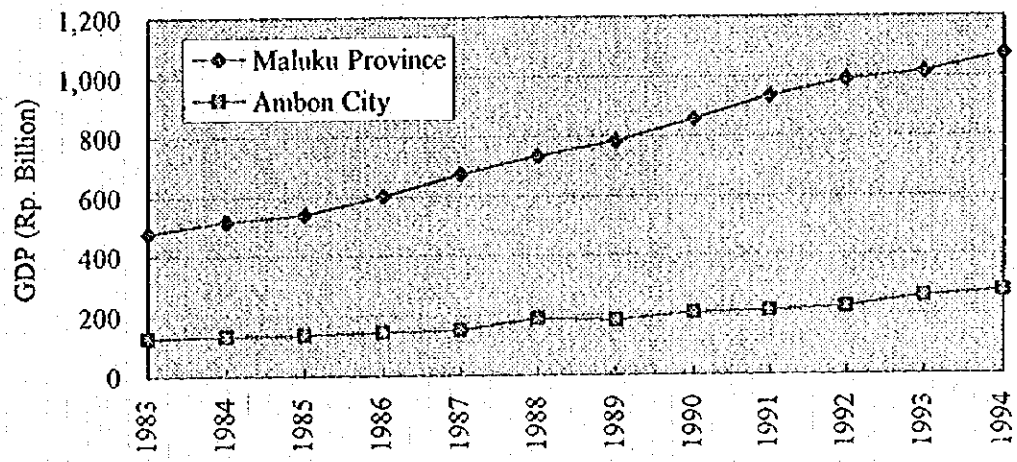


Figure-A.1.1 Growth of Regional GDP at 1983 constant prices

Table-A.1.1 Breakdown of GDP, Ambon City (1994)

Sector	Share
Trade and Non-Government Services	22%
Government Services	18%
Agriculture	17%
Transportation	12%
Financial Services & Leasing	11%
Manufacture & Mining	10%
Construction	5%
Telecommunications, Water & Electricity	4%
Hotel & Restaurant	2%

Processed from : Pendapatan Regional Kabupaten Dan Kotamadya Provinsi Maluku 94, Bappeda and BPS, Maluku Province

Average income per capita in Maluku Province and Ambon City is around Rp. 1.1 million. Since each household has five to six family members, average household income is estimated to be around Rp. 5 million to 7 million.

Ambon residents work mostly in governmental and non-governmental services, retail, hotel/restaurant and transportation; around 80% of all workers fall into these sectors. Table-A.1.2 describes by category the occupations of the residents of Maluku Province and Ambon City.

Table-A.1.2 Occupations of Inhabitants (1994)

Category of Occupation	Maluku Province		Ambon City	
	Number of workers	(Share)	Number of workers	(Share)
Agriculture	450,535	(61.6%)	4,913	(6.0%)
Mining	5,109	(0.7%)	892	(1.1%)
Manufacturing	33,939	(4.6%)	4,576	(5.6%)
Electricity, Gas, Water	1,771	(0.2%)	614	(0.8%)
Construction	15,536	(2.1%)	5,539	(6.8%)
Trade, Hotel, Restaurant	84,609	(11.6%)	21,665	(26.4%)
Transportation	17,344	(2.4%)	6,317	(7.7%)
Financial	1,405	(0.2%)	2,402	(3.0%)
Services	121,413	(16.1%)	35,094	(42.8%)
Total	731,661	(100%)	82,012	(100%)

Source: Kotamadya Ambon Dalam Angka 1994, & Maluku Dalam Angka 1995

1.1.2 Agriculture and Fishery

Agricultural activities are carried out on 9% of the total land in Ambon City. The major food crops produced are: cassava, sweet potatoes, corn, cabbage, spinach, peas, cucumbers, eggplant, and tomatoes. Spices such as red onions and chili are also produced. There are no rice fields or irrigated lands in Ambon City. The major tree crops are: coconut, cloves, and sago palms. Ambon Island has abundant fishery resources. One can easily catch fish close to the coast, even without a motorboat. There are around 5,000 fishermen in Ambon City, many of whom hold multiple jobs in areas such as farming or retail.

1.1.3 Manufacturing

Manufacturing represents only 10% of the Ambon City's GDP. It is difficult to fully evaluate the state of industry in Ambon City since industry data are scattered among divisions within the Ministry of Trade and Industry and are also contradictory. Table-A.1.3 shows the recapitulative figures collected from several divisions. ("large manufacturer" represents companies with more than Rp. 500 million investment.)

Table-A.1.3 Manufacturing in Ambon City

Manufacture Scale	Number of Plants	Total Number of Workers	Total Value of Production (Rp.)	Total Value of Investment (Rp.)
Large Manufacturer	28	2,762	35,943 million	N.A.
Medium Manufacturer	78	4,406	N.A.	122,295 million
Small Manufacturer	1,102	4,598	7,542 million	6,037 million

There are apparently significant double-counts in the number of plants and workers, while quite a few plants which have seemingly closed are included. Temporary workers are employed in most of the small plants. The average value of production of the small manufacturing plants (mainly home industry) is Rp. 7 million and their average investment, most of which is in inventory, is Rp. 6 million.

1.1.4 Retail and Services

Most of the retail services in Ambon City are small shops; many of them apparently belong to the informal sector, operating in temporary facilities or in houses. Medium- to large-sized retail shops are found only in the Central City. Since Ambon City is the capital of Maluku Province, 47% of governmental services in the province is concentrated in Ambon City.

1.2 Current Social Conditions

1.2.1 Population

According to the population register of Ambon City, there has only been a 0.8% increase per year in population from 1990 to 1994. This figure seems unrealistically small compared to the overall population growth in Indonesia, which is currently estimated at 1.9% per year.

According to the census in October 1990, the population of Ambon City was 275,888. The recent census conducted by the Statistics Office of Ambon City shows that the population in June 1996 was 304,334. If these figures are used, the average annual increase in population in Ambon City is 1.7%. The population of Ambon City increased 4.5% per year from 1971 to 1980 and 2.9% per year from 1980 to 1990.

Table-A.1.4 Population Growth in Ambon City, 1971-1996

Year	1961	1971	1980	Oct. 1990	Jun. 1996	Dec. 1996*
Population	99,142	139,704	207,702	275,888	304,334	305,252
Population Growth Rate per year	-	3.5 %	4.5 %	2.9 %	1.7 %	1.7 %

Source: Ambon City Statistics
* Estimation by JICA Study Team

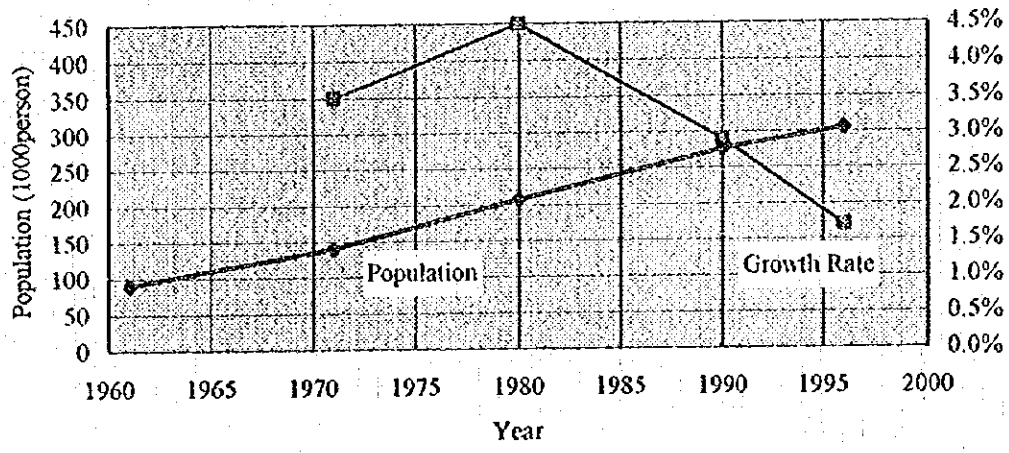


Figure-A.1.2 Population Growth in Ambon City

The Study Area includes 20 Desa/Kelurahan, which are expected to be more or less influenced by the project. The Central City includes Honipopu, Ahusen, Batu Gajah, Uritetu, Batu Meja, Rijali, Karang Panjang, Amantelu, Pandan Kasturi, Batu Merah, Hative Kecil (Kecamatan Sirimau), Silale, Urimessing, Wainitu, Kudamati, Waihaong, Manggadua (Kecamatan Nusaniwe), and the Upstream Area includes Soya, Hatalai (Kecamatan Sirimau) and Urimessing (Kecamatan Nusaniwe). Table-A.5 shows the population, size and population density of the above Desa/Kelurahan as of June 1996, and Figure-A.1.3 shows the administrative division of the Central City. The population of the Study Area is about 160,000: 149,000 in Central City and 11,000 in the upstream area. The population density in the Central City, excluding Batu Merah, is 105 persons/ha, while it is only 1.1 person/ha in the upstream area.

Table-A.1.5 Population, Area and Population Density (June 1996)

Desa/ Kelurahan	Population (person)	Area (ha)	Population Density (person/ha)
Central City Area			
Honipopu	6,579	34.2	192
Ahusen	5,080	23.5	216
Batu Gajah	6,269	44.7	140
Uritetu	5,934	35.4	168
Batu Meja	10,473	84.8	124
Rijali	5,828	27.6	211
Karang Panjang	6,353	43.4	146
Amantelu	8,009	115.3	69
Pandan Kasturi	8,193	400	20
Batu Merah	29,671	1,667	18
Hative Kecil	12,568	153	82
Silale	3,780	18	210
Urimessing	4,353	26.9	162
Wainitu	12,541	29.8	421
Kudamati	13,872	66.5	209
Waihaong	5,472	15	365
Manggadua	3,858	18.4	210
Central City Total	148,833	2,804	53
Central City excluding Batu Merah	119,162	1,137	105
Upstream Area			
Soya	5,257	5,965	0.9
Hatalai	840	500	1.7
Urimessing	5,549	4,616	1.2
Upstream Area Total	11,646	11,081	1.1

Source: Ambon City Statistics, June 1996 Census

1.2.2 Religion

One of the characteristics of Ambon City is that the Christian population is larger than the Muslim population - 59% versus 41%. There are also a small number of Buddhists and Hindus. According to the June 1996 census, there are 114 mosques and 130 churches in Ambon City, of which 45 mosques and 52 churches are located in the Central City. People of each religion are generally tolerant of one another, and therefore, very few religious conflicts have occurred in Ambon City.

