INTRODUCTION

OUTLINE OF THE STUDY

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1. Background of the Study

The basic targets of national development in Indonesia, as stated in the First Long Term Plan (from 1989) and the Second Long Term Plan (1994), can be summarised in the three principles of:

1) ensuring a fair distribution of the results of development
2) maintaining sustained growth
3) securing social stability

One of the policies raised by the Government of Indonesia in order to achieve these goals is the support and promotion of development of the eastern regions, which are relatively undeveloped within Indonesia. In line with this central government policy to develop the eastern regions, development investment was initially concentrated in Sulawesi, but in recent years the Government and investors have turned their attention to further eastern areas such as Maluku Province.

Maluku Province is located roughly halfway between Sulawesi and Irian Jaya and is composed of the islands of Ambon (location of the provincial capital Ambon City), Seram, Buru, Halmahera, etc. Ambon City is blessed with a good natural port and has been the social and economic centre of the region ever since the days of colonial rule by the Netherlands. The importance of Ambon as a commercial centre of eastern Indonesia is exceeded only by the city of Ujung Pandang on the island of Sulawesi. The population of Ambon City, which currently stands at 305,000 as of 1996, is forecast by the Study Team to rise to 420,000 by the end of 2015. However, despite being such an important commercial centre, Ambon, like other cities in the east of the country, lacks the infrastructure to support future growth.

One of the projects being most urgently implemented in the effort to develop the infrastructure of Ambon is that to put flood prevention measures in place in the urban districts of the city. Five main rivers flow into Ambon Bay and, although flood walls and other flood prevention facilities do exist, these are not sufficient to prevent the frequent flooding of the Ambon urban area. In order to prevent the occurrence of such flood damage, the implementation of countermeasures such as dam construction, river improvements, etc. has become an issue requiring urgent attention. Moreover, in order to secure the urban water supply to respond to increased demand in the future, water resources development needs to be carried out in unison with the said flood prevention measures. Plans to conduct these measures are being advanced at the provincial government level, however, no planning has yet been conducted based on a long term and comprehensive point of view.

The Government of Indonesia and the Government of Maluku Province, wishing to resolve these issues facing Ambon City, requested the Government of Japan to conduct a study for the formulation of a flood countermeasure master plan and also a feasibility study of priority projects. In response to this request, the Government of Japan entrusted JICA to carry out a development study. Furthermore, at the strong wishes of the Indonesia side, it was also decided to examine a conceptual plan for flood countermeasures in the irrigation development districts of Pasahari on the island of Seram next to Ambon. These areas are also vulnerable to flood damage.

2. Objectives of the Study

The objectives of the study can be summarized into three points:

1) formulation of a comprehensive flood countermeasure master plan for the urban city area of Ambon
2) implementation of a feasibility study into priority projects raised within the master plan that require particularly urgent attention
3) preparation of a flood countermeasure conceptual plan for the Pasahari area on Seram Island.

In line with the above, the study also aims to conduct technical transfer to the counterparts on the Indonesia side.

3. Study Areas

The study areas include the basins of the rivers stated below. The overall location of the study areas is shown in Figure-1.

Area and River Name		Catchment Area
<Ambon Central Area>	:	43.70 km^2
1) Ruhu River	:	16.84 km^2
2) Batu Merah River	:	7.03 km^2
3) Tomu River	:	5.64 km^2
4) Batu Gajah River	:	5.97 km^2
5) Batu Gantung River	:	6.87 km^2
<Pasahari, Seram Island>	:	540.7 km^2
1) Samal River	:	268.9 km^2
2) Kobi River	:	271.8 km^2

4. Scope and Contents of the Study

Regarding the central area of Ambon City, the scope of the study includes formulation of a flood control master plan and implementation of a feasibility study of high priority projects to confirm the appropriateness of those projects. As for the Pasahari area on Seram Island, the scope of the study is limited to compilation of a flood prevention conceptual plan.

The study is divided into two phases:

- Phase 1 consists of the master plan study for Ambon Area and conceptual plan study for Pasahari Area. (The study results of Phase 1 are included in this Report.)
- Phase 2 is the feasibility study for the priority projects in Ambon Area.

The issues and major study contents in each of the phases are shown in Table-1. The study flow chart is illustrated in Figure-2.

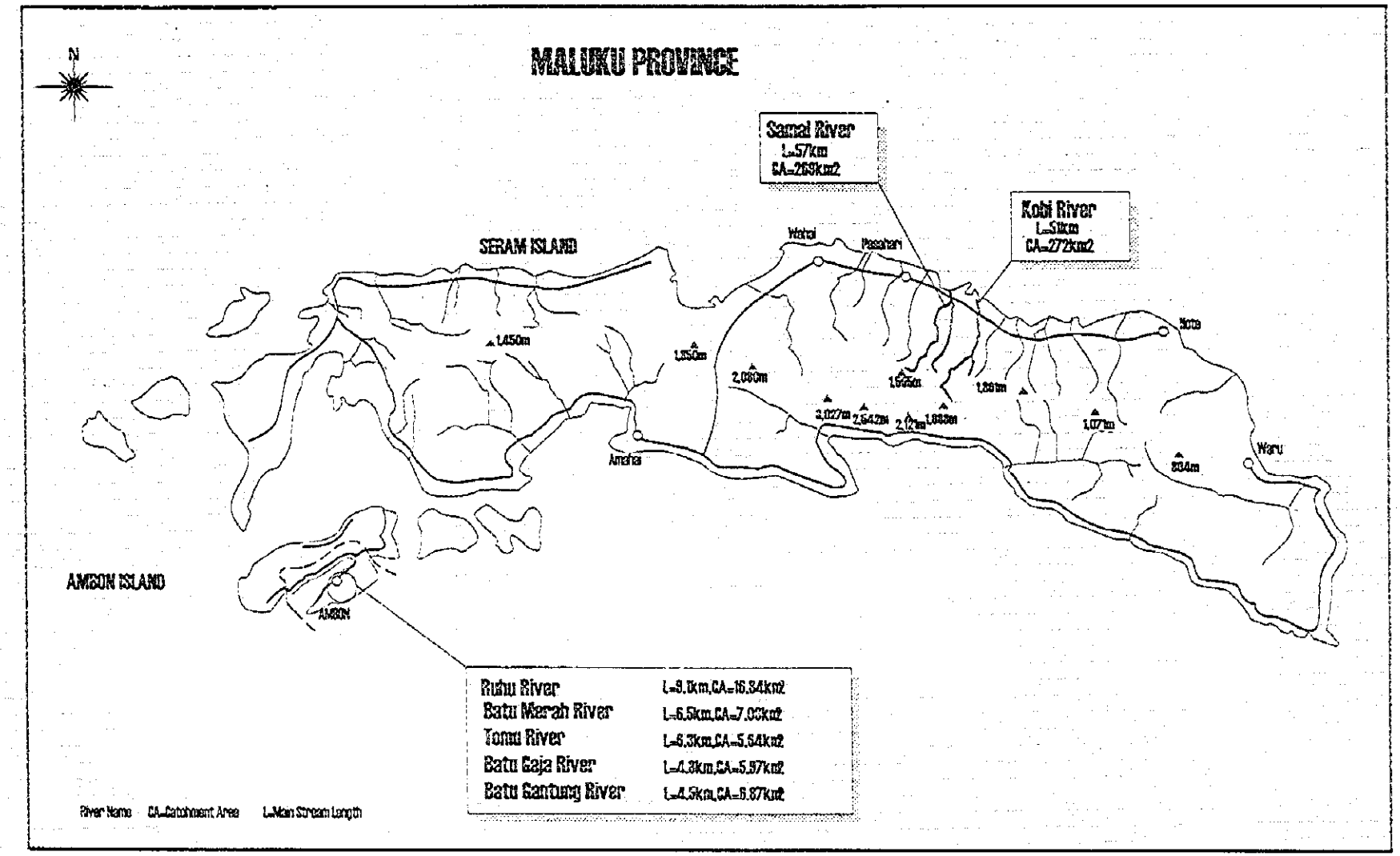


Figure-1 Overall Location of the Study Areas

Table-1 Major Work Contents in Study Phases 1 and 2

Contents of Study Phase	Work Period	Main Issue	Main Work Item
<Phase 1> Master Plan study and conceptual plan study [Ambon City Urban Area] Preparation of flood control master plan [Pasahari Area] Preparation of flood control conceptual plan	First Work in Indonesia	•Understanding of local conditions and materials •Preliminary study of flood control master plan •Preliminary study of flood control conceptual plan	•Explanation and discussion of Inception Report •Collection and analysis of existing materials •Site surveys •Implementation surveys •Analysis and examination of master plan formulation •Examination of the conceptual plan basic concept •Preparation of Progress Report (1)
	First Work in Japan	•Formulation of the Ambon flood control master plan based on the local conditions •Compilation of the Pasahari flood control conceptual plan based on the local conditions	•Formulation of master plan •Assessment of master plan •Selection of priority projects •Compilation of conceptual plan •Preparation of Interim Report
<Phase 2> Feasibility Study	Second Work in Indonesia	Verification of the appropriateness of emergency and priority projects	•Explanation and discussion of Interim Report •Local complementary surveys •Plane surveying •Geological and soil surveys •Environmental Impact Assessment •Examination of project components •Examination of contents of technical transfer seminar •Preparation of Progress Report (2)
	Second Work in Japan	Preparation of Draft Final Report	•Outline design of facilities •Construction plan •Operation and management plan •Estimation of project costs •Project assessment •Project implementation plan •Preparation for implementation of technical transfer seminar •Preparation of Draft Final Report
	Third Work in Indonesia	Explanation and discussion of Draft Final Report	•Explanation and discussion of Draft Final Report •Holding of technical transfer seminar
	Third Work in Japan	Preparation of Final Report	•Review of the results of the technical transfer seminar •Preparation of the Final Report

YEAR	1996						1997					
MONTH	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
Phase	Phase 1: Formulation of Flood Control Master Plan and Conceptual Plan						Phase 2: Feasibility Study for Priority Projects					
Work Stage	[1] First Work in Indonesia				[2] First work in Japan		[3] Second Work in Indonesia			[4] Second Work in Japan	[5] Third Work in Indonesia	[6] Third Work in Japan

Work Item

- [11] Presentation, Explanation and Discussion of Inception Report
- [12] Collection and Analysis of Existing Materials and Information
- [13] Field Survey
  - (a) Topography and Geology
  - (b) Current Condition of River and River Basin
  - (c) Current Water Use Conditions
  - (d) Socioeconomic Conditions and Land Use
  - (e) Sanitary and Environmental Conditions
- [14] Implementation Surveys
  - (a) Longitudinal and Cross Sectional Survey of Rivers
  - (b) Meteorological and Hydrological Observations
  - (c) Survey of Flood Damage
  - (d) Survey of Flood Forecasting and Warning Systems
  - (e) River Water Quality Survey
  - (f) Sediment Survey(Suspended Load, River Bed Material)
  - (g) Survey of Social and Natural Environment
  - (h) Understanding of Socioeconomic Conditions and Land Use
- [15] Analysis and Examination of Master Plan Planning
  - (a) Hydrological and Runoff Analysis
  - (b) Flood Analysis
  - (c) Flood Damage Analysis
  - (d) Sediment Discharge Analysis
  - (e) Forecast of Future Socioeconomic Conditions
  - (f) Forecast of Future Water Use Amount
  - (g) Examination of Basin Development Policy
  - (h) Examination of Water Utilization Through Flood Control Facilities
  - (i) Outline Formulation of Master Plan
- [16] Examination of the Conceptual Plan Basic Policy
- [17] Preparation of Progress Report (1)
- [21] Formulation of master Plan
  - (a) Layout Plan of Major Structures
  - (b) Plan for Multi-purpose Utilization of Flood Control Structures
  - (c) Outline Design of Facilities
  - (d) Non-structural Flood Control Measures
  - (e) Operation and Maintenance Plan
  - (f) Estimation of Project Costs
- [22] Evaluation of Master Plan
  - (a) Social and Natural Environmental Evaluation
  - (b) Economic Evaluation and Financial Plan
- [23] Selection of Project in the Feasibility Study
  - (a) Comparison and Evaluation of Alternative Plans
  - (b) Selection of Optimum Plans
  - (c) Setting of Project Composition and Contents
- [24] Compilation of Conceptual Plan
- [25] Preparation of Interim Report
- [31] Presentation, Explanation and Discussion on Interim Report
- [32] Complementary Field Survey
- [33] Plane Surveying
- [34] Geological and Soil Survey
- [35] Environmental Impact Assessment
- [36] Examination of Planning Components
  - (a) Examination of Facilities Plans
  - (b) Implementation Setup
  - (c) Operation and Maintenance Setup
  - (d) Funding Plan
  - (e) Social and Natural Evaluation Assessment
- [37] Examination of the Contents of the Technical Transfer
- [38] Preparation of Progress Report (2)
- [41] Outline Design of Facilities
- [42] Project Execution Scheme
- [43] Management and Operation Plan
- [44] Estimation of Project Costs
- [45] Project Evaluation
  - (a) Social Impact Assessment
  - (b) Economic Evaluation and Financial Plan
- [46] Project Implementation
- [47] Preparation for Implementation of the Technical Transfer Seminar
- [48] Preparation of Draft Final Report
- [51] Presentation, Explanation and Discussion of Draft Report
- [52] Holding of Technical Transfer Seminar
- [61] Compilation of the Results of the Technical Transfer
- [62] Preparation of Final Report
- Presentation of Final Reports