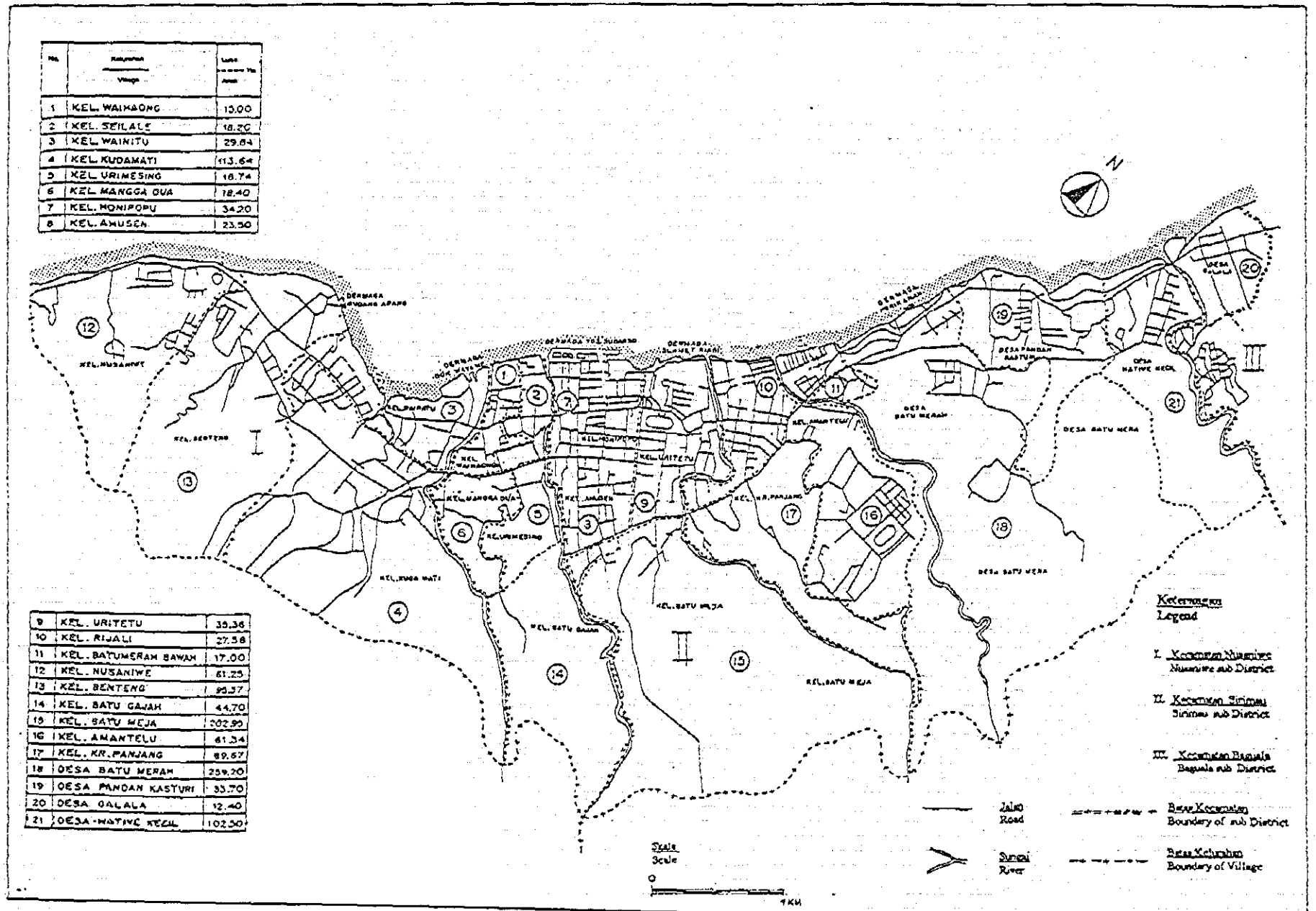


Figure-A.1.3 Administrative Division of Ambon Central City

1.2.3 Education

The status of education in Ambon City is relatively good: the illiteracy rate is reported to be only 3%. According to the June 1996 census, there are 63 kindergartens, 185 elementary schools, 38 junior high schools, 32 senior high schools and 5 colleges/universities. The number of students per teacher is 17 for elementary schools, 14 for junior high schools and 13 for senior high schools.

1.3 Projection of Future Socio-economic Conditions

1.3.1 Population Projection

As was discussed in Section 1.2.1, the study estimated current population increase at 1.7% per year in Ambon City. Based on the expectations that rapid expansion of commercial activities will not occur due to Ambon City's limited land availability and that the City will, nevertheless, continue in its role as the commercial center of Maluku Province, the study team applies the same rate, 1.7%, as future annual population increase rate in Ambon City. Table-A.6 shows the projected future population in Ambon City.

Table-A.1.6 Population Projection in Ambon City

Year	1990	1996	2000	2005	2010	2015	2020	2025	2030
Population	275,888	305,252	326,544	355,261	386,502	420,490	457,469	497,698	541,466

Source: JICA Study Team

It is envisaged that Ambon City's commercial district will expand into the residential area, while the population will continue to spread to the outer areas of the Central City, along Ambon Bay. The future population increase in the Central City is estimated to be 0.5% per year, which will only be attained by vertical development of land. The population increase in the upstream area is estimated to be the same as that of Ambon City, namely 1.7 %. The Table-A.1.7 shows the future population in the Central City and Upstream Area and Figure-A.4 shows the projected population growth in Ambon City and the Study Area.

Table-A.1.7 Population Projection in the Study Area

Year	1996	2000	2005	2010	2015	2020	2025	2030
Central City	149.205	152.212	156.055	159.996	164.036	168.178	172.425	176.779
Upstream Area	11.646	12.458	13.554	14.746	16.043	17.453	18.988	20.658
Study Area	160.851	164.670	169.609	174.742	180.078	185.631	191.413	197.437

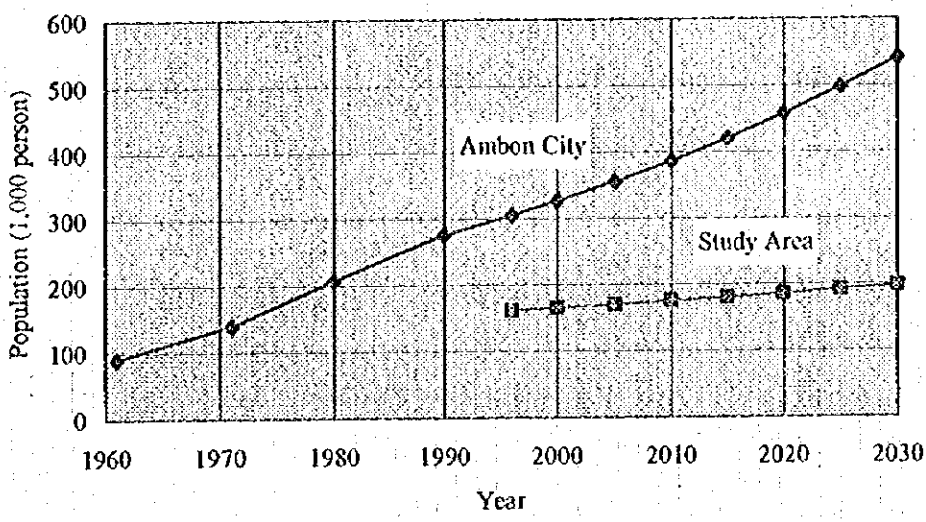


Figure-A.1.4 Population Projection in Ambon City and the Study Area

1.3.2 GDP Projection

The growth rate of Ambon City's GDP per capita averaged 4.4% per year from 1983 to 1994. However, due to statistical errors rather than business cycles, the observed GDP per capita fluctuated significantly. Table-A.1.8 shows the annual growth rate of the City's GDP per capita, based on its own statistics. The growth rate of Ambon City's GDP per capita was 4.4% per year in 1983-1994, 5.5% in 1983-1988, 3.4% in 1988-1994, and 5.7% in 1990-94.

Table-A.1.8 Annual Growth Rate of Ambon City's per capita GDP

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Growth Rate(%)	2.3	0.7	3.0	1.1	22.0	-7.0	5.3	1.2	4.0	13.1	5.0

Source : Ambon City Statistics Office

Based on the trend over the last ten years, the study team applied a rate of 4.5% to determine future annual increase in per capita GDP in Ambon City. As a result, the real GDP increase becomes 6.3% per year since the population increase is forecast at 1.7% per year. Table-A.1.9 shows the estimated growth in GDP at 1996 prices and per capita GDP of Ambon City, based on the above assumption.

Table-A.1.9 Future GDP and per capita GDP of Ambon City at 1996 prices

Year	1996	2000	2005	2010	2015	2020	2025	2030
GDP (Rp. million)	904,595	1,155,014	1,567,666	2,127,746	2,887,920	3,919,096	5,320,007	7,220,705
Per capita GDP (Rp. thousand)	2,963	3,537	4,413	5,505	6,868	8,568	10,689	13,336

Source: JICA Study Team

CHAPTER 2 LAND USE

2.1. Current Land Use in the Study Area

The catchment area of the five rivers can be divided into two areas by their land use characteristics. Three Desa, Soya, Hatalai and Urimessing, are located in the hilly area, upstream of the five rivers. The land of these three Desa is mostly covered with bushes and grass although cropping trees and small cultivated farmland are also observed. The 17 Desa / Kelurahan mentioned in Section 1.2.1 are located in the Central City and are directly or indirectly influenced by the project.

The Central City covers most of the urban area in Ambon City. Around 150,000 people live in this area, accounting for about half of the total Ambon City population, although the area covers only 7.8 % of the total city area. Table-A.2.1 describes the overall land use situation of Ambon City, the Central City, and the upstream area.

Table-A.2.1 Land Use Situation

Land Use Type	Ambon City (50 Desa / Kelurahan)	Central City (17 Desa / Kelerahan)	Upstream Area (3 Desa)
Agricultural Use	43%	4%	53%
- Tree Crop	8%	2%	5%
- Food Crop	33%	1%	40%
- Forest	3%	1%	8%
Non-Agricultural Use	37%	96%	8%
- Residential Area	16%	92%	7%
- Industry, Office, Shop, etc	1%	2%	0%
Un-used Land	40%	3%	40%
Total Size of Land	35,945 ha	2,803 ha	11,081 ha

Processed from 1996 Census, Ambon City Statistics Office

Although 92% of the land is classified as residential area in the Central City for statistical purposes, the residential area also includes unpopulated hillsides, where grass and bushes predominate because the steep land does not allow for construction of houses.

According to the "Current Land Use", Figure-A.2.1, prepared by BPN (National Land Agency), residential areas are found along the Ambon Bay and the five rivers. Although there are small forest areas in the upstream of Merah, Gajah and Gantung rivers, mixed garden and grass and bush areas predominate most of the upstream area of the five rivers.