Report Submission	▼IC Inception Report			▼PG1 Progress Report (1)			▼IR Interim Report			▼PG2 Progress Report (2)	▼DFR Draft Final Report	▼FR Final Report
MONTH	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
YEAR	1996						1997					

Figure-2 Study Flow Chart

PART I

FLOOD CONTROL FOR AMBON AREA

CHAPTER 1 GENERAL CONDITIONS OF THE STUDY AREA

1.1 *Socio-economy*

1.1.1 Current Social Conditions

(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-I.1.1 Population Growth in Ambon City, 1961-1996

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)

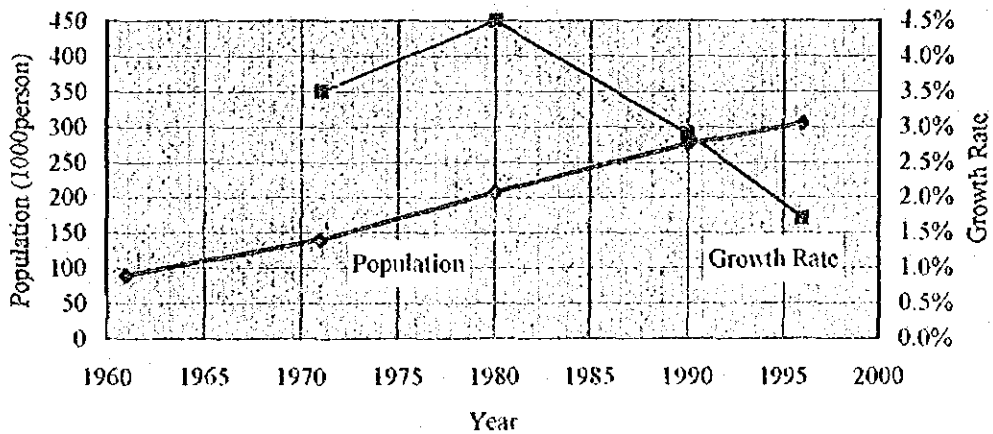


Figure-I.1.1 Population Growth in Ambon City

The Study Area includes 20 Desa/Kelurahan, which are expected to be more or less influenced by the project. The Central City Area includes 17 Desa/Kelurahan and the Upstream Area includes 3 Desa/Kelurahan as described in Table-I.1.2 and Figure-I.1.2. 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-I.1.2 Population, Area and Population Density (June 1996)

Desa/ Kelurahan		Population (person)	Area (ha)	Population Density (person/ha)
Central City Area	(1) Waihaong	5,472	15	365
	(2) Silale	3,780	18	210
	(3) Wainitu	12,541	29.8	421
	(4) Kudamati	13,872	66.5	209
	(5) Urimessing	4,353	26.9	162
	(6) Manggadua	3,858	18.4	210
	(7) Honipopu	6,579	34.2	192
	(8) Ahusen	5,080	23.5	216
	(9) Uritetu	5,934	35.4	168
	(10) Rijali	5,828	27.6	211
	(11, 18) Batu Merah	29,671	1,667	18
	(14) Batu Gajah	6,269	44.7	140
	(15) Batu Meja	10,473	84.8	124
	(16) Amantelu	8,009	115.3	69
	(17) Karang Panjang	6,353	43.4	146
	(19) Pandan Kasturi	8,193	400	20
	(21) Hative Kecil	12,568	153	82
	Total and Average	148,833	2,804	53
	Total and Average (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
	Total and Average	11,646	11,081	1.1
Grand Total and Average		160,479	13,885	11.6

Source: Ambon City Statistics, June 1996 Census

* Figure-I.1.2 shows the administrative division of the Central City

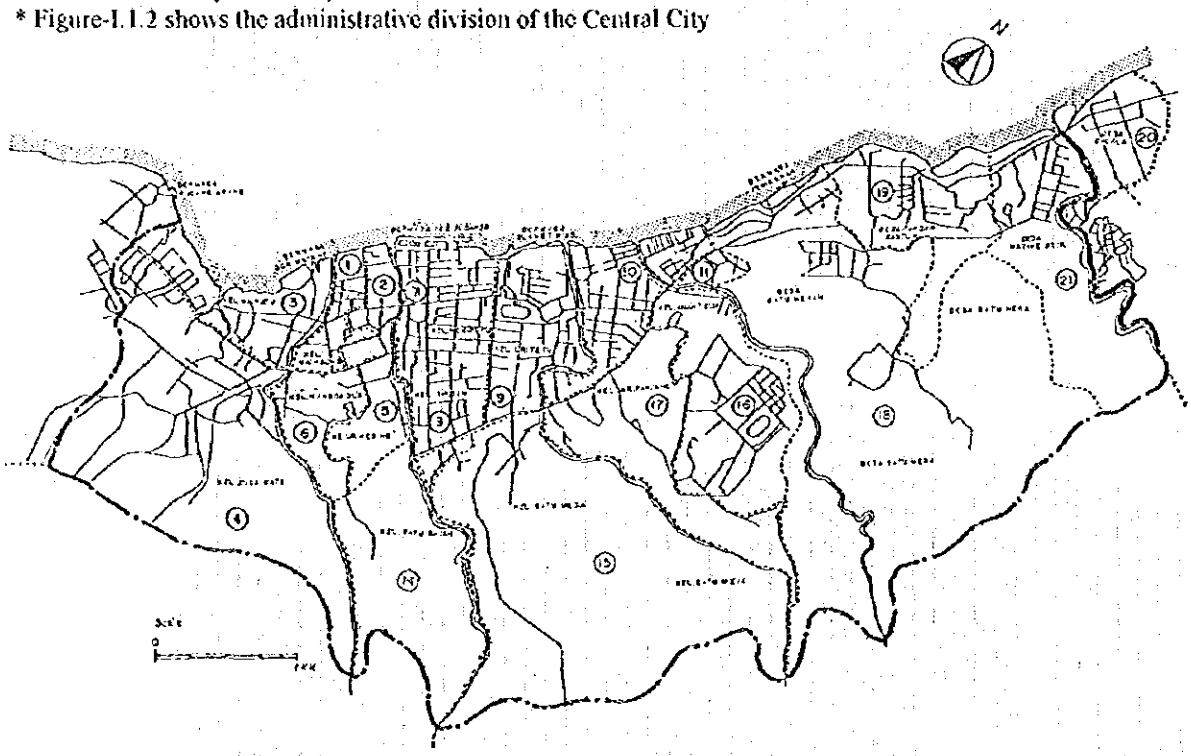


Figure-I.1.2 Administrative Division of Central Ambon City

1.1.2 *Current Economic Conditions*

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. GDP Occupation of Ambon City in Maluku Province 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-I.1.3 and the breakdown of GDP of Ambon City is given in Table-I.1.3.

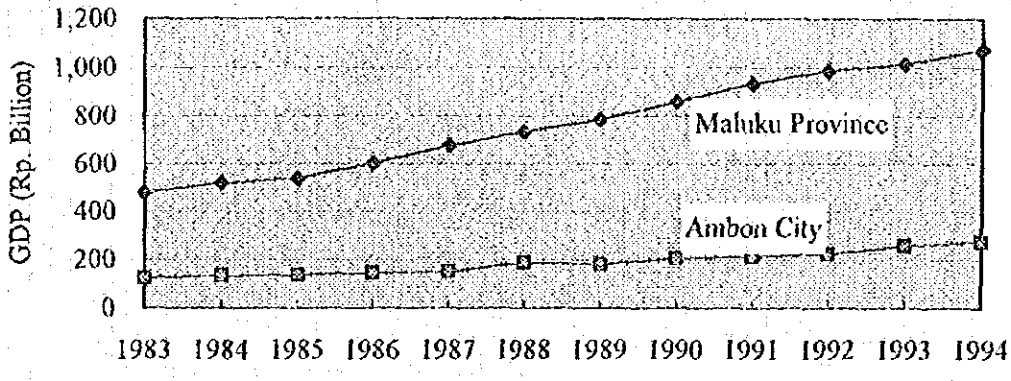


Figure-I.1.3 Growth of Regional GDP at 1983 constant prices

Table-I.1.3 Breakdown of GDP, Ambon City (1994)

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

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-1.1.4 describes by category the occupations of the residents of Maluku Province and Ambon City.

Table-I.1.4 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

1.1.3 Projection of Future Socio-economic Conditions

(1) Population Projection

As was discussed in Section 1.1.1, 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-I.1.5 shows the projected future population in Ambon City.

Table-I.1.5 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-I.1.5 shows the future population in the Central City and Upstream Area and Figure-I.1.4 shows the projected population growth in Ambon City and the Study Area.

Table-I.1.6 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

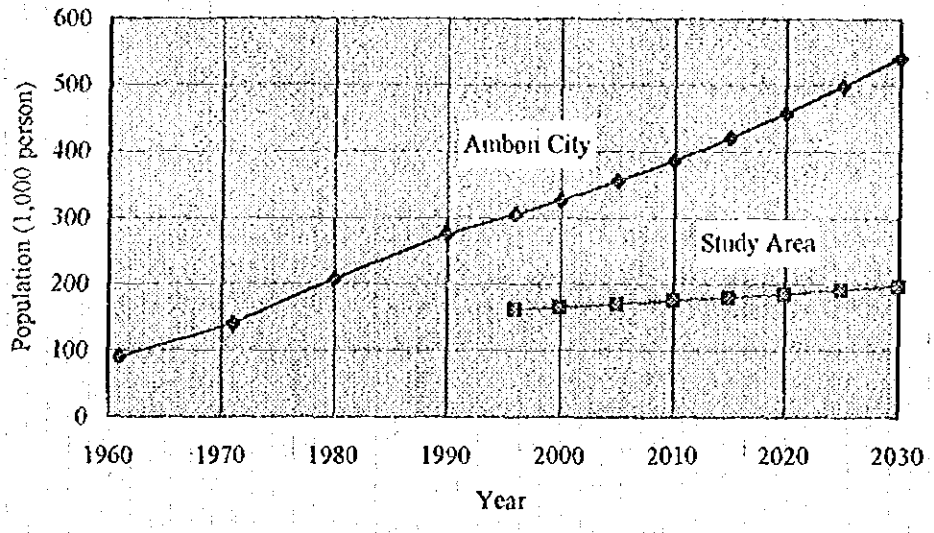


Figure-I.1.4 Population Projection in Ambon City and the Study Area

(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-I.1.7 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-I.1.7 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-I.1.8 shows the estimated growth in GDP at 1996 prices and per capita GDP of Ambon City, based on the above assumption.

Table-I.1.8 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

1.2 Physical Geography

1.2.1 Topography and Geology

(1) Regional Topography and Geology

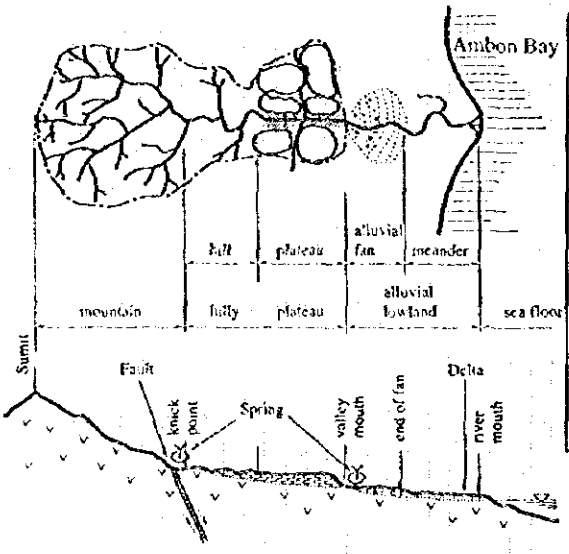
Ambon Island located in the northern reaches of the Banda Sea in Maluku Province of eastern Indonesia. Banda Sea is surrounded by the Sunda arc and Banda arc. The Banda arc is comprised of an outer arc (non-volcanic) which connects the islands of Sumba, Timor, Tanimbar, Seram and Buru from west to east 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.