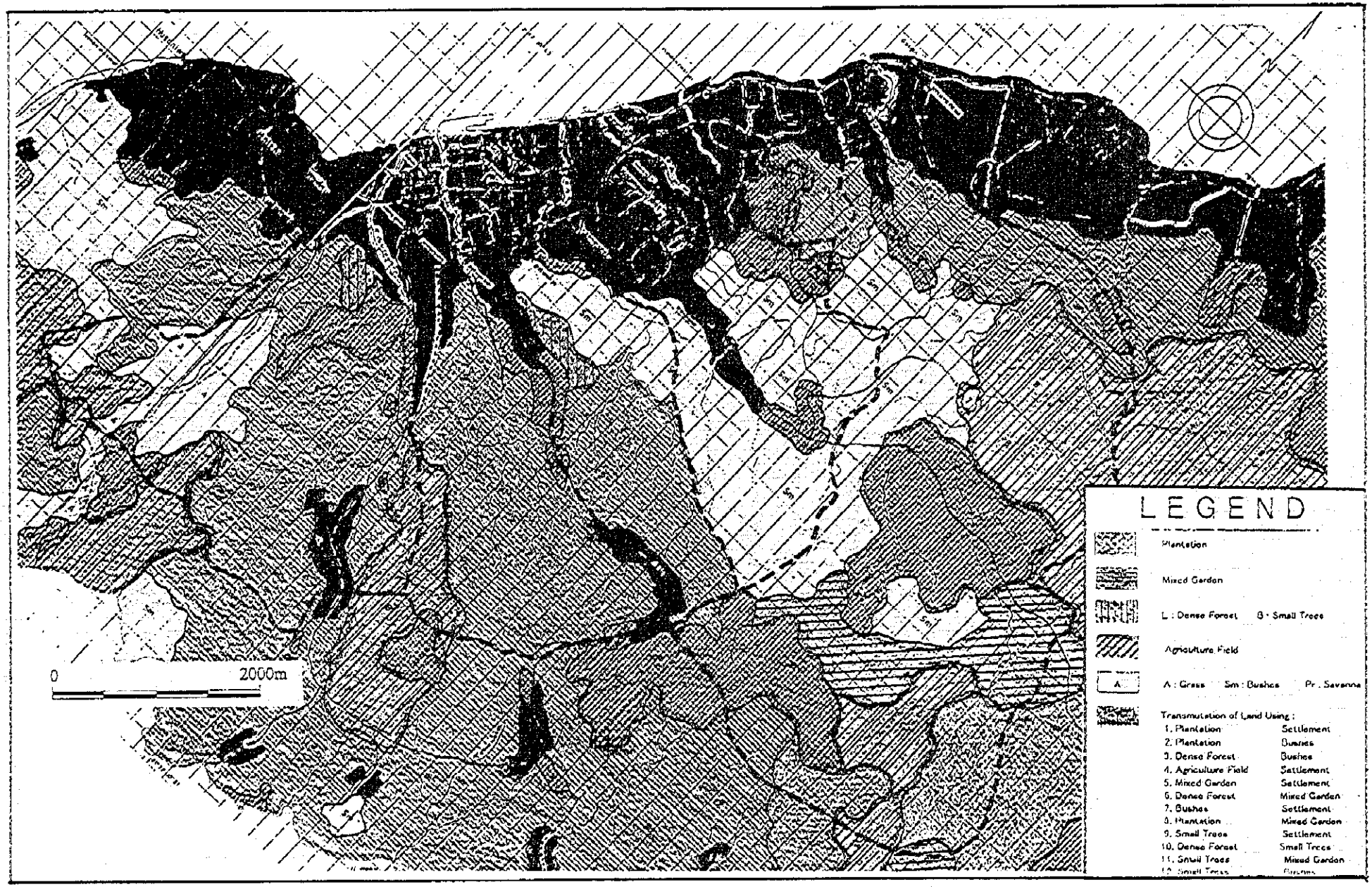


Figure-A.2.1 Current Land Use
Source : BPN (National Land Agency)

2.2 Future Land Use

2.2.1 Future Land Use and Restrictions

As mentioned in Section 1.3, it is estimated that Ambon City will attain a 1.7% increase in population and a 6.3% increase in regional GDP every year. Considering that Ambon City is the biggest trade center in Maluku Province and that there is not enough land in the Central City for future industrial growth, land in the Central City will continue being used primarily for housing and commercial activities, as the "Land Use Year 2005", Figure-A2.2, prepared by BAPPEDA, shows. Since the population has saturated the Central City, especially along the five rivers, it will continue spreading mainly outside the Central City along the Ambon Bay.

Since there are currently no substantive regulations to restrict land use and BAPPEDA does not have enough financial or human resources to control or direct land use, the real land use has already diverged from the "Land Use Year 2005". Moreover, the Indonesian Government does not have laws or regulations on land rehabilitation and soil conservation: it has only technical guidelines in the provincial level. Since these guidelines do not have a legal basis, their enforcement is quite limited, especially on private land. As a result, several new settlements have already been established by excavating land inside the forest area where careful soil conservation is needed to avoid land slide and increase water retention.

AMDAL regulations are applicable only when the development site is more than 100 ha. The project has to go through RKL and RPL when the site is between 25 to 100 ha, and for the project with its site less than 25 ha, environmental impact is examined only by the authorities directly concerned with the project. The involvement of the Forest Department is not always requested except for AMDAL.

2.2.2 Land Use Guidelines

The Forest Department in Ambon City established a field technical plan in 1989, in which the entire land in the city was classified into nine categories in terms of soil conservation measures (Figure-A.2.3). The following is a summary of measures to be applied to each category.

a. Hillside Ditch: Hillside ditch is applied to the land with a relatively constant slope of over 25 percent, mostly plantation areas. Ditches are made crossing the field slope, a row with a gradient of 2 to 5 percent toward a water disposal channel, with a distance of 11 to 30 meters.
b. Contour Terrace: Contour terrace is applied to the land with a slope of 10 to 50 percent. It is made crossing the field slope, a row with a gradient of 0.1 percent or less toward a natural disposal channel. Distance between contours is 10 meters.
c. Bench Terrace: Bench terrace is applied on the land with a slope of 13 to 30%, with a gradient of 1%. Revetment is applied to each terrace, under which is provided a ditch slanting toward a water disposal ditch.
d. Planted Fence: Planted fence is applied to the border of housing areas or yards to control surface runoff and increase soil water retention.
e. Rock Area: In rock areas, planting of vegetable crops or horticulture is promoted to increase soil water retention.
f. Water Spring Protection: Water springs are protected by planting perennial crops

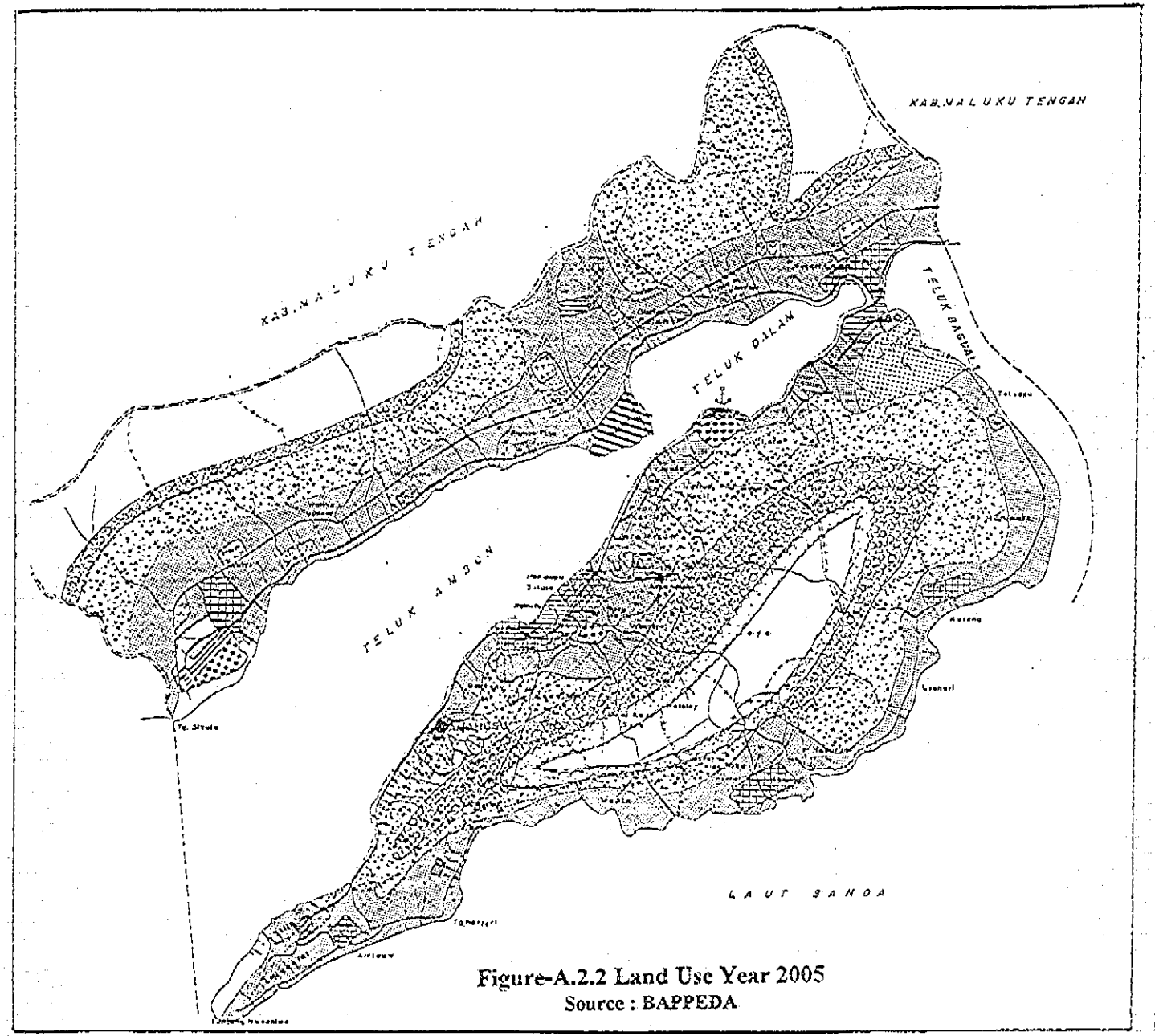
around the springs.

g. Mixed Garden / Agroforestry: Agroforestry is a form of multiple cultivation for planting trees and fruits with food crops, livestock or fishery. Agroforestry is applied to the areas with a slope of 15 to 45 percent, cultivated every year.

h. Private Forest: Private forests are the forests, with a slope of 45 percent, owned by local people but not intensively cultivated. Trees are to be planted with a distance of 3 x 2 m. Intercropping is promoted to the areas where the slope is not so steep.

i. Reforestation and Maintenance: Reforestation and maintenance of forests are applied to conserve natural forest resources, soil and water. Intercropping is to be allowed to local people under an agreement with the authorities.

Due to lack of resources, enforcement of the above mentioned guideline is quite limited. Since proper soil conservation is one of the critical factors for non-structural flood control measures, mechanisms to promote coordination between agencies relevant to land use and to enforce land use restrictions and soil conservation measures should be developed and legislated as soon as possible.