(2) Topography in the Study Area

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.

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-I.1.5 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.



	Mountain	Hilly plateau	Alluvial lowland	Sea floor
Geology	*Basement* Rocks :Volcanic :Rocks :Kanikeh F. :*Granite*	*Basement* Rocks Corralline Limestone	*Alluvial* deposits	*Marine* deposits
Topo-graphical Phenomena	·Creep ·Slope Failure ·Land slide ·Debris Flow ·Fault ·Spring	·Land slide ·Slope Failure ·Debris Flow ·Flood ·Downward Erosion ·Lateral Erosion	·Flood ·Sediments ·Scour ·Lateral Erosion ·Ambon City	·Sediments

Figure-I.1.5 Schematic Topography and Geology of the River Basins in the Study Area

1.2 Physical Geography

1.2.1 Topography and Geology

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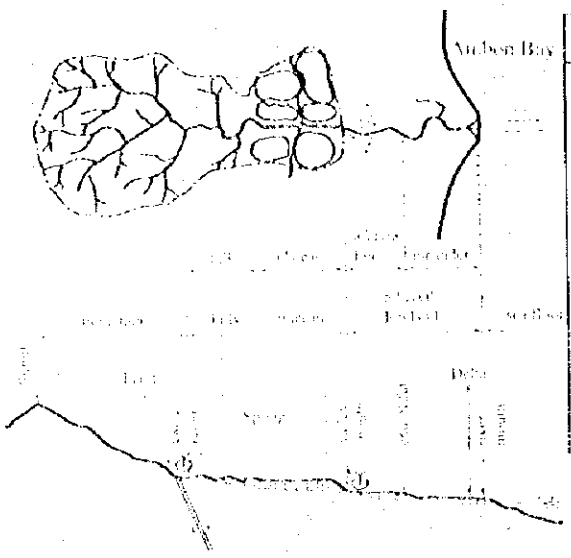


	Mountain	Hilly plateau	Alluvial lowland	Sea Floor
Geology	Basement Rocks Volcanic Rocks Kanikeh F. Granite	Basement Rocks Coralline Limestone	Alluvial deposits	Marine deposits
Topographical Phenomena	・Creep ・Slope Failure ・Landslide ・Debris Flow ・Fault ・Spring	・Landslide ・Slope Failure ・Debris Flow ・Flood ・Downward Erosion ・Lateral Erosion	・Flood ・Sediments ・Scour ・Lateral Erosion ・Ambon City	・Sediments

Figure-1.1.5 Schematic Topography and Geology of the River Basins in the Study Area

(3) Geology in the Study Area

The geological composition can be summarized as shown in Table-I.1.9 and Figure-I.1.6. The oldest rocks in this area are the Kanikeh Formation Ultrabasic, 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 outcrop in the northern part of the 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.

Table-I.1.9 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

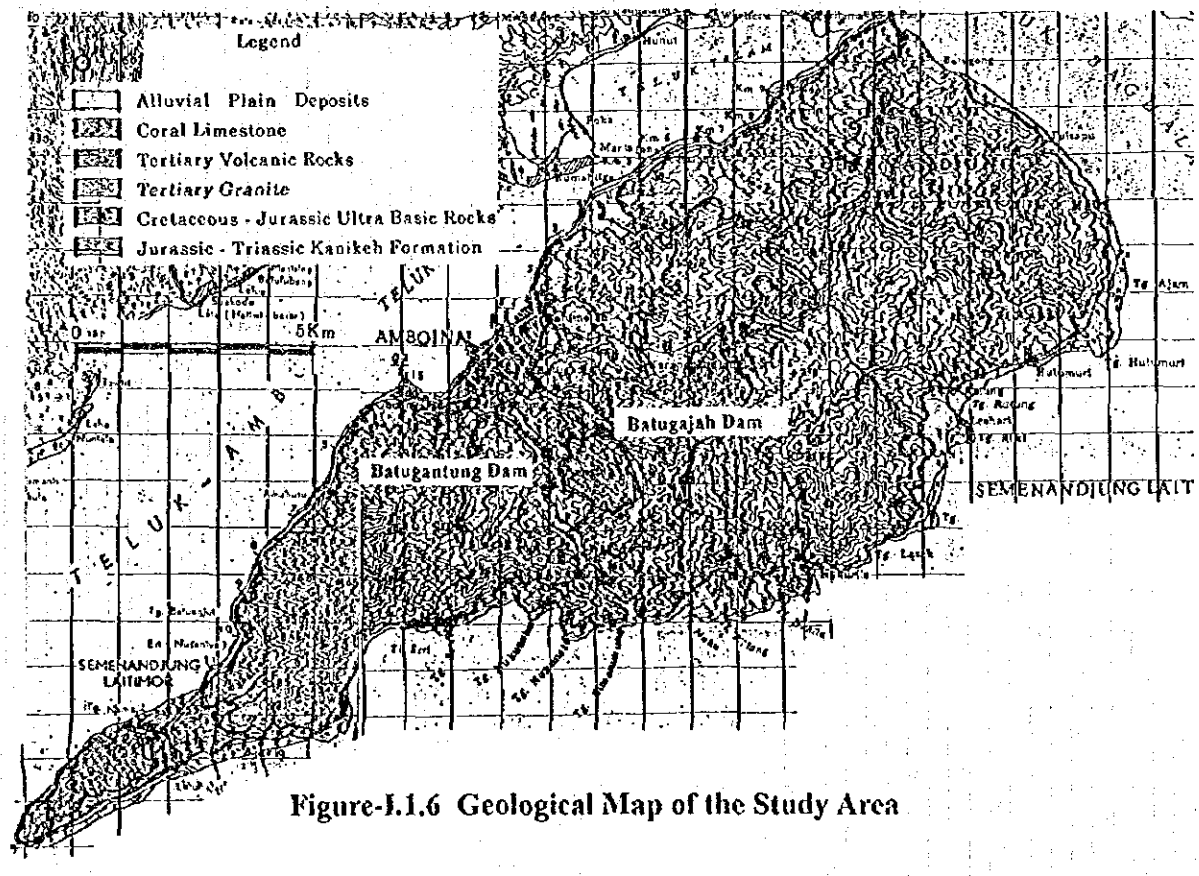


Figure-I.1.6 Geological Map of the Study Area

(3) *Geology in the Study Area*

The geological composition can be summarized as shown in Table-I.1.9 and Figure-I.1.6. The oldest rocks in this area are the Kanikeh Formation Ultrabasic, 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 outcrop in the northern part of the 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.

Table-I.1.9 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*

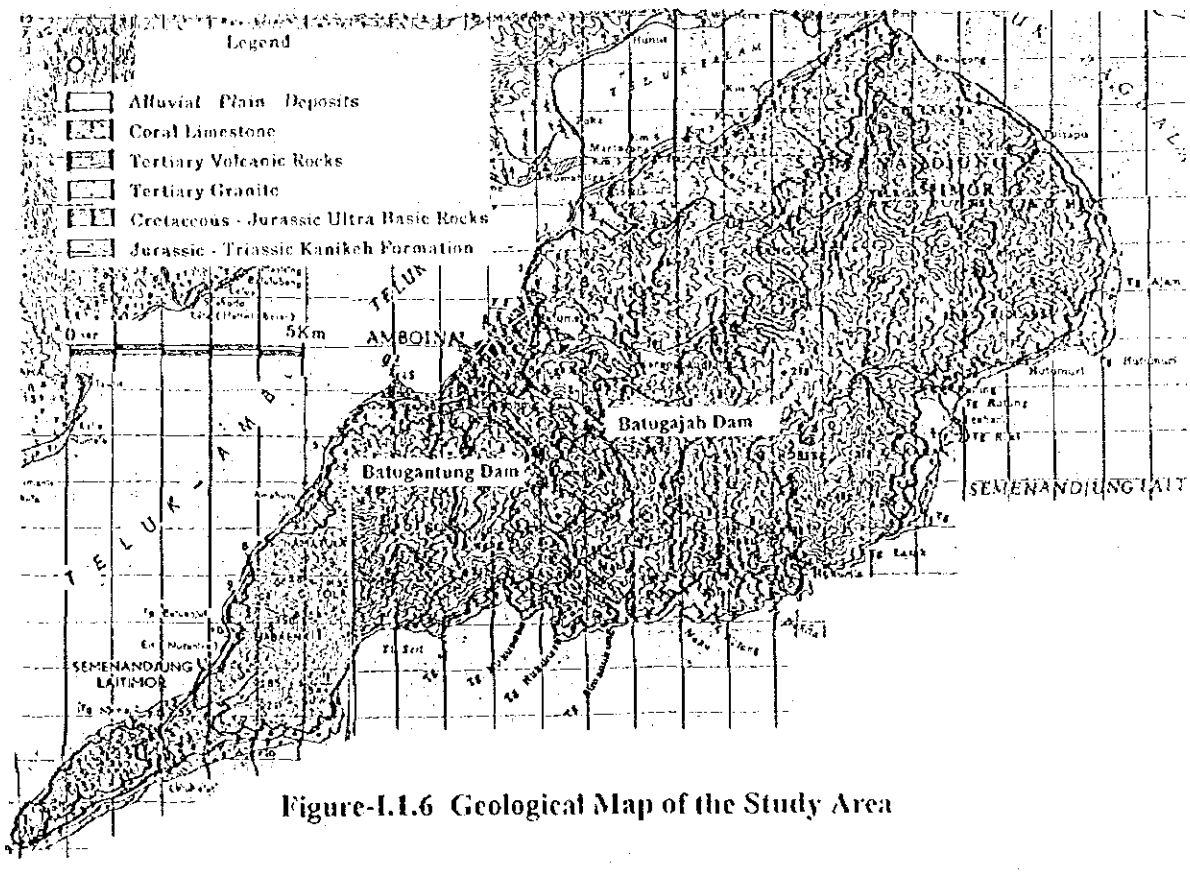


Figure-I.1.6 Geological Map of the Study Area

1.2.2 Land Use

(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, namely Upstream Area and Central City Area (Refer to Table-I.1.2). The Upstream Area is mostly covered with bushes and grass although cropping trees and small cultivated farmland are also observed. The Central City Area covers most of the urban area in Ambon City. Table-I.1.10 describes the overall land use situation of Ambon City, the Central City, and the upstream area.

Table-I.1.10 Land Use Situation

Land Use Type	Ambon City (50 Desa / Kelurahan)	Central City Area (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%	94%	7%
- Residential Area	16%	92%	7%
- Industry, Office, Shop, etc	1%	2%	0%
Un-used Land	20%	2%	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 Area for statistical purposes, the residential area also includes un-populated hillsides, where grass and bushes predominate because the steep land does not allow for construction of houses.

According to the "Current Land Use", Figure-I.1.7, 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 Batu Merah, Batu Gajah and Batu Gantung rivers, mixed garden and grass and bush areas predominate most of the upstream area of the five rivers.

(2) Future Land Use

Ambon City : According to the "Future Land Development", Figure-I.1.8, prepared by BPN, 40% of the total study area is designated as forest reserve. However, since there are currently no substantive restrictions on land use, some new settlements are already established in this area. Human settlement on the hillside should be restricted in order to prevent further soil erosion of the mountain.

Study Area : 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 to be used primarily for housing and commercial activities. The population has saturated the Central City, especially along the five rivers, and thus Karang Panjang, which is located on the hillside along the Central City, was chosen by Ambon City as one of the recipient areas for future populations. However, the Karang Panjang city plan has not materialized because of the high costs of development on the hillside. The city population will continue to spread mainly outside of the Central City, along the Ambon Bay.

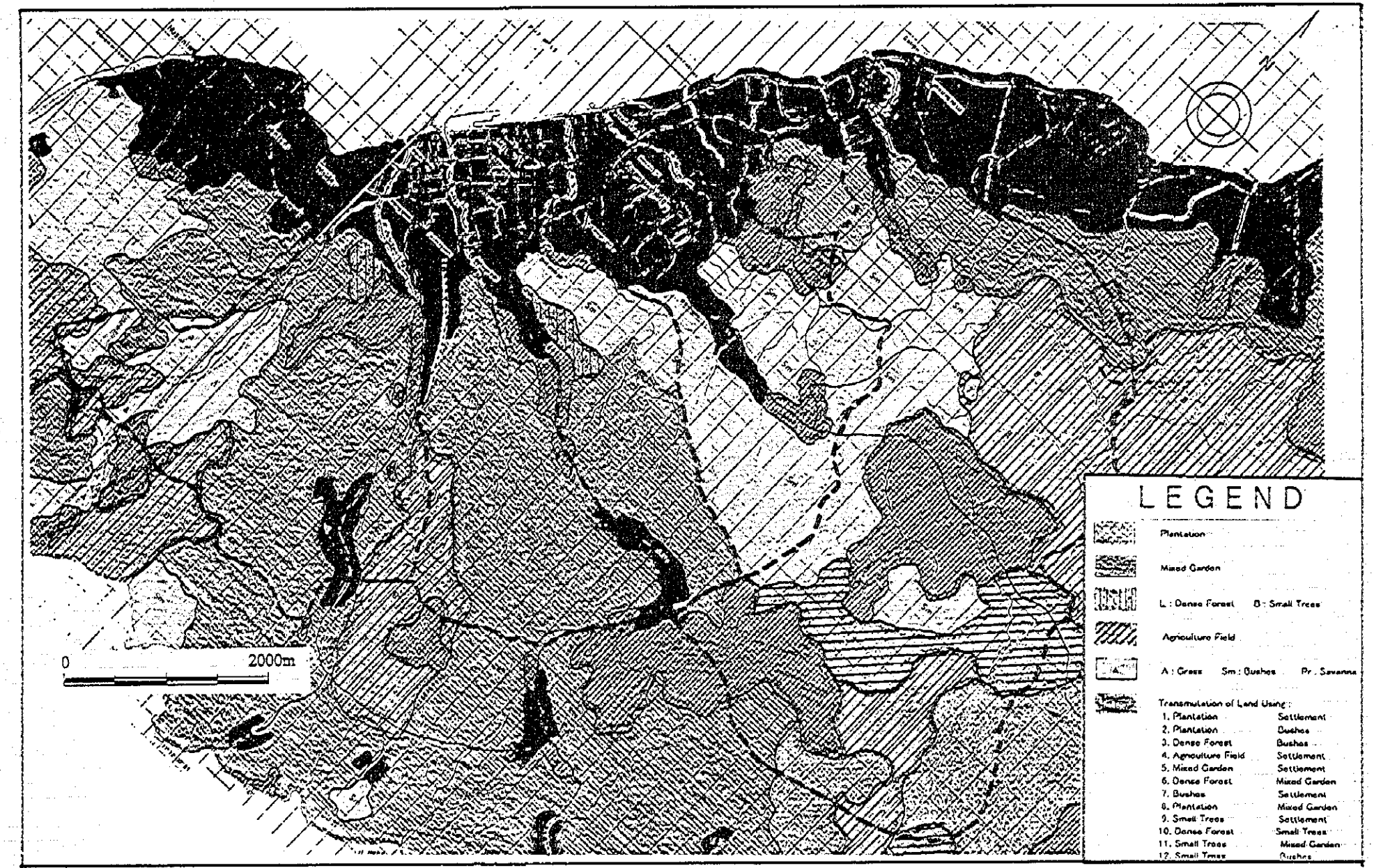


Figure-I.1.7 Current Land Use
Source : BPN (National Land Agency)

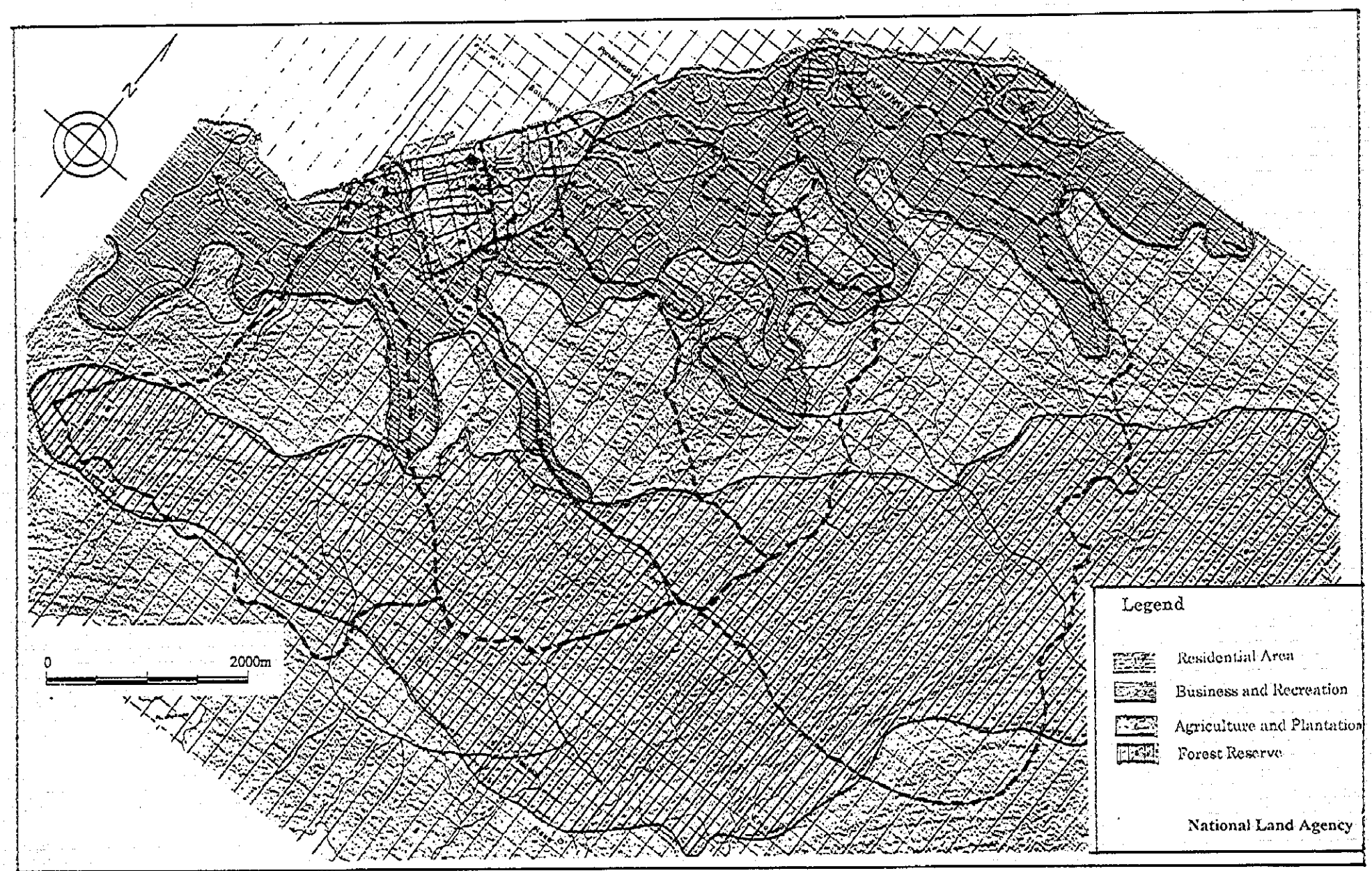


Figure-I.1.8 Future Land Development
Source : BPN (National Land Agency)

1.3 Hydrology and Flood Damage

1.3.1 Climate

The climate in Indonesia can generally be described as marine tropical with high temperatures and much rain. Temperature variation is small and there is a rainy season from October to March and a dry season from April to September. The division of the rainy season and dry season is usually clear in the west region from Sumatra to Bali and in Irian Jaya, but the rainy season is shorter in much of the east region except for Irian Jaya.

In the study area of Ambon, the rainy season is from May to September and the trend is exactly the opposite of the west region from Sumatra to Bali. The weather conditions in the Ambon Study Area are outlined in Table-I.1.11. The average temperature and humidity are as high as 26.1 °C and 83 % respectively, indicating a hot and humid climate. Figure-I.1.9 characterizes the seasonal fluctuation of weather.

Table-I.1.11 Weather Conditions in Ambon Area (Pattimura Ambon Station)

Month/Year	Rainfall (mm)	Fine Weather Ratio (%)	Relative Humidity (%)	Maximum Temperature (°C)	Minimum Temperature (°C)	Average Temperature (°C)
January	135	54	79	31.5	23.8	26.8
February	100	60	78	31.6	23.8	27.1
March	152	65	80	31.2	23.6	26.8
April	179	63	84	30.7	23.6	26.6
May	396	54	87	29.7	23.6	26.1
June	556	38	88	28.6	23.2	25.3
July	511	37	86	27.8	22.7	24.8
August	367	42	85	27.7	22.7	24.8
September	284	62	85	28.7	22.7	25.2
October	113	71	83	29.9	23.1	26.1
November	74	77	81	31.3	23.6	27.1
December	124	59	81	31.5	23.7	26.9
Total/Average	3,000	57	83	30.0	23.4	26.1

Note : Figures are average values from 20 years between 1976-1995.

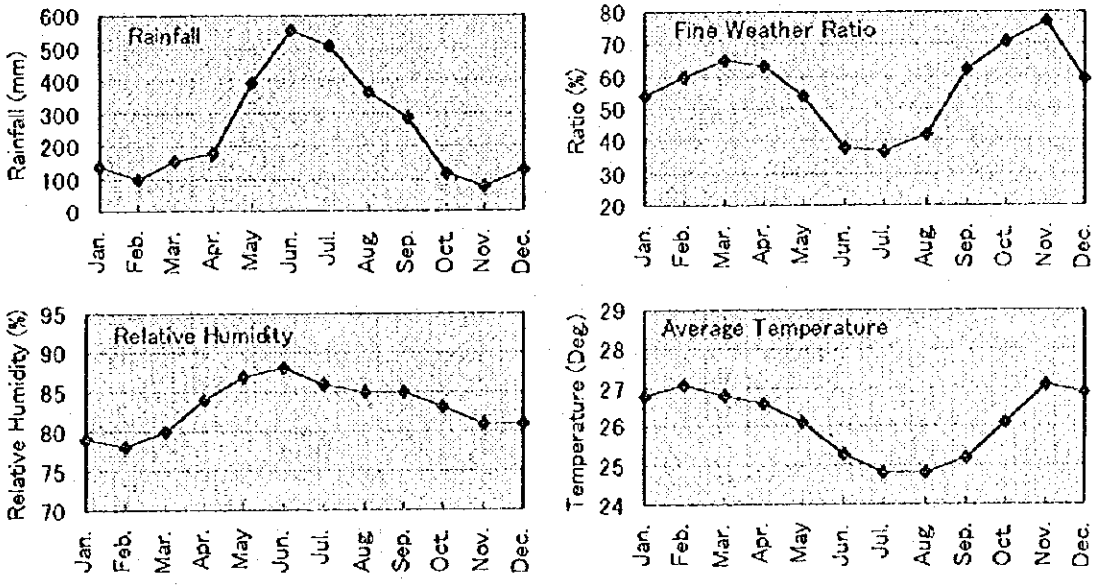


Figure-I.1.9 Seasonal Fluctuation of Weather at Pattimura Ambon Station

1.3.2 River Systems and Hydrology

(1) River Systems

The Study area includes the basins of the five rivers named Ruhu River, Batu Merah River, Tomu River, Batu Gajah River and Batu Gantung River, from the north. The catchment areas and main river lengths are shown in Table-I.1.12 and the river systems and basin boundaries are illustrated in Figure-I.1.11.

Table-I.1.12 Catchment Area and Length of Study Rivers

River Name	Catchment Area (km^2)	Length of Main Course (km)
Ruhu River	16.84	12.7
Batu Merah River	7.03	7.3
Tomu River	5.64	7.0
Batu Gajah River	5.97	6.7
Batu Gantung River	6.87	5.7

The longitudinal profiles of these five rivers are shown in Figure-I.1.10 and are summarized as follows :

- Ruhu River, the most northerly of the target rivers and whose downstream and river mouth is away from the other rivers, has the largest basin and the most gentle river slope of the five rivers.
- Batu Merah River, Tomu River and Batu Gajah River, which are located in the center of the central city area, have similar features of basin area and slope. However, Batu Merah River has a slightly more gentle slope than the other two rivers.
- Batu Gantung River, which is located to the south of the target rivers, has the steepest slope of the five rivers.