REVISI RENCANA UMUM TATA RUANG KOTA

AMBON

PETA : 4.6

LAND USE YEAR 2005

Legend

- Business Area
- Sub Centers
- Industry Area
- Houses
- Military Complex
- Small Holder Plantation
- Jointly Managed Forest
- Bush Area / Private Forest
- Forest Area

Sumber

Digambar

Diperiksa

Diketahui

Disetujui

Tanggal	No. Proyek	Jml. Lembar	No. Lembar

SKALA : 1 : 125.000

PEMERINTAH KOTAMADYA DATI II

AMBON

Figure-A.2.2 Land Use Year 2005
Source : BAPPEDA

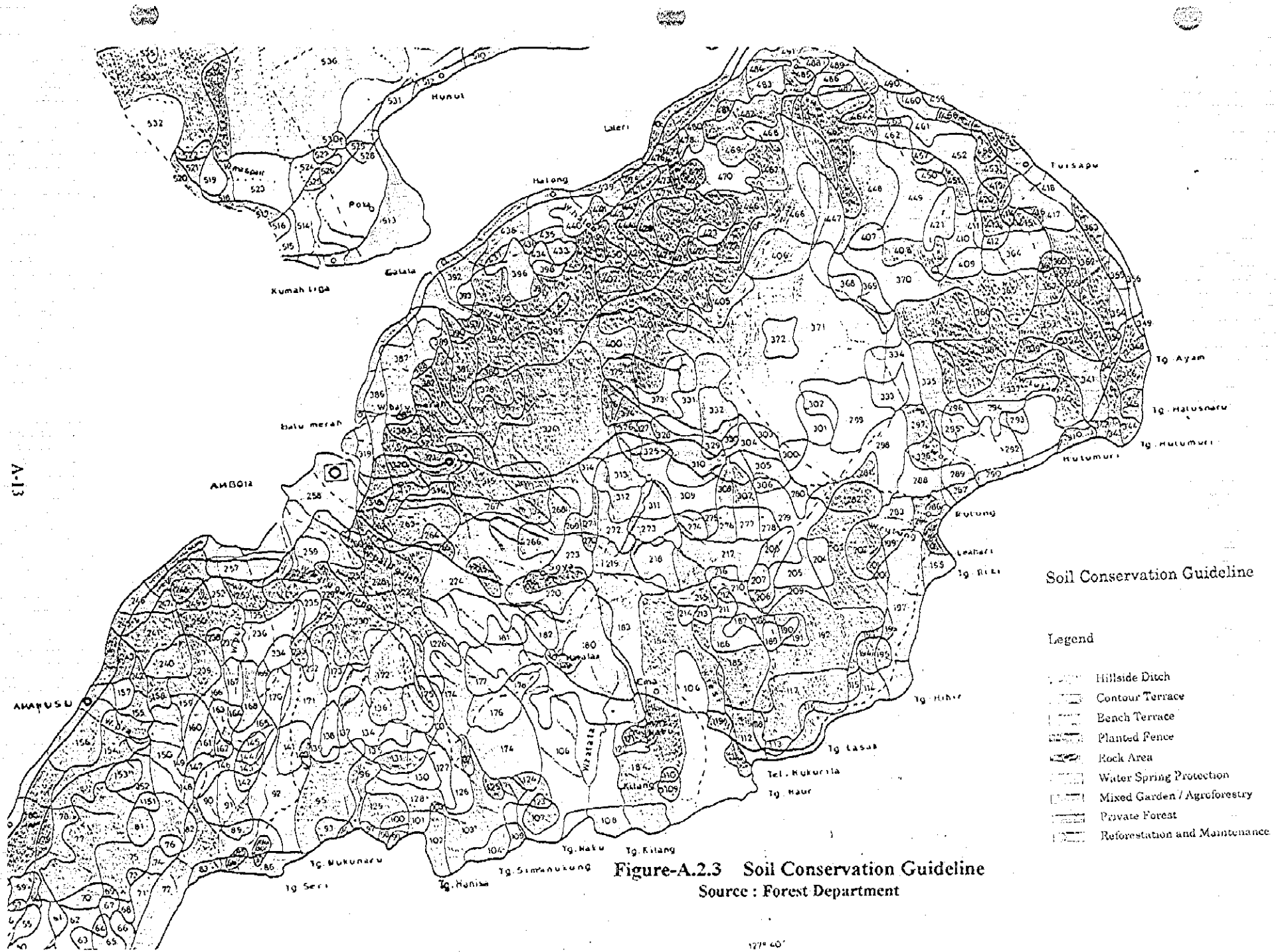


Figure-A.2.3 Soil Conservation Guideline
Source : Forest Department

SUPPORTING REPORT

PART-B

TOPOGRAPHY AND GEOLOGY

THE STUDY ON FLOOD CONTROL FOR AMBON AND PASAHARI AREA
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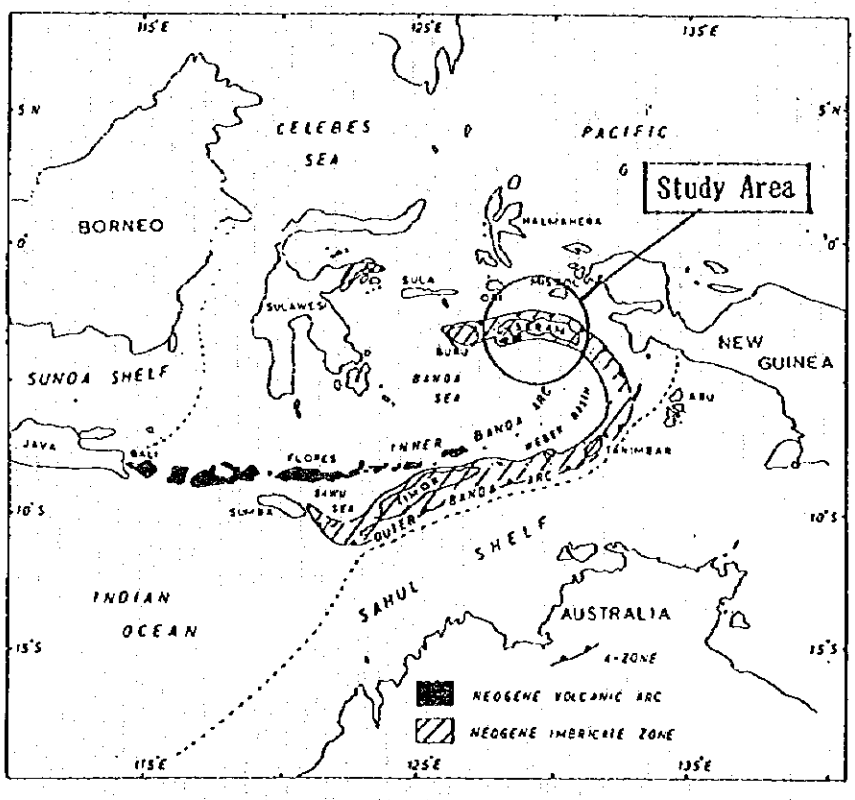
CHAPTER 1 REGIONAL TOPOGRAPHY AND GEOLOGY

As shown in Figure-B.1.1 and Figure-B.1.2, Ambon Island located in the northern reaches of the Banda Sea in Maluku Province of eastern Indonesia. Banda Sea is an epicontinental sea partially separated from the open seas by islands and peninsulas. The sea is surrounded by the Sunda arc that runs from east to west and Banda arc which comprises the eastern reaches of the Sunda arc and extends counterclockwise from Tanimbar Island. Banda Sea is a basin of depth 5 km at its deepest point and is believed to have been formed in the neogene tertiary period (Hamilton 1979).

The Banda arc is comprised of an outer arc (non-volcanic) which connects the islands of Sumba, Timor, Tanimbar, Seram and Buru from west to east and an inner arc (volcanic) that connects the islands of Flores, Alor, Wetar, Banda and Ambon.

On the whole, Ambon Island comprises a part of the inner arc and the majority of its basement rock is made up of volcanic rocks from the neogene tertiary period. This indicates that Ambon Island is an area that gave rise to complex geological structures.



Location map for the Banda Arcs, eastern Indonesia. The A-zone (northern margin of the imbricate zone) is plotted from Bally (1975) at the boundary of the imbricate zone with the gently deformed Australian craton and cover, except in the northern Banda sea-E Sulawesi region, where young rifting may have separated it from Buru and the Sula islands. The position of the Benioff zone, not indicated, is controversial. The dotted line marks the edge of the Australian continental shelf. (Source: M.G. Andley-Chales et al., 1979)

Figure-B.1.1 Schematic Location Map of the Study Area

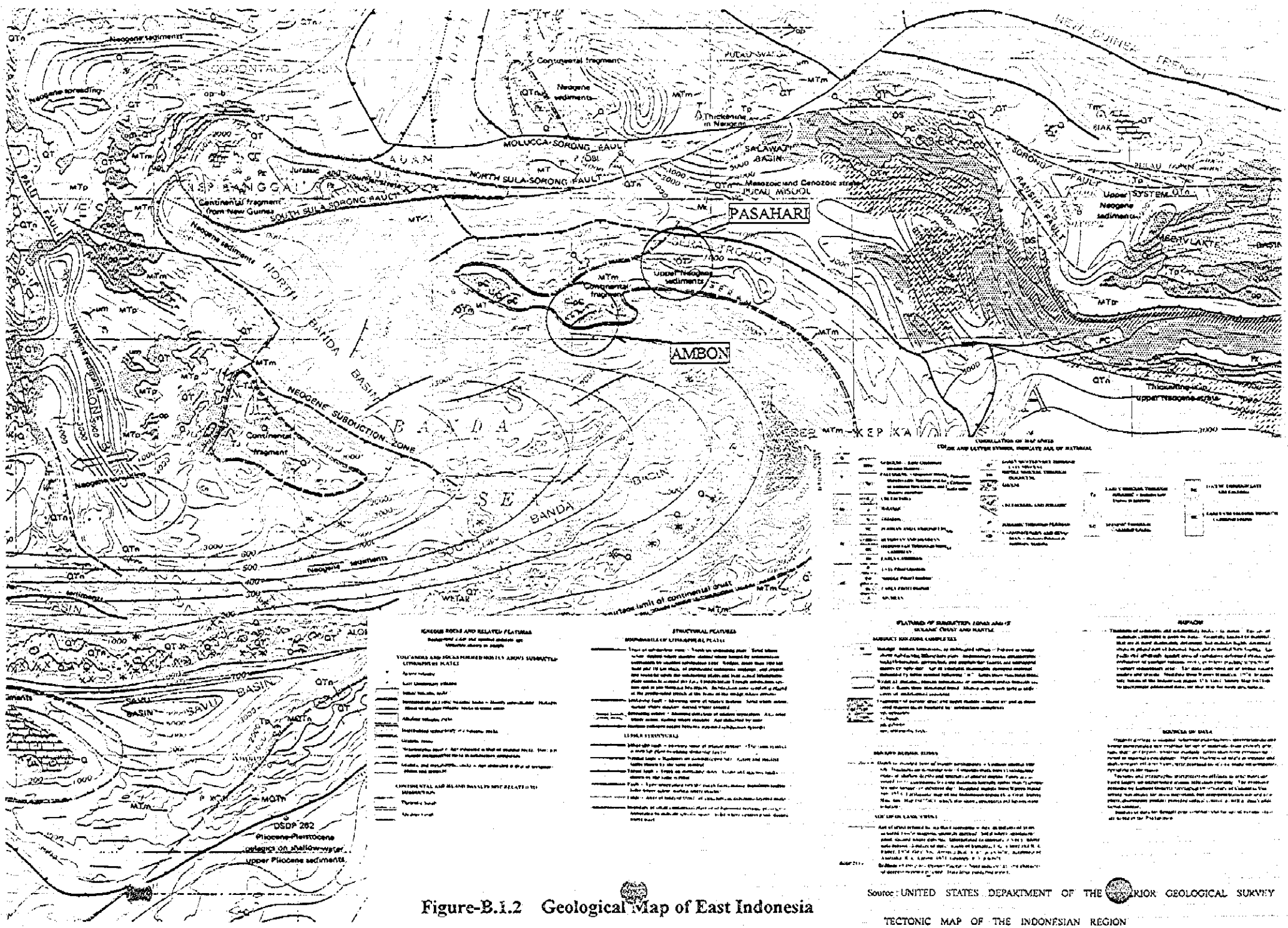


Figure-B.1.2 Geological Map of East Indonesia

CHAPTER 2 TOPOGRAPHY AND GEOLOGY IN THE STUDY AREA

2.1 Topography

The island of Ambon comprises the north island (Semenanjung Hitu) and the south island (Semenanjung Lai Timor) situated on either side of Ambon Bay which is a tectonic valley. Although the two islands were originally separate, a sand bar formed at the northern tip (near the village of Paso) of the south island thus connecting the two into a land tied island.

Transversing the south island in the NE-SW direction is a backbone range forming marine terrace of varying heights and size at various points around the island. Topographically, the study area covers the area from the northwest slope at the center of the backbone range to the waterfront. The topographical characteristics of the area are described below.

The five target rivers start their flow in the backbone range and flow northwestward down the steep mountain side, towards Ambon Bay via hilly plateaus and alluvial lowlands. Figure-B.2.1 shows a typical example of terrain comprising the reaches of the river and topographical phenomena encountered in such terrain. The reaches of the rivers can be generally categorized into mountainous region, hilly plateau and alluvial lowland.

2.1.1 Mountainous Region

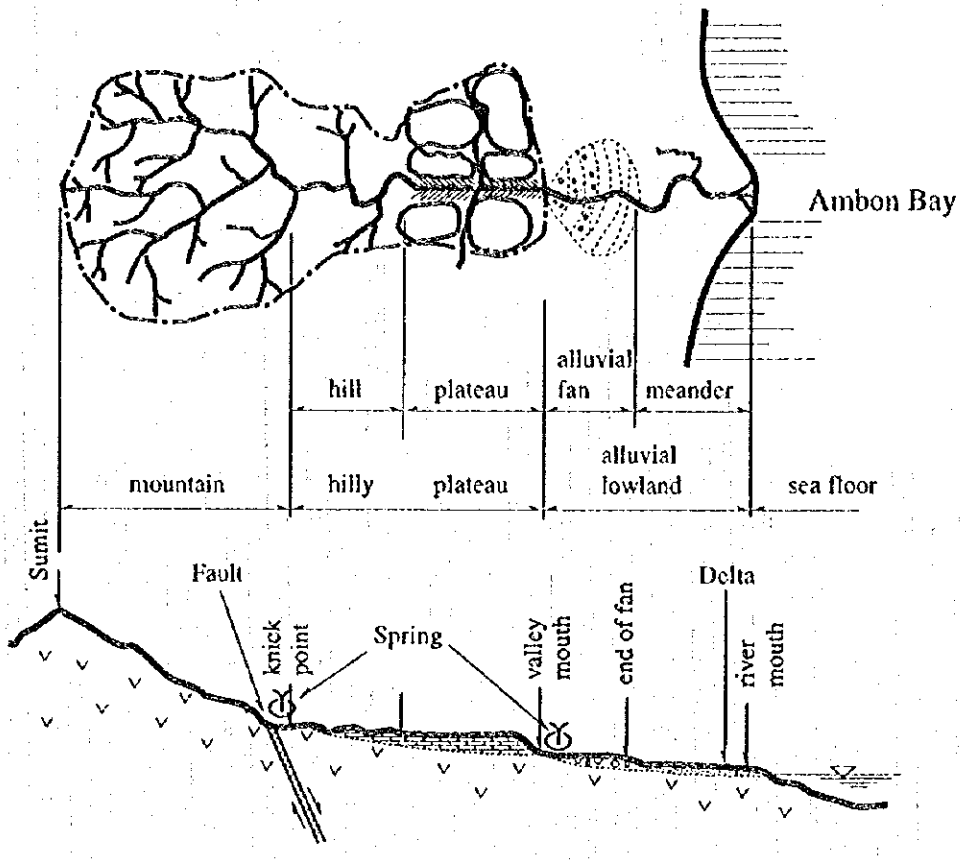
The region was uplifted, and the heights of the peaks of the mountain area where the rivers start are between 300 and 500 meters above sea level. The mountain slope comprises a complex combination of extremely steep and relatively moderate slopes. This reflects the difference in the geological make up of the basement rocks. The more massive and solid rocks form the steeper slope and cliffs. The mountainous region is in fault contact with hilly plateau.

2.1.2 Hilly Plateau

Generally ranging in altitude from about 100 to 200 meters above sea level, there are moderately sloping hills forming a wavy pattern and flat plateaus at approximately the same height. As the slope here is moderate, the rivers that flow in the hills and plateaus meander slightly. On the plateau at the part close to the sea, downward erosion caused by uplift causes the rivers to form sharp V shape valleys. In these hilly plateaus, small quantities of quaternary karst can be found. Furthermore, limestone caverns formed by cracks in the limestone or by the dissolving effect of underground water that circulates along the bedding plane can be found in the lower reaches of the current river bed.

2.1.3 Alluvial Lowland

In each of the target rivers, alluvial lowlands have been formed between the valley mouth (elevation about 10 meters) and the river mouth. The main rivers and their tributaries have steep gradients and have overloaded the target rivers at their mouth, forming alluvial fan and deltas. It is assumed that before large scale artificial reconstruction were carried out, corals must originally have been widespread along the current coast line.



Geology	Basement rocks (Volcanic Rocks, Kanikeh F., Granite)	Basement rocks Corralline Limestone	Alluvial deposits	Marine deposits
Topographical Phenomena	· Creep · Slope Failure · Land slide · Debris Flow · Fault · Spring	· Land slide · Slope Failure · Debris Flow · Flood · Downward Erosion · Lateral Erosion	· Flood · Sedimentation · Scour · Lateral Erosion · Ambon City	· Sediments

Figure-B.2.1 Schematic Topography and Geology of the River Basins in the Study Area

2.2 Geology

The geological composition of Ambon South Island can be summarized as shown in Table-B.2.1 and Figure-B.2.2 and Figure-B.2.3 from the existing data (Geological Map of Ambon, Sheet 1994) and the information acquired by field investigation.

Table-B.2.1 Geological Composition of Ambon Island

Period	Formation	Rocks
Quaternary	Alluvial Deposits	Cobble, Pebble, Sand, Silt, Clay
	Coral Limestone	Coral Limestone
Tertiary	Ambon Volcanic Rocks (Ambonite)	Andesite, Dacite, Volcanic Breccia, Tuff Breccia,Tuff
	Ambon Granite	Biotite Granite Biotite Cordierite
Cretaceous-Jurassic	Ultrabasic Rocks	Harzburgite, Dunite,Serpentinite,Gabbro
Jurassic-Triassic	Kanikeh Formation	Sandstone, Shale, Siltstone, Conglomerate, Limestone

The oldest rocks in this area are the Kanikeh Formation which consists of sandstone, shale, siltstone, conglomerats and limestone from Triassic to Jurassic time. This formation is ascribed to the repeated diastrophism that occurred throughtout the late Mesozoic Period. Ultrabasic rocks which consist of harzburgite, dunite, serpentine and gabbos, intruding of the late Mesozoic age, occur in the southern part of the island.

Ambon granite, intruding of the tertiary age, is exposed in the upper reaches of the target rivers.The rocks near the foot of the mountain are greatly altered by superficial weathering. Tertiary Ambon volcanic rocks, composed of andesite, dacite, volcanic breccia, tuff breccia, and tuff, outcrop in the northern part of the island. The rocks were subjected to hydrothermal alteration during the late Tertiary period. Hot springs, having temperatures up to 90° , occur in these rocks of the Ambon north island. In the plateaus, Quaternary coral limestone covers the above mentioned basement rocks. The bed is about 100 meters in maximum thickness and carries many coralline fossils of Quaternary age.

The alluvial lowlands which comprise the lower reaches of the rivers are mainly covered with alluvial fan deposits (cobbles, pebbles, sand) at the mouth of the valleys and alluvium (pebbles, sand, clay etc.) near the river mouth. Back swamp deposits (sand, silt, clay) are assumed to have been distributed behind the current beachline before artificial reconstruction.