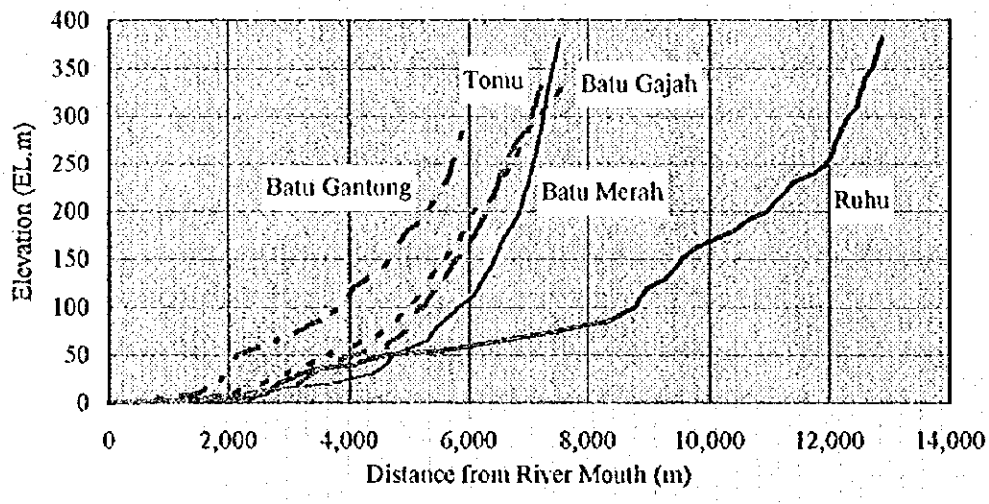


Figure-I.1.10 Longitudinal Features of the Target Five Rivers

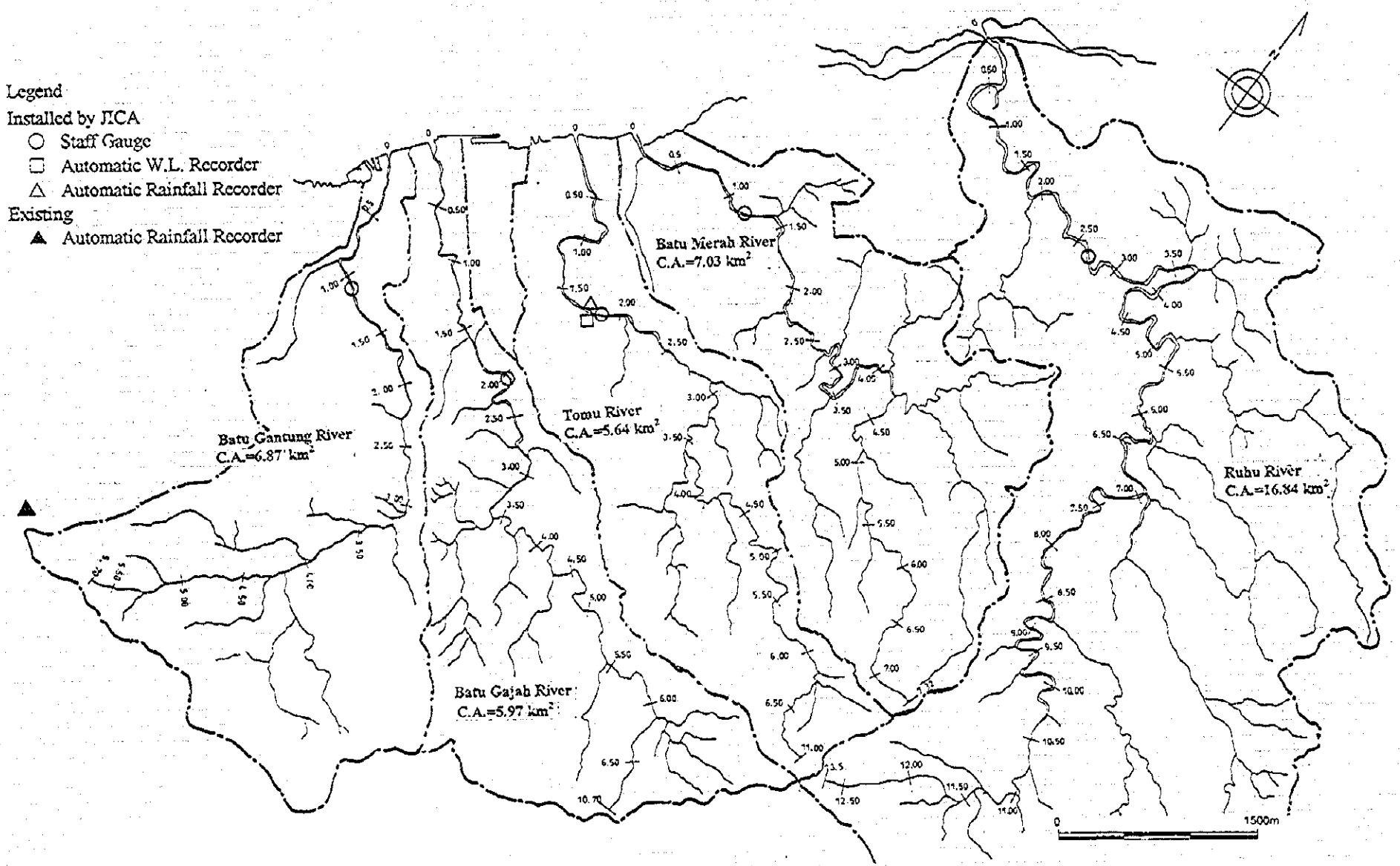


Figure-I.1.11 River Systems of the Target Rivers

(2) Hydrology

(a) Observation Stations

The following hydrometric observation stations were installed in the Ambon area by the Study Team :

- Automatic rainfall recorder (ARR) : 1 in Ambon
- Automatic water level recorder (AWLR) : 1 in Ambon
- Staff gauges : 5 in Ambon (1 on each river)

The locations of the observation stations installed by the Study Team in the Ambon area are shown in Figure-I.1.11 and the stations are listed in Table-I.1.13 below. The catchment areas at the location of each staff gauge and for each river basin are also indicated.

Table-I.1.13 Installed and Existing Observation Stations

Target Area	Item	Station Code	Condition	River or Basin	Catchment Area (km^2)	
					Station	Total
Ambon Area	Staff Gauge	S-RH-1	Renewal	Ruhu River	14.91	16.84
		S-BM-1	New	Batu Merah River	6.14	7.03
		S-TM-1	Renewal	Tomu River	3.99	5.64
		S-GJ-1	Renewal	Batu Gajah River	4.92	6.61
		S-GT-1	New	Batu Gantung River	5.89	6.87
	AWLR	AW-TM-1	New	Tomu River	3.99	5.64
	ARR	AR-TM-1	New	Tomu River	-	5.64
		AR-GT-1	Existing	Near Gantung River	-	6.87

AWLR : Automatic Water Level Recorder, ARR : Automatic Rainfall Recorder

(b) Flow Regime

Due to lack of discharge observation data, the H-Q curves were thus obtained by using the results of the uniform flow calculation with a roughness coefficient of n = 0.050. Flow regime for the target rivers was obtained by reviewing the data of past 10 years. Since there are only two years' observation data (from October 1994 to September 1996) of daily average water level, those for the other 8 years were estimated by using the daily flow rate data and considering a proportional conversion factor of the annual rainfall. The flow regimes are shown in Table-I.1.14.

Table-I.1.14 Flow Regime

Year	Flow Regime (m^3/s)							Volume of Run-off ($10X6m^3$)	Depth of Run-off (mm)
	Mean	Maximum (1)	High (95)	Median (185)	Low (275)	Drought (355)	Minimum (365)		
Ruhu River									
Mean	1.77	33.91	1.65	0.91	0.55	0.28	0.16	56.06	3,760
Specific Q	11.90	227.44	11.08	6.11	3.72	1.86	1.10	-	-
Tomu River									
Mean	0.34	4.00	0.47	0.14	0.12	0.11	0.06	10.56	2,647
Specific Q	8.45	100.14	11.88	3.52	3.02	2.82	1.61	-	-
Batu Gajah River									
Mean	0.39	5.03	0.43	0.22	0.13	0.10	0.00	12.13	2,459
Specific Q	7.84	102.18	8.65	4.41	2.69	1.96	0.00	-	-

Notes : - Rainfall data for the years 1984, 1987-1989 and 1994 are not available.
- Specific Q : Specific Discharge ($m^3/s/100km^2$)

1.3.3 Flood Damage and Flood Forecasting and Warning System

(1) Experienced Flood Damage

Based on the flood damage survey, the inundation area of each flood for each river were drawn and areas are shown in Figure-I.1.12. Inundation area, inundation flood water depth, inundation hours and the number of hours required for cleaning / repairing damaged houses are summarized in Table-I.1.15.

Table-I.1.15 Features of Past Flood Damage

Item	Flood	Ruhu		Batu Merah		Tomu		Batu Gajah		Batu Gantung	
		Ave.	Max.	Ave.	Max.	Ave.	Max.	Ave.	Max.	Ave.	Max.
Flooded Area (ha)	1984/06/22	-	28.2	-	14.7	-	16.7	-	27.3	-	11.5
	1989/06/22	-	28.4	-	18.5	-	30.5	-	29.2	-	7.8
	1996/08/22	-	5.3	-	15.3	-	8.5	-	9.9	-	8.3
	Annual	-	5.3	-	11	-	7.6	-	8	-	4.2
Flood Water Depth (cm)	1984/06/22	75	150	118	400	116	189	84	170	75	120
	1989/06/22	84	200	160	450	125	220	87	190	45	100
	1996/08/22	48	150	92	180	43	150	69	165	29	75
	Annual	43	80	41	100	23	60	44	80	32	75
Inundation Hours (hour)	1984/06/22	5	7	6	11	3	7	6	12	11	24
	1989/06/22	4	6	7	11	4	8	6	12	5	12
	1996/08/22	2	5	5	8	1	3	5	12	2	7
	Annual	2	4	2	6	1	1	3	4	3	7
Cleaning/Repairing Days (day)	1984/06/22	3	7	6	30	2	7	2	7	3	9
	1989/06/22	3	14	9	60	2	7	2	7	2	3
	1996/08/22	2	9	3	25	1	2	2	3	2	3
	Annual	1	2	2	20	1	2	1	2	2	3

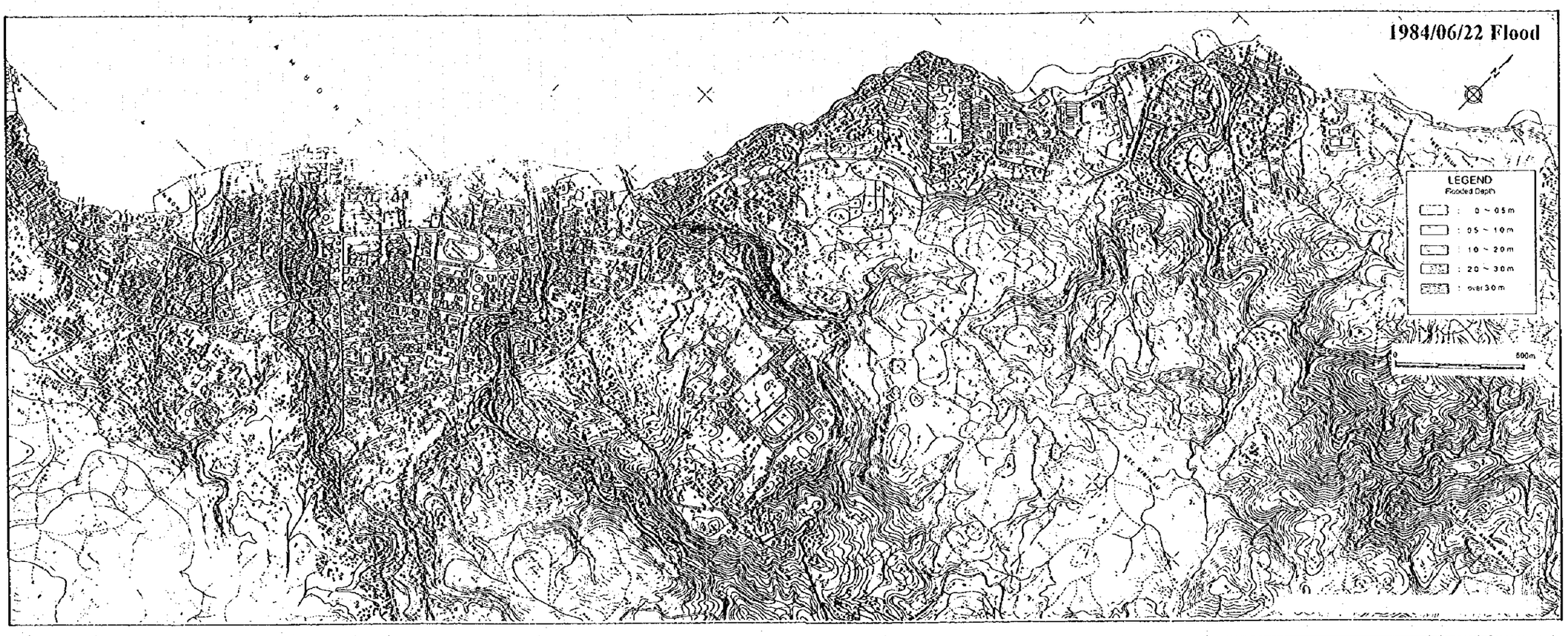
(2) Flood Forecasting and Warning System

(a) Flood Forecasting System

Floods, as one of the natural disasters in traditional society life, can be forecast by interpreting natural indications such as rainfall. For inhabitants in Ambon, flood forecasting is only based upon the experienced rainy season in June, July and August. In addition to forecasting based upon experience, Central Meteorological Office Ambon said that flood occurrence depends completely on the rainfall intensity and flood will occur if the rainfall reaches 230-450 mm/day.

(b) Flood Warning System

To protect people from either material loss or personal injury caused by flood disaster, it is necessary to take preventive action by providing flood warning system for inhabitants living in flood prone areas. In certain areas, flood warning information is usually provided by the mosque drum, church bell, traditional wooden signal drum or other means depending on local conditions. Flood information is also given from the government level directly or indirectly by telephone. However, for most people living in the study area, generally there is no flood warning system. It is found that the most common warning system is limited to shouting on the river banks.



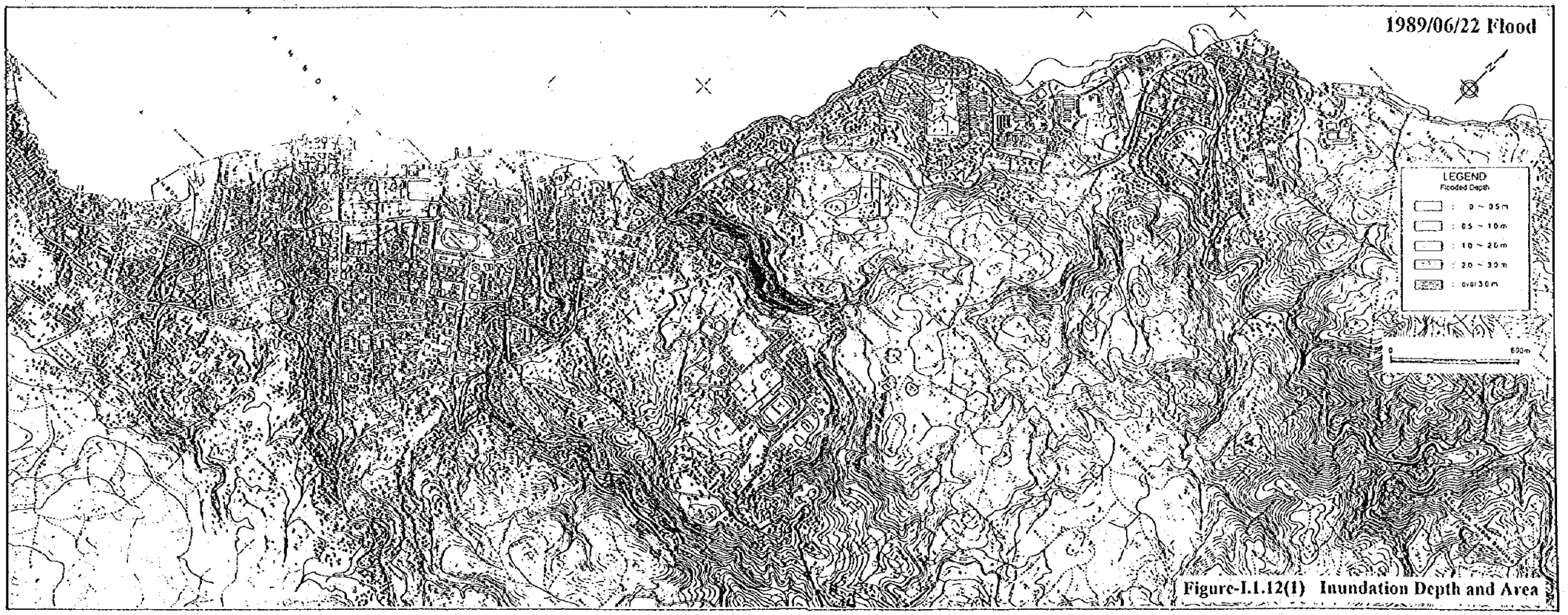
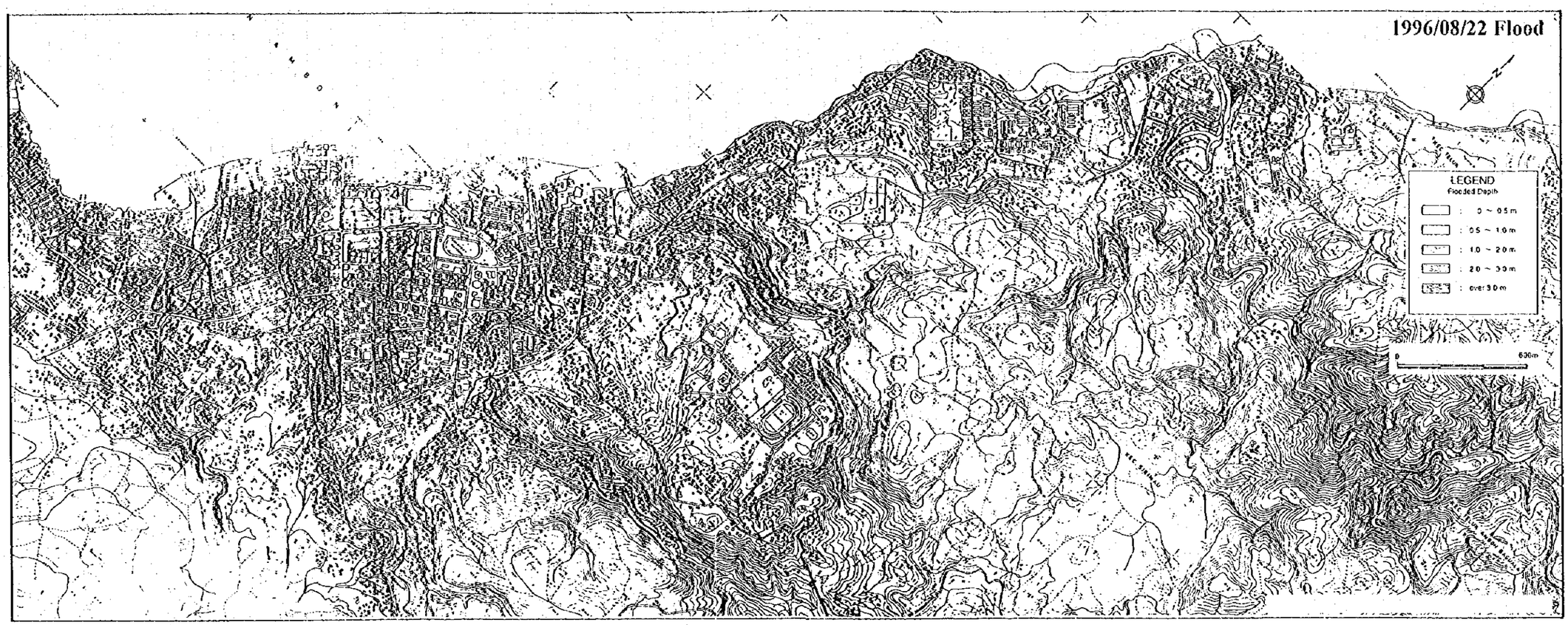


Figure-I.1.12(1) Inundation Depth and Area



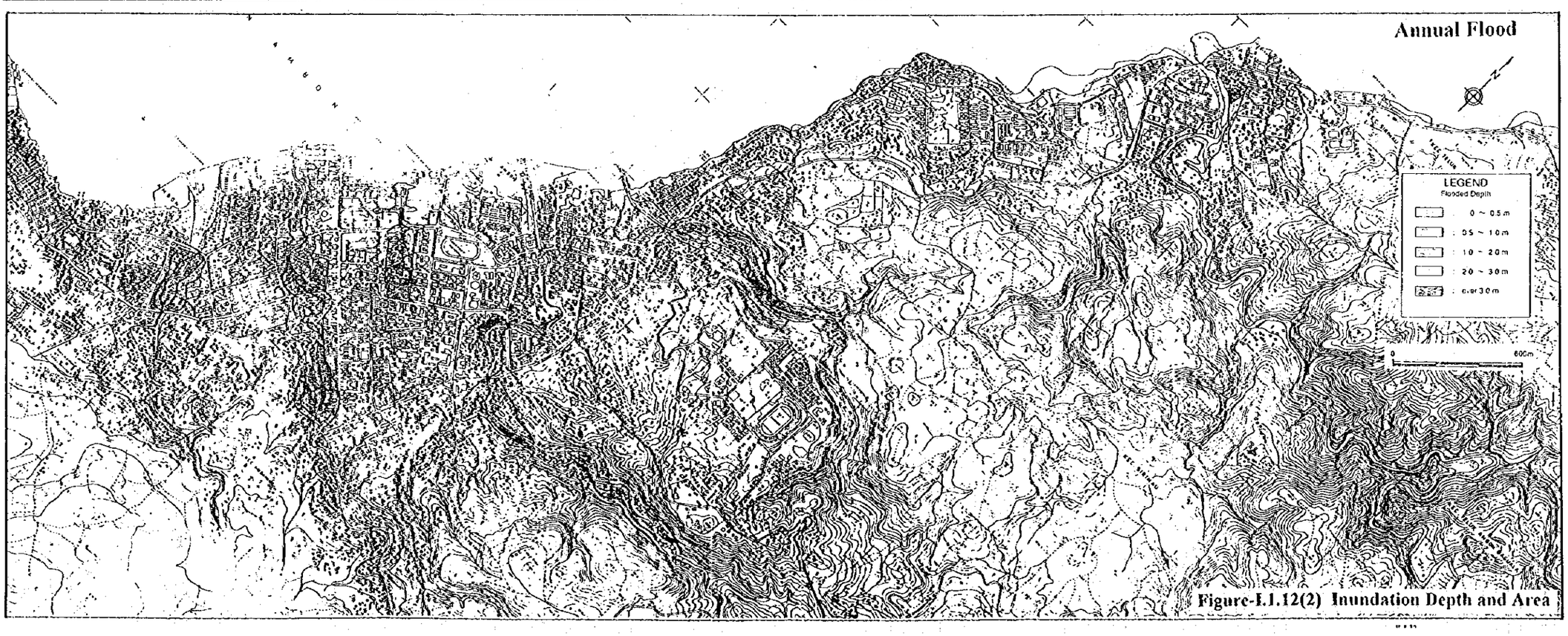


Figure-I.1.12(2) Inundation Depth and Area

1.4 Water Use and Demand

1.4.1 Current Water Use

(1) Domestic Water Use

Water for domestic use in Ambon city is provided by PDAM through both individual household connections and public taps. The main water sources are springs and deep wells connected by a distribution network. No water treatment is currently provided although chlorination is sometimes necessary at water supply reservoirs. Drinking water for areas not served by PDAM is usually taken directly from springs or wells.

PDAM currently serves 20 of Ambon's 50 Desa / Kelurahan, mostly within the Study Area. It is estimated that water supply by PDAM reaches 28% of the city residents. Some industry or commercial facilities have their own source of water and others have metered connections with PDAM. Around 70% of PDAM's water is sold for domestic use. The following Table-I.1.16 shows the number of connections, amount of water sold and the PDAM revenue from the sales of water, by category of consumers in 1995.

Table-I.1.16 Connection and Sales of Water by PDAM in Ambon City (Average 1995)

Item	Number of Connections*	Amount of Water Sold ('000 m3)	Revenue from Water Sales (Rp million)	Unit Price (Rp/m3)
Domestic Water Sales	**8,245**	**2,456**	**1012.2**	**412**
Households	8,117	1,897	929.6	490
Public Taps	128	559	82.6	148
Non-Domestic Water Sales	**926**	**1,077**	**713.6**	**663**
Government	111	544	310.9	572
Commercial	720	214	193.4	904
Industry	6	171	33.5	196
Others	89	148	175.8	1,188
TOTAL	**9,171**	**3,533**	**1725.8**	**488**

*as of Dec. 31, 1995

Source : processed from PDAM monthly report

From the above table, per capita water consumption can be estimated for both household connections and public taps. PDAM assumes that each household has an average of 6.5 occupants which means that approximately 53,000 people obtained water from household connections in 1995. Using the annual total of water sold, the per capita consumption is estimated at 98.5 liters/capita/day (lcd) for consumers supplied by household connections.

It is more difficult to estimate the consumption of the population served by public taps. PDAM assume that each tap supplies 100 people with an average supply of 35 lcd. This estimate appears far too low as the total supplied would be only 164,000 m^3/year compared to the actual volume sold in 1995 of 559,000 m^3. However, based on interviews conducted by the JICA Study Team, it was found that the typical charge for use of water from a public tap is Rp 1,500 per household per month. Using this value, the number of households using water from public taps is approximately 4,600, or about 30,000 people assuming 6.5 occupants / household. This figure is equivalent to a per capita consumption of 50 lcd.