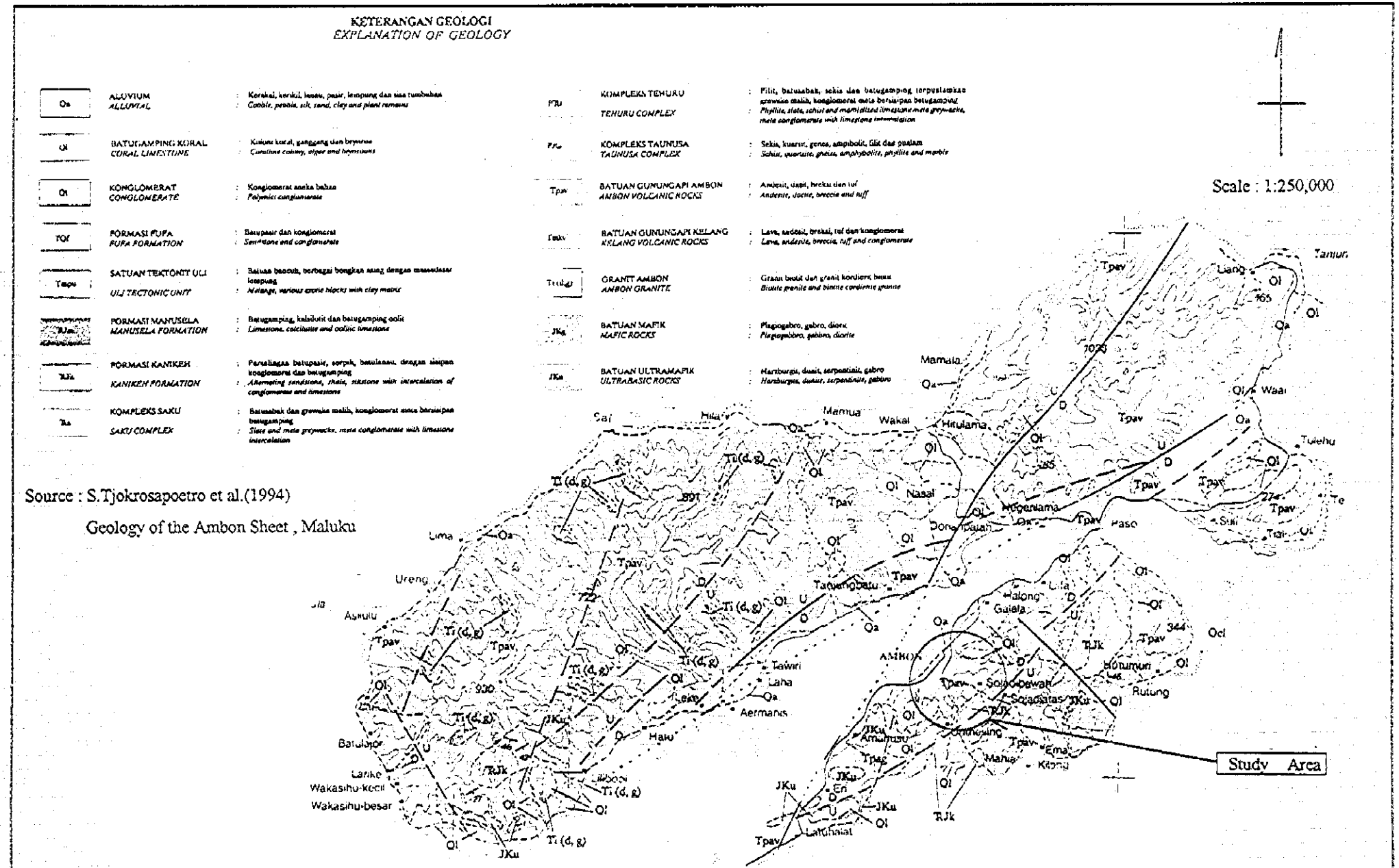


Figure-B.2.2 Geological Map of Ambon Island

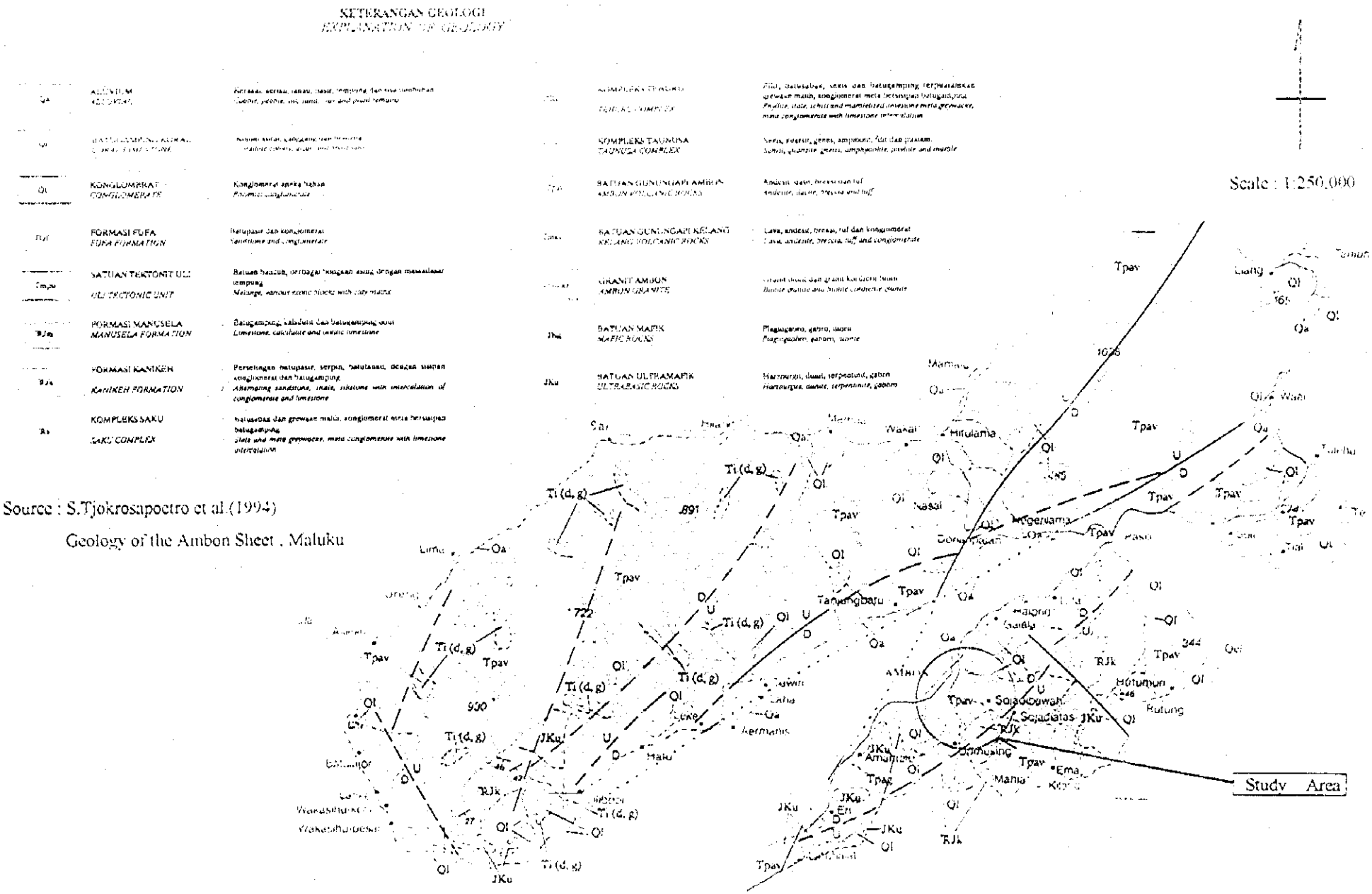


Figure-B.2.2 Geological Map of Ambon Island

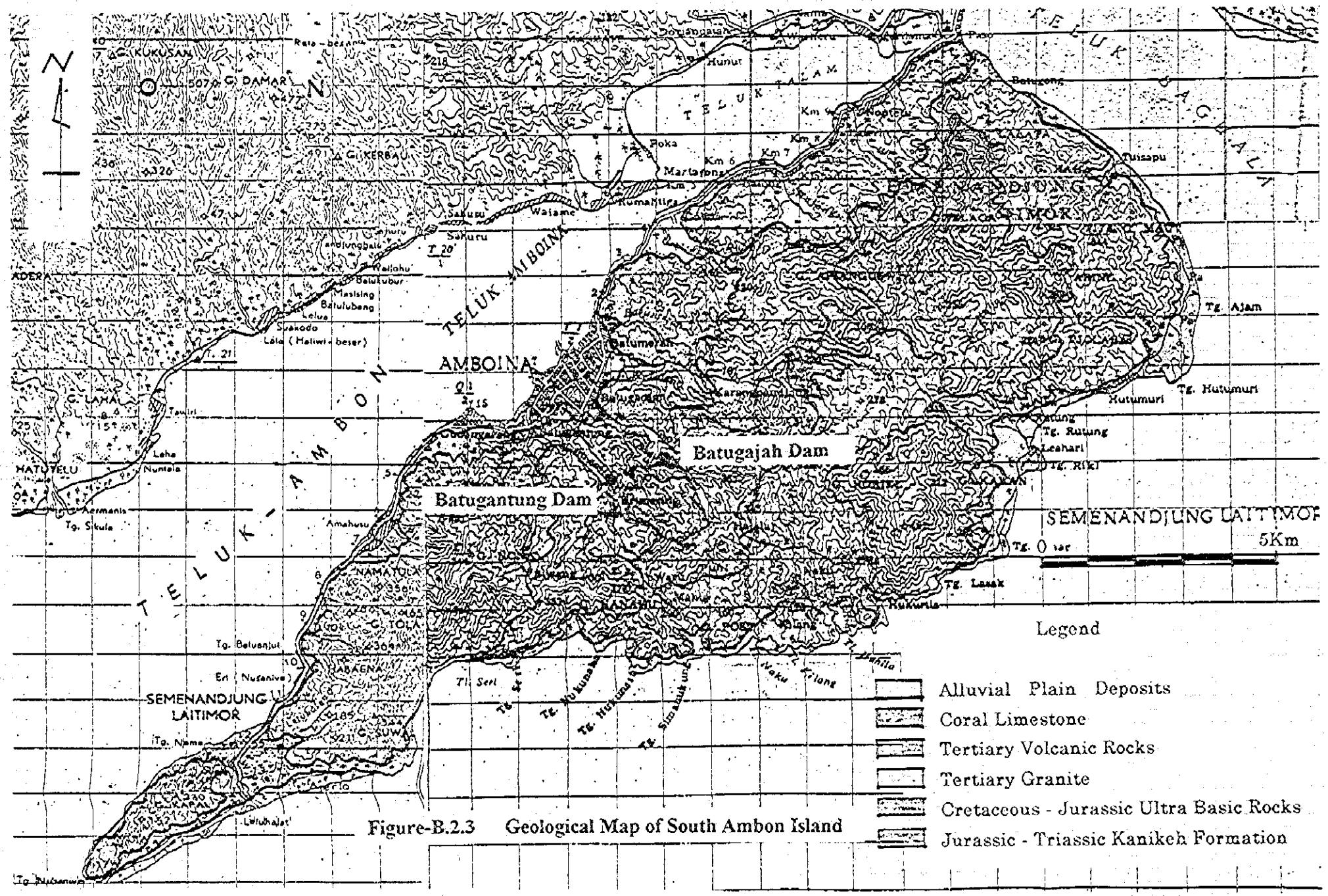


Figure-B.2.3 Geological Map of South Ambon Island

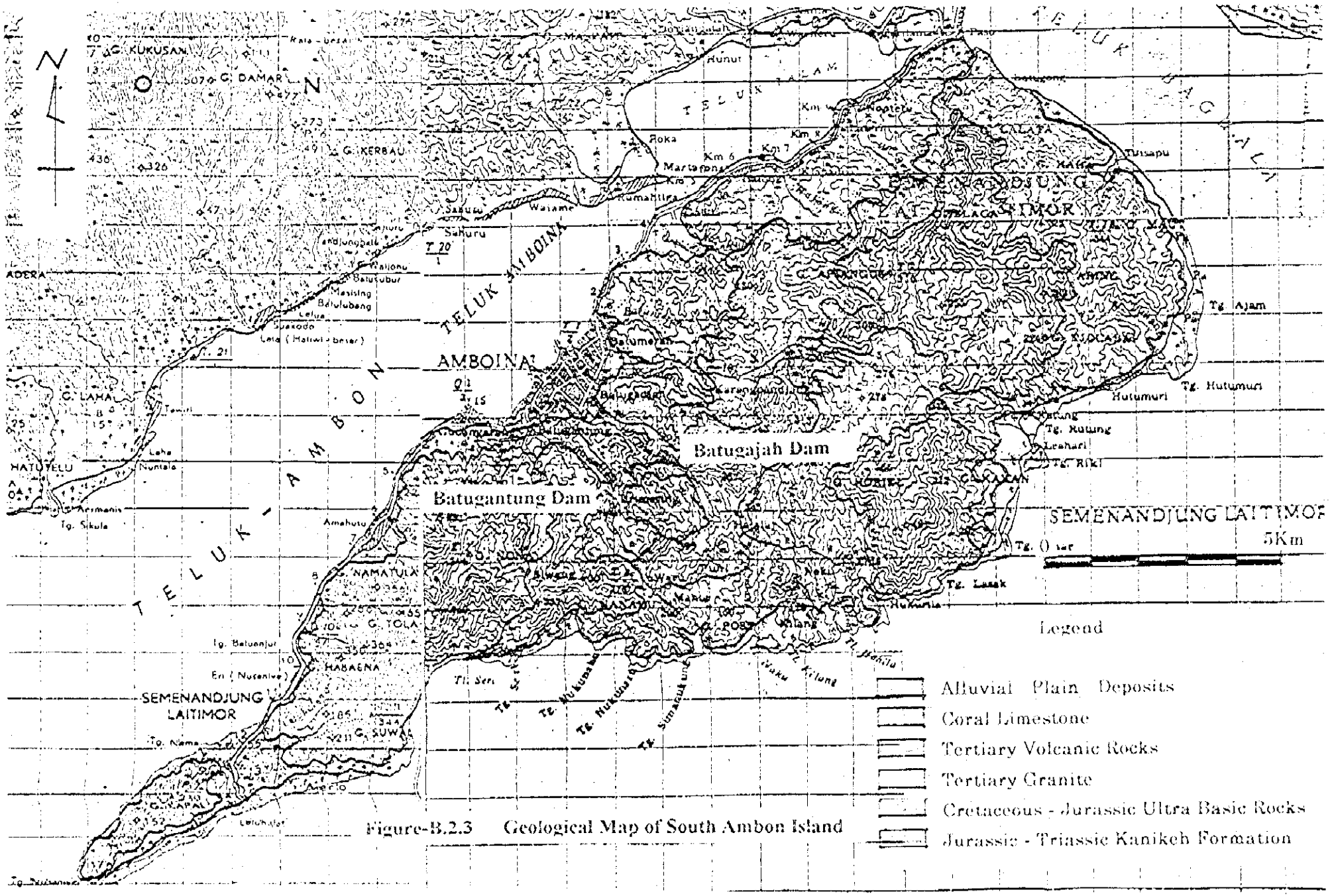


Figure-B.2.3 Geological Map of South Ambon Island

CHAPTER 3 GEOLOGICAL INVESTIGATION OF CANDIDATE DAM SITES

3.1 Selection of Candidate Dam Sites

The five rivers in the Ambon Area have common topographic and geological characteristics. That is to say, they all flow through mountainous areas of steep incline with basement rock formation , hilly plateaus formed by uplifted corralline limestone and flat alluvial lowlands.