(2) River Water Use

Water for other domestic uses such as washing of clothes and personal washing is also taken

from springs and wells. Springs are often located within the river water course and it is common to see women and children doing laundry at the sides of the rivers.

The rivers through the city are used extensively by the urban population as a means of garbage disposal. Many toilets are also located in the river courses and consequently the water quality is of a very low standard.

(3) Non-Domestic Water Use

There are no large industrial water users in the Ambon area. However, non-domestic water sales from PDAM still accounted for 45% of the total sales in the central city in 1995. 50% of the non-domestic water sales were to government customers, including government offices, schools, hospitals and other public facilities. PDAM also provides water to over 700 commercial customers, mainly shops, businesses, hotels and restaurants in the central city area of Ambon. Other commercial and industrial users have sunk deep wells to meet water supply requirements.

There is very little agricultural water use within the Ambon study area. Small scale agriculture in the upper river basins is rain fed only.

1.4.2 Future Water Demand

Future demand for domestic and non domestic water use has been predicted for the Study Area and for the whole of Ambon City until the Year 2030. The results are summarized in Table-I.1.17 below and given in full in Table-I.1.18. The results are presented graphically in Figure-I.1.13 and explained below.

Table-I.1.17 Summary of Future Water Demand (m^3/day)

Year	1996	2000	2005	2010	2015	2020	2025	2030
Population Projection								
Study Area	160,851	164,670	169,609	174,742	180,078	185,631	191,413	197,437
Ambon Municipality	305,252	326,544	355,261	386,502	420,490	457,469	497,689	541,466
Domestic Water Demand								
Study Area	3,700	5,146	7,208	10,266	12,605	14,850	16,749	18,757
Ambon Total	7,021	10,205	15,099	22,707	29,434	36,598	43,548	51,439
Non Domestic Demand								
Study Area	3,027	4,210	5,898	8,400	10,314	12,150	13,703	15,346
Ambon Total	3,027	4,477	6,774	10,595	14,521	17,587	20,403	23,517
Total Future Demand								
Study Area	6,726	9,356	13,106	18,666	22,919	27,001	30,452	34,103
Ambon Total	10,048	14,681	21,873	33,302	43,955	54,185	63,951	74,956
System Losses								
Study Area	4,484	6,238	7,057	8,000	7,640	9,000	10,151	11,368
Ambon Total	6,698	9,787	11,778	14,272	14,652	18,062	21,317	24,985
Total Water Requirement								
Study Area	11,211	15,594	20,163	26,665	30,559	36,001	40,603	45,470
Ambon Total	16,746	24,468	33,651	47,574	58,607	72,246	85,268	99,942

According to the Water Supply System Development Plan included in the Final Report of the Eastern Island Urban Development Project, the aims of PDAM's regional service plan should be to :

- Meet the National Planning target of supplying water to 80% of the population in the serviced region by the planning target year of 2010.
- Extend water service to developed areas of Ambon not yet served by water supply.
- Improve the water service in the existing serviced area.
- Extend water service to planned development areas in accordance with regional urban development plans.

The prediction of future water demand in this Study is based on the objectives stated in the Water Supply System Development Plan, and makes the following assumptions :

(1) Domestic Water Demand

Population Projection

The projection of population growth for the Study Area and for the whole of Ambon city was outlined previously in Section 1.1.3.

Water Supply Coverage

Currently, less than 30% of Ambon's population is served by the PDAM water supply network. In accordance with National Planning, it is assumed that water supply coverage will be extended to 80% of the population by the target year of 2015. The PDAM plan aims to achieve 80% coverage by 2010 and assumes that 70% of the population will be served by individual household connections and 10% by public taps. This target is considered to be optimistic and the current prediction assumes 60% served by household connections and 20% by public taps by 2015. After this date, it is assumed that water supply coverage will continue to increase, aiming to serve 100% of the population by 2030 with the reliance on public taps reduced to 10%.

Per Capita Water Consumption

Per capita water consumption is estimated from current PDAM water supply statistics. A value of 100 liters/capita/day (lcd) is assumed for the individual household connections and 50 lcd for the population served by public taps. Although per capita water consumption can be expected to increase with the level of development, it is assumed to remain constant for estimation purposes until such time as the water supply service area is extended to serve most of the population.

(2) Non Domestic Water Demand

Non domestic water demand for government, commercial and industrial users currently accounts for 45% of the total water supplied by PDAM in the central Ambon area. The category of government includes schools, hospitals and other public facilities, in addition to government offices. Commercial users include shops, restaurants, hotels and businesses in the central city. It is assumed that the water demand by such consumers will remain at 45% of the total supplied in the central Study Area.

PDAM does not supply water for non domestic use outside the central city at the present time. However, as population grows in the outer areas of Ambon city, the need for facilities such as shops and schools will develop and so non domestic water demand will grow. The level of this water demand is assumed to increase gradually to reach 20% of the total water demand in these areas by the target year of 2015.

(3) System Losses

Current water losses are estimated by PDAM to account for nearly 40% of the total water volume abstracted from the springs and deep wells serving Ambon. This value for system losses is based on the difference between the measured (estimated) volume of water supplied and the known volume of water sold. Although the PDAM Development Plan gives the reduction of system and production losses a high level of priority, the assumed improvement from 40% at present to only 20% by the year 2000 is considered overly optimistic. For the purposes of this water demand projection, the system losses are assumed to remain at 40% until the year 2000 and thereafter reduce gradually to 25% by the target year of 2015. To achieve even this improvement, significant investment to replace leaking transmission and distribution networks would be required. Further reduction of losses beyond 25% of total volume of water produced is not considered feasible.

(4) Total Water Requirement

As shown in Tables-I.1.17 & 18 and in Figure-I.1.13, the total water requirement for the whole of Ambon municipality will increase from the present production of around 16,700 m^3/day (194 l/s) to over 58,000 m^3/day (670 l/s) in 2015 and to nearly 100,000 m^3/day (1,160 l/s) by 2030. This represents an increase of 350% to 2015 and nearly 600% to 2030 over present production levels. The figures for the current Study Area, corresponding to the central city area where the majority of non-domestic water users are concentrated, are 30,000 m^3/day (350 l/s) in 2015 increasing to over 45,000 m^3/day (520 l/s) by 2030. The percentage increase in required water volume from the current capacity of 11,200 m^3/day (130 l/s) is 270% to 2015 and 400% to 2030.

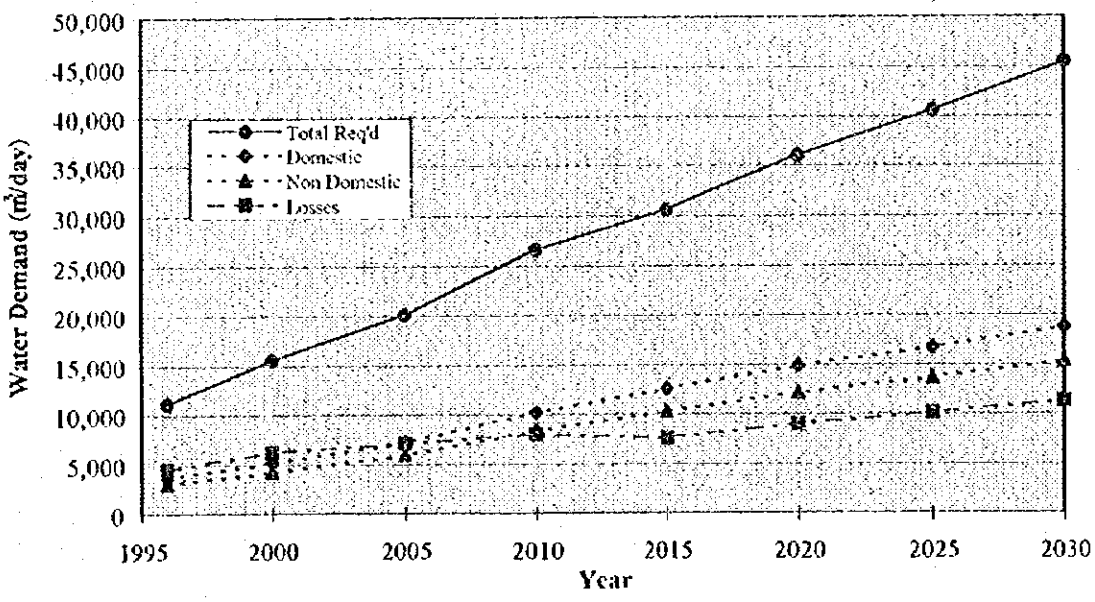


Figure-I.1.13 Future Water Demand Projection (Study Area : Central City)

Table-I.1.18 Future Water Demand Projection

Year		1996	2000	2005	2010	2015 Target	2020	2025	2030
Population Projection									
Ambon Municipality Total		305,252	326,544	355,261	386,502	420,490	457,469	497,689	541,466
Study Area		160,851	161,670	169,609	174,742	180,078	185,631	191,413	197,437
Other Areas		144,401	161,874	185,652	211,760	240,412	271,838	306,276	344,029
Water Supply Coverage									
Households	%	18.0	25.0	35.0	50.0	60.0	70.0	80.0	90.0
Public Taps	%	10.0	12.5	15.0	17.5	20.0	20.0	15.0	10.0
Not Served	%	72.0	62.5	50.0	32.5	20.0	10.0	5.0	0.0
DOMESTIC DEMAND									
Study Area									
Population Served									
Households		28,953	41,168	59,363	87,371	108,047	129,942	153,130	177,693
Public Taps		16,085	20,584	25,441	30,580	36,016	37,126	28,712	19,744
Not Served		115,813	102,919	84,805	56,791	36,016	18,563	9,571	0
Water Demand	m^3/d								
Households : 100 lcd		2,895	4,117	5,936	8,737	10,805	12,994	15,313	17,769
Public Taps : 50 lcd		804	1,029	1,272	1,529	1,801	1,856	1,436	987
Total Demand	m^3/d	3,700	5,146	7,208	10,266	12,605	14,850	16,749	18,757
Other Areas									
Population Served									
Households		25,992	40,469	64,978	105,880	144,247	190,287	245,021	309,626
Public Taps		14,440	20,234	27,848	37,058	48,082	54,368	45,941	34,403
Not Served		103,969	101,171	92,826	68,822	48,082	27,184	15,314	0
Water Demand	m^3/d								
Households : 100 lcd		2,599	4,047	6,498	10,588	14,425	19,029	24,502	30,963
Public Taps : 50 lcd		722	1,012	1,392	1,853	2,404	2,718	2,297	1,720
Total Demand	m^3/d	3,321	5,059	7,890	12,441	16,829	21,747	26,799	32,683
Total Domestic Demand									
Domestic Demand	m^3/d	**7,021**	**10,205**	**15,099**	**22,707**	**29,434**	**36,598**	**43,548**	**51,439**
	l/sec	81	118	175	263	341	424	504	595
NON DOMESTIC DEMAND									
Study Area	%	45	45	45	45	45	45	45	45
Total Demand	m^3/d	3,027	4,210	5,898	8,400	10,314	12,150	13,703	15,346
Other Areas	%	0	5	10	15	20	20	20	20
Total Demand	m^3/d	0	266	877	2,195	4,207	5,437	6,700	8,171
Total Non Domestic Demand									
Non Domestic Demand	m^3/d	**3,027**	**4,477**	**6,774**	**10,595**	**14,521**	**17,587**	**20,403**	**23,517**
	l/sec	35	52	78	123	168	204	236	272
TOTAL DEMAND									
Ambon Total	m^3/d	**10,048**	**14,681**	**21,873**	**33,302**	**43,955**	**54,185**	**63,951**	**74,956**
	l/sec	116	170	253	385	509	627	740	868
Study Area	m^3/d	**6,726**	**9,356**	**13,106**	**18,666**	**22,919**	**27,001**	**30,452**	**34,103**
	l/sec	78	108	152	216	265	313	352	395
SYSTEM LOSSES									
System Losses	%	40	40	35	30	25	25	25	25
Ambon Total	m^3/d	6,698	9,787	11,778	14,272	14,652	18,062	21,317	24,985
Study Area	m^3/d	4,484	6,238	7,057	8,000	7,640	9,000	10,151	11,368
TOTAL WATER REQUIREMENT									
Ambon Total	m^3/d	**16,746**	**24,468**	**33,651**	**47,574**	**58,607**	**72,246**	**85,268**	**99,942**
	l/sec	194	283	389	551	678	836	987	1,157
Study Area	m^3/d	**11,211**	**15,594**	**20,163**	**26,665**	**30,559**	**36,001**	**40,603**	**45,470**
	l/sec	130	180	233	309	354	417	470	526

1.5 Environment

1.5.1 Social Environment

(1) Resettlement and Land Acquisition

Ambon City has a couple experiences in land acquisition and resettlement. The largest resettlement took place for the construction of the fishery port in Pandan Kasturi (Kelurahan Batu Merah), implemented by the provincial level of the Directorate of Fishery, Ministry of Agriculture in the fiscal years 1985/86 and 1986/87. The project was initially financed by the national government, but the financing was eventually taken over by the Asian Development Bank due to budget constraints.