Of these, the mountainous areas in which the river beds slope is steep and the alluvial lowlands in which they are flat are not appropriate as dam sites under the following condition that dams require a reservoir and are limited to the hilly plateaus when the topographic and geologic characteristics are taken into consideration and the 13 locations shown in Table-B.3.1 and Figure-B.3.1 are selected as the initial candidates.

Table-B.3.1 List of Initial Candidate Dam Sites

Name of River	Candidate Site
W.Ruhu	Rh-1 , Rh-2
W.Batu Merah	Bm-1 , Bm-2 , Bm-3
W.Tome	Tm-1 , Tm-2 , Tm-3
W.Batu Gajah	Gj-1 , Gj-2 , Gj-3
W.Batu Gantung	Gt-1 , Gt-2
	(Total 13 sites)

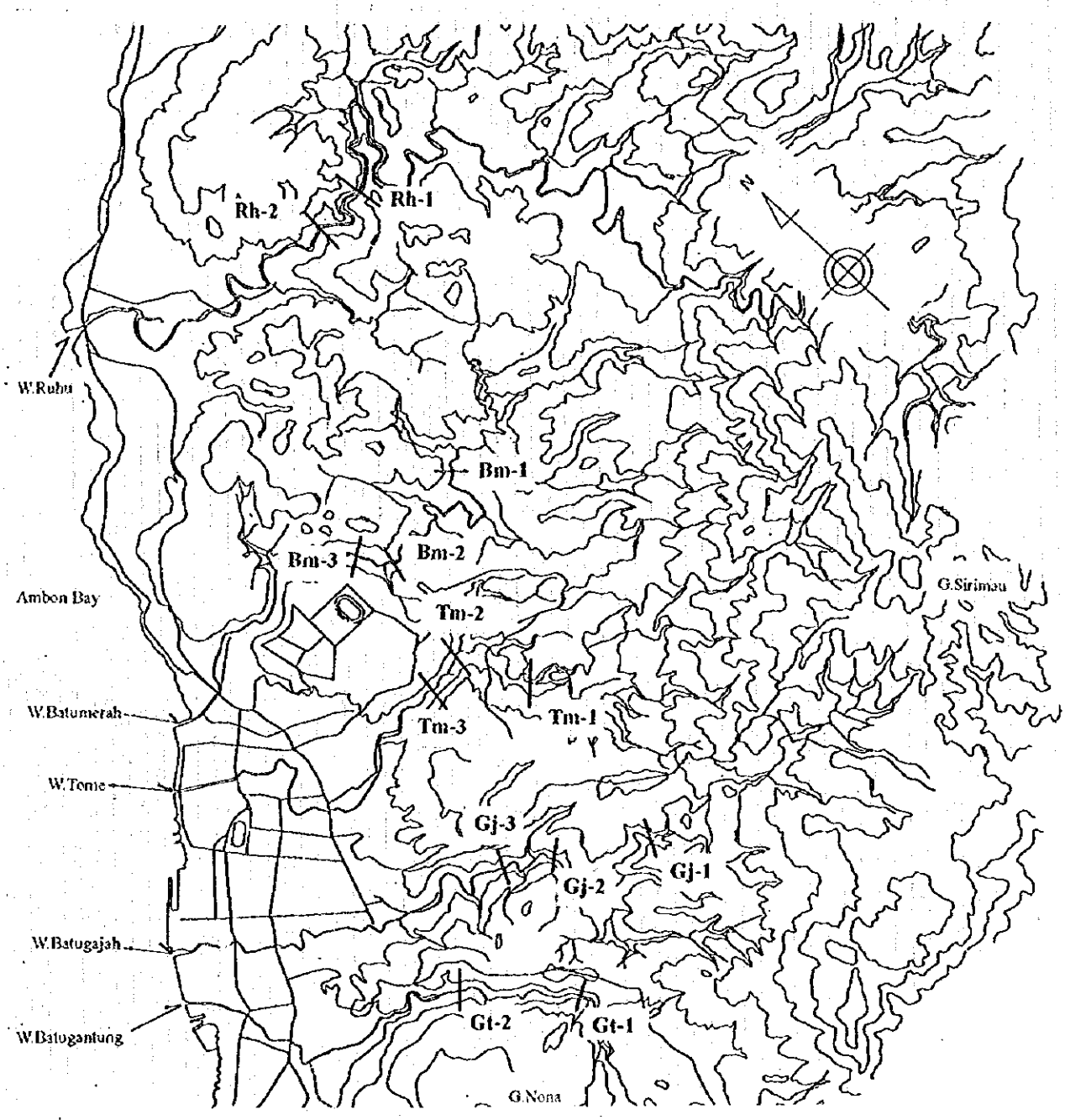
3.2 Geological Investigation on the Most Suitable Candidate Dam Sites

3.2.1 Field Reconnaissance

Batu Gajah dam site is located topographically in the hilly plateau at about 3,300 meters upstream from the river mouth as shown in Figure-B.3.2. There are several houses in the visinity of the dam site and reservoir. The slope of the left bank is rather steep (about 45 degrees), on the other hand, the right bank slope is very moderate. The current river bed is about 10 meters wide and is underlain by sand, pebbles and cobbles. Batu Gantung dam is located near the edge of hilly plateau at about 3,100 meters upstream from the river mouth as shown in Figure-B.3.3. The slopes of both banks are rather steep and the cross section of the dam axis shows a distinct V-shape.

3.2.2 Boring

As shown in Table-B.3.2 and Figure-B.3.4 , 6 (six) boring points are located along the two proposed dam axes. Each boring hole is about 40 meters deep, the diameter of the holes being 66mm. Permeability tests (Lugeon Test) are carried out every 5 meters, with exception of the first 5 m.



S = 1 : 15,000

List of Candidate Dam Sites

River	Dam Site
Ruhu	Rh-1 , Rh-2
Batumerah	Bm-1 , Bm-2 , Bm-3
Tome	Tm-1 , Tm-2 , Tm-3
Batugajah	Gj-1 , Gj-2 , Gj-3
Batugantung	Gt-1 , Gt-2

Figure-B.3.1 Location of Candidate Dam Sites

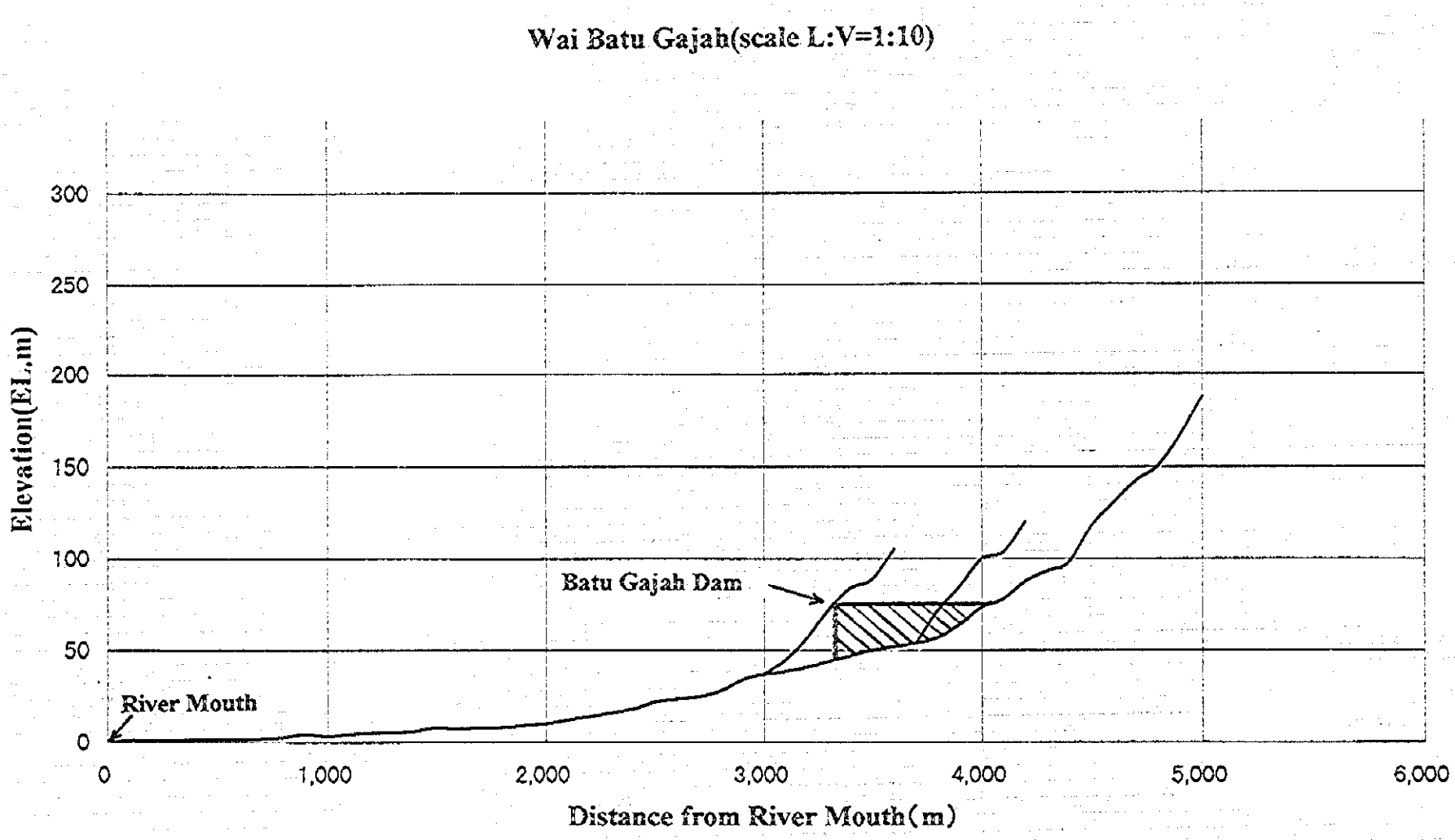


Figure-B.3.2 Longitudinal Section of the Batu Gajah River

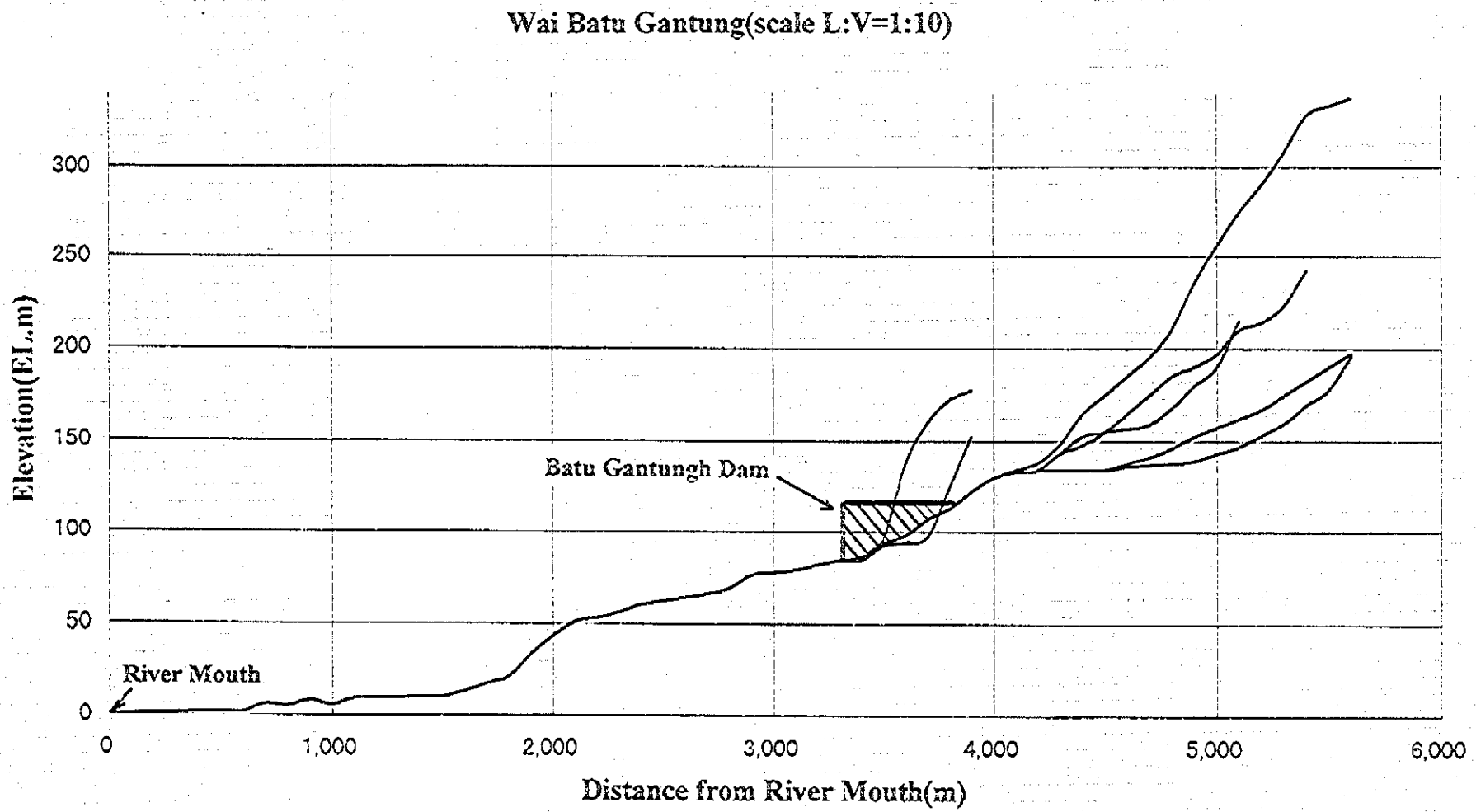


Figure-B.3.3 Longitudinal Section of the Batu Gantung River

Table-B.3.2 List of Boring Hole

Dam Site	Name	Length(m)	Elevation(m)	Permeability Test (times)	Location
Batu Gajah	Gj-1	45.0	65.483	8	Left bank
	Gj-2	40.0	31.808	7	River bed
	Gj-3	40.0	65.490	7	Right bank
Batu Gantung	Gt-1	40.0	110.162	7	Left bank
	Gt-2	35.0	75.216	6	River bed
	Gt-3	40.0	110.576	7	Right bank
	Total	240.0	-	42	

Boring logs and core photos of each boring hole are attached in the appendices. Results of Lugeon Tests are shown in Talbe-B.3.3. Most of Lugeon Value are more than 30 Lu at both Batu Gajah and Batu Gantung dam sites. This indicates that foundations of both dam site have very high permeability.

Table-B.3.3 Results of Lugeon Tests

Stage	Depth (m)	Batu Gantung			Batu Gajah		
		GT - 1	GT - 2	GT - 3	GJ - 1	GJ - 2	GJ - 3
1	0.00 - 5.00						
2	5.00 - 10.00	180	56	95	745	285	2
3	10.00 - 15.00	21	64	27	107	69	*
4	15.00 - 20.00	21	7	12	75	61	*
5	20.00 - 25.00	83	29	20	87	133	28
6	25.00 - 30.00	8	14	39	86	152	11
7	30.00 - 35.00	9	15	69	51	199	11
8	35.00 -40.00	8		35	88	94	9
9	40.00 - 45.00				78		

Note: *... Test could not be performed due to failure of bore hole.

3.3 Geotechnical Consideration on Dam Foundation

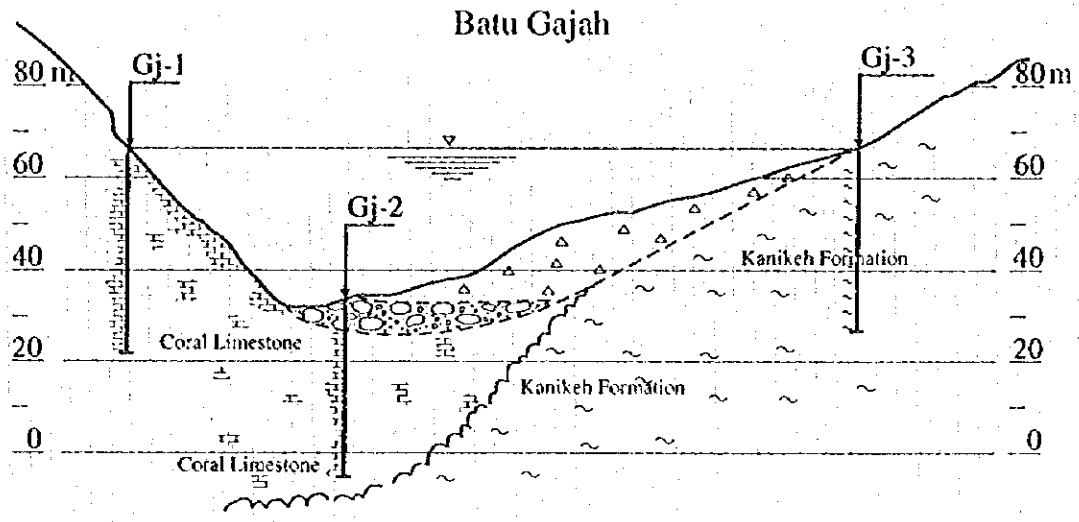
The major problems to be considered during dam design and construction can be given as follows from a geotechnical point of view.

3.3.1 Batu Gajah Dam

Judging from the core investigation, rock quality of the dam foundation is either soft or medium hard.

(1) Left bank and river bed are dominated by coral limestone, which incipient consolidation is insufficient and with the additional effects of advanced weathering or alteration. The rock quality of right bank, consisting of Kanikeh Formation rocks, is moreover soft. It is necessary for design of spillway to take deformation of foundation and stability of excavated slope into consideration.

(2) As a result of permeability tests, it can be stated that coral limestone is usually porous and highly permeable, showing a Lugeon value of more than 30 Lugeon. Further, there are limestone caverns at various points of the boring logs. Spring water constantly flows out of the limestone caverns, especially from the left bank near the river bed. Therefore sufficient measures to stop water flow should be taken in the dam design and construction.



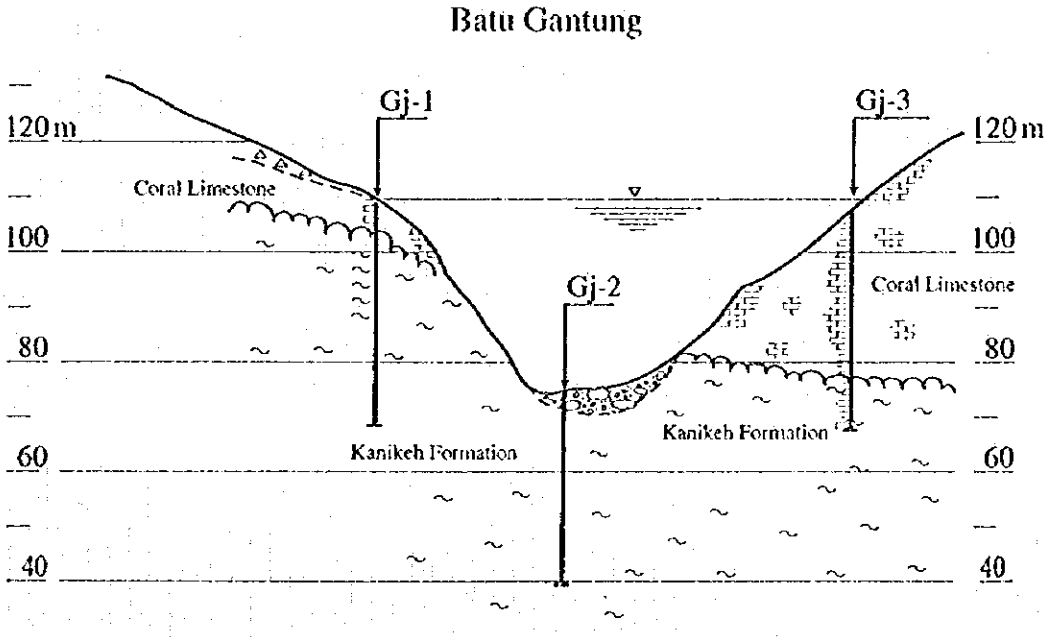


Figure-B.3.4 Geological Cross Section of Dam Axis

(3) The surface layer of the slope in the reservoir is composed of reddened laterite. As a result of field reconnaissance and analysis of aerial photographs, it is estimated that small scale landslides have occurred in the past in the slope of the proposed reservoir. It is necessary to be taken the measures of stability to the slope.

3.3.2 Batu Gantung Dam

(1) Foundation of the river bed consists of Kanikeh Formation rocks (merange type), of soft to medium hard quality. Both left and right banks are composed of coral limestone, which is porous and with advanced weathering.

(2) As a result of permeability test, foundation rocks are generally permeable. It is necessary to take a leakage from Batu Gantung river to Batu Gajah river, as well as dam foundation, into consideration.