The project site is located in the center of Ambon City. It consisted of two communities (Desen), composed of 34 households and 174 households. Most of the villagers were small retailers and the housing environment was relatively poor. Mainly due to the budget constraints of the Government, the authorities could obtain substitute land for the small one of the communities (34 households) in Kebon Cengkeh in the same town (Kelurahan), which is located 2 km away from Pandan Kasturi. On the other hand, 174 households had to be displaced to Desa Wayheru, 20 km away from downtown Ambon where most of the villagers worked, regardless of villagers' wishes to stay closer to town. In order to avoid land speculations, the Government held a meeting to explain about the project only three months before the actual acquisition of the land. Compensation payment was also discussed in the same meeting, in the form of collective negotiations.

The following facts were learned from the interview with the Head of the Desen resettled to Waiheru. Although villagers had been requesting the issuance of land titles to the National Land Agency (BPN) for a long time before the project was decided, only three households had been issued the land titles due to slow administrative procedures. However, all the villagers were finally given the right for full land tenure since customary land tenure was commonly acknowledged in Ambon City. Housing and moving costs were paid in cash, and substitute land was given in Waiheru, where infrastructure was prepared by the Government. At first, the villagers were not content with the new living environment because: 1) it costs them Rp. 1,200 every day to commute between Waiheru and the downtown; 2) there was some friction between the resettlers and the existing community since the former were Muslims and the latter were Christians; and 3) public facilities such as electricity and water were not available immediately to each household. However, these problems were settled eventually. Around half of the resettlers bought farmlands close to their houses and as a result, their overall income has increased due to the sales of food crops such as cassava. Religious conflicts have been subdued after the heads of communities talked with each other and mutual understanding was attained. With their resettlement compensation, villagers could built houses that were bigger and nicer than their old houses in Pandan Kasturi.

(2) Historical Sites and Protected Areas

In the Study Area, there are three historical sites designated by Maluku Province Government as protected cultural properties: Victoria Fort, Devil Foot Print and Japanese Cave. The Victoria Fort was built by Dutch more than 200 years ago when Indonesia was under the control of the colonialism government. The Devil Foot Print was found on a huge rock near

the upper stream of Tomu River. The Japanese Cave is a cave used by Japanese Army in 1942-1945 during the Second World War. It has been preserved as a historical site for patriotic education.

Near the Study Area, two forest areas, Gunung Sirimau and Gunung Nona have been designated as protected areas by Maluku Province Government. Only a small part of the Gunung Sirimau Forest Area is within Ruhu River watershed but to the extremely upper stream side, and the Gunung Nona Forest Area is completely outside the Study Area.

(3) Public Health

In Ambon Municipality, there are 9 hospitals with a total number of 849 beds in 1995. Considering the total population of 286,475 (datum of 1995), the medical service is at a level of 337.5 persons/bed on average. There are also 17 community health centers and 30 sub-centers for simple medical care. There are totally 1,161 staff working for medical service, including 74 doctors and pharmacists and 625 nurses. Data were collected regarding the disease and illness treated in hospitals and health centers in Ambon Municipality from 1993 to 1995. Of the victims of diarrhea, the numbers of death in the 3 years are 13, 12 and 25 respectively. Since diarrhea is usually caused by contaminated food, drink, water etc., the comparatively high death rate is thought to be due to the poor sanitary condition. For example, 1995 was a year of fruits harvest in Ambon and the volume of garbage from fruits was far beyond the capacity of solid waste collection and disposal in the City. This resulted in emission of offensive odors and unusual growth of disease vectors such as flies and mosquitoes. This is thought to be the reason for the higher rate of death from diarrhea.

(4) Disasters

In the Study Area, river flooding is the main natural disaster which has resulted in serious damage. As for other natural disasters, there are no records at all. However, on December 31, 1996 earthquakes occurred in Ambon area several times with the magnitude of the biggest two quakes as 5.5 and 5.3 degrees on Richter scale and people in Central Ambon area experienced strong shake. Although there was no damage reported since the seismic center was 30 km south from Latuhalat Beach and 55 km below sea level, taking necessary measures to prevent earthquake damage may become a subject in the future. Besides natural disasters, fire incidents happen in Ambon Municipality and the whole island very often. The total number of fire incidents in 1995 amounted to 19 and one big incident occurred in a residential area. 219 households lost their homes and transmigrated to Seram Island.

(5) Environmental Sanitation

In the Study Area, domestic and industrial water is supplied by 1) Regional Water Supply Company (PDAM), 2) local water companies and 3) private wells and other facilities. PDAM water supply system including water resources (springs and wells), reservoirs and main water transfer pipes. Its distribution network mainly covers the central part of Ambon Municipality and serves about 30% of population in 1996. PDAM also has 5 mobile tankers for selling water to areas where the network does not cover. There are 8 local water companies selling drinking water by 10 mobile tankers mostly with spring water. However, the capacity of water supply and population served are not clear. There is hardly any treatment conducted before water is supplied to the customers. PDAM has chlorination equipment at some of the water

sources, but seldom being operated. As will be described in Section 1.5.3, water from many of the wells does not meet the drinking water quality standard especially for total coliform and/or fecal coliform. Although people usually drink boiled or bottled water, there is still considerable risk of bacterial infection through gargling, kitchen ware washing etc. using contaminated water.

There is no public sewer system in Ambon and therefore natural rivers and streams receive most of the domestic sewage and even night soil from all residential areas and finally discharge them into the Ambon Bay. Many toilets are located directly on the rivers. The condition is worse at the downstream area where population concentrates and the pollutant amount far excesses the maximum allowable load that the river can perform self-purification functionally. The only sewerage facility in Ambon Municipality is a sewage disposal plant newly built and put into operation in later 1996. There are 9 stabilization ponds to perform anaerobic and/or facultative decomposition of the sewage from septic tanks collected by 2 vacuum tankers from city area.

As for sanitary facilities used in Ambon Municipality, about 36% of the population are served with water closets but about one third of the population do not have proper toilets to use.

(6) Solid Waste

Regarding facilities employed in Ambon Municipality for solid waste collection and disposal, there had been only one open dump site for final disposal until 1995. A new sanitary landfill site was put into service in 1996. According to statistic data, about 95% amount of the solid waste is disposed daily. However, heaps of garbage are seen everywhere on road sides, river banks, sea shore and residential areas. Arbitrary dumping of garbage into the river is another reason of river water contamination.

1.5.2 Natural Environment

(1) Flora and Fauna

Flora in the Study Area can be categorized as those in the protected forest, community forest, agroforestry area and gardening area. Data were collected regarding the main species in these areas. There is no information on endangered flora species.

Wildlife in the Study Area is dominated by several species of birds found in the forest area such as Lorry, Parrot, Bayan, Perkici, Wild chicken, Wild pigeon, Crested dove etc. There exist also Wild boar, Momitor lizard, Snake, Deer and Wild dogs. The number of species are decreasing gradually with the increase of human activity such as deforestation and hunting. Kus-kus, a kind of mammal, is specified as endangered fauna species.

(2) Coastal Environment

The 5 rivers in the Study Area flow into the Ambon Bay which is a harvest area for fishery industry, functions as a passage for marine transportation and possesses tourist attractions, and therefore is very important to Ambon's development. The Research Center of Oceanology Development, LIPI has conducted a systematic investigation on the coastal environment of Ambon Bay. Study results show the characteristics of biodiversity of the Ambon Bay and its high potential of fishery production. Unfortunately the coastal

environment has been deteriorated recently due to human activities with the development in the relate areas, especially the coastal area near central Ambon. Deterioration of coral reefs and mangrove forests is the most serious result.

There used to be 10 locations with well grown coral communities. Of them only the 3 near the outlet of the Bay are still in good condition. The others have been damaged gradually and the coral reef at Pandan Kasturi, a location near the estuaries of Ruhu River and Batu Merah River, has already disappeared. Damage on coral reefs is due to many natural and human related reasons. Generally speaking, coral reefs can only grow in warm salt water where sunlight can penetrate sufficiently. In an estuary area, sediment runoff causes sea water turbid, shuts out light penetration and therefore results in an environment unsuitable for corals to grow. This condition is observable in the Study Area. Of course human activities such as fishing using dynamite or cyanide, motor boat sailing, collection of coral stone, may cause physical and chemical damage on coral reefs.

Of the 5 rivers in the Study Area, the estuary of Ruhu River (Galala) used to possess large area of mangroves. However, all mangrove trees were cut out in these 10 years before houses and workshops were built near the river mouth. The ruin of mangroves can still be found in that area. Similar thing occurs at other mangrove locations as well. Collection of firewood for everyday life and clearance of land for house construction are the main reasons of mangroves deterioration.

(3) *Landscape*

Topographically the Central Ambon can be categorized to three zones: sea front, plateau and mountain zones. With different characteristics, the three zones composite a unique landscape of this area. The sea front zone faces the Ambon Bay where rugged coastline bends counterclockwise to the inner bay side and extends to the outer bay side. Ambon Bay is famous for its beaches with various sand texture and beautiful coral reefs which attracts tourists from all the world for marine activities as diving, snorkeling etc. However, such kind of spots have gradually disappeared from Central Ambon area due to increasing development activities. Most of the plateau zone is covered with tropical rain forests. Although deforestation has become a serious environmental problem recently, this zone is still a green area with trees, bushes and grasses. The government is starting a reforestation program to recover the deforested area. Mountains behind the plateau rise to 400 - 500 meters above the sea. Near the southwestern boundary of the Study Area, the Nona Mount is an attractive spot from where one can take a panorama view of the Central Ambon and Ambon Bay.

1.5.3 Environmental Pollution

(1) Water Pollution

In the Study Area, there are few existing data on river water quality due to lack of water quality monitoring. Only one report of LIPI mentioned high concentration of heavy metals such as Pb, Cd, Cu and Zn discharged from some rivers into Ambon Bay. This is thought to be from the solid waster dumped to the river. The results of water quality analysis conducted during this Study show that the 5 rivers in the Study Area have been severely polluted. By walking along the river side, it can be seen that sewage and night soil are flowing into the river from everywhere - houses, public facilities, toilets etc. Dumping garbage into the river is also a habit of the residents living near the river.

Groundwater is the source of water supply in Ambon. According to the data provided by the Dept. of Health, Maluku Province, groundwater in most of the wells in the Study Area is more or less contaminated and unsuitable to be used directly for drinking purpose according to the Ministry of Health Regulation No. 416/MENKES/PLR/IX/1990 for Drinking Water Quality, especially for total coliform bacteria. However, these wells are being used for domestic water supply without any treatment.

(2) Ocean Pollution

There are no monitoring data about water quality in the Ambon Bay. The only information available is from some reports of study conducted by the Research Center of Oceanology Development, LIPI in later 1980th and early 1990th. Sediment from river runoff is the main pollutant for the Ambon Bay. In a dry season or during a period with no rainfall, sunlight can penetrate to a depth of 17-30 m, while in a rainy season sunlight penetration depth is only 0.7-2 m. In the estuary area, sea water often turns yellow or greenish and indicates a condition of pollution by both sediment and microorganism. There are not COD or BOD analysis data, but an measurement of dissolved oxygen shows an average value of 5.12 ppm in July, 1990 (monthly rainfall 373 mm) and 5.33 ppm in October of the same year (monthly rainfall 17 mm). Sea water may have been slightly organically polluted. However, nutrient and heavy metal analysis results do not show much problem. Besides pollutant runoff from the river, dumping garbage and sewage directly into the sea is another reason for ocean pollution.

(3) Others

There are no monitoring data on air quality in the Study Area. However, air quality is thought to be good because there is almost no source of exhaust fumes except automobiles on the street.

Using of pesticides for agriculture is thought to be a problem to result in accumulation of toxic substances such as organic phosphate compounds etc. in the soil. But there are not any data available.

As for noise and vibration, there is no source of intense noise or vibration in the Study Area.

Offensive odor is often emitted from places where heaps of garbage are naturally decomposed or night soil and sewage are stagnated. The situation is serious in downstream area of the rivers. However, no data are available on offensive odor analysis.