PART II

FLOOD CONTROL FOR PASAHARI AREA

CHAPTER 1 GENERAL CONDITIONS OF THE STUDY AREA

1.1 Socio-economy

1.1.1 Current Socio-economic Conditions

(1) Current Social Conditions

Transmigration to Seram Island is concentrated in the Pasahari Area. It is located in the Seram Utara Sub-District of the Central Maluku District. The study area is composed of seven villages (Wailoping, Kobi, Waitonipa, Marasahua, Morokai and Samal) and other new transmigration units outside the villages. Most of the families in the Pasahari Area migrated under the Government's transmigration policy. There were 27 resettlement units as of August 1996.

The Seram Island transmigration was started in the fiscal year 1982/83, and was administrated by the Transmigration Agency. Eight areas were selected as the destinations for transmigration to Seram Island: Samal I (on the right bank of the Samal River), Samal II (on the left bank of the Samal River), Kobi and Lofin, Matakabo, Bote, Musala and Namto, out of which Samal I, Samal II and Kobi are located within the Study Area. According to the Transmigration Agency, total transmigration to Seram Island will number 9,800 households by the time the program is completed; around 7,000 households have already migrated. Each of these households has been provided with two ha of land: one ha for main crops, 3/4 ha for supplemental crops and 1/4 ha for housing. Table-II.1.1 shows the number of households and population in the Study Area, including both transmigrated and local people.

Table-II.1.1 No. of Households and Population in the Study Area (December 1996)

Transmigration Area	Potential Irrigation Area	No. of Households	Population
Samal I	2,217 ha	1,488	5,764
Samal II	2,500 ha	815	3,500
Kobi	2,898 ha	1,779	6,522
TOTAL	7,515 ha	4082	15,786

Source : JICA Study Team

There are currently five resettlement units in Samal I, six units in Samal II and eight units in Kobi. Most of the families originate from East or West Java, where Islam is the only religion. There are also several small groups of native families in the Pasahari Area. Overall, the relationship between the resettlers and native residents has been good; native residents provide seeds to resettlers, who, in turn, transfer rice plantation technology to native residents (rice was not produced in this area before the transmigration). According to interviews with resettlers, more than 100 households went back to Java after the severe dry season in 1988 (all rice fields were rain-fed at that time) and several have already returned to Pasahari. All the resettlers who transmigrated in the 1980s have already been issued land certificates.

Social facilities such as schools, clinics and religious facilities are provided by the Government under the transmigration scheme. No public transport is available yet; bicycles and motorcycles are the major means of transport within the villages, while private trucks/vehicles are available for transport between or outside the villages.

(2) Irrigation Scheme

The construction of the Ministry of Public Works' irrigation scheme, which has mainly been financed by the Asian Development Bank, started in the fiscal year 1993/94. It is expected that construction on 1,884 ha in Samal I and 1,411 ha in Kobi (and 281 ha in Lofin) will be completed by the end of the fiscal year 1996/97. Although the construction of the irrigation network in Samal II is envisaged for the fiscal year 1998/99, the designing phase has not yet begun due to budgetary constraints. Financing by the OECF for the uncompleted part of the irrigation network for Samal I and Kobi is currently under consideration. The total construction costs are expected to be Rp 3,250 million for Samal I and Rp 10,550 million for Kobi. Figure-II.1.1 shows the Ministry of Public Works' irrigation scheme in the Pasahari Area.

(3) Current Agricultural Production

The population is highly dependent on the agricultural sector for employment. With the exception of some small shops and restaurants, no industrial or commercial services exist. However, trading activities are expected to increase in accordance with the increase in agricultural production; food crops are already shipped to Ambon City through Kobisadar Port, which is located close to the mouth of the Samal River. This port is equipped with a relatively large pier that enables loading of agricultural products onto several medium-sized boats at one time. It takes about four days to go by boat from Kobisadar to Ambon.

The following table shows the production volume of major food crops, their planted area and productivity in the Pasahari Area.

Table-II.1.2 Planted Area and Production of Major Food Crops (Fiscal Year 1995/96)

Crops	Planted Area (ha)	Production (ton)	Productivity (ton/ha)
Rice (Wet Land)	649	3,505	5.4
Rice (Dry Land)	1,330	2,128	1.6
Maize	240	480	0.5
Mung Bean	70	70	1.0
Peanut	200	240	1.2
Soybean	1,550	1,550	1.0
Cabbage	9	27	3.0
Cowpea	6	15	2.5
String bean	4	6	1.5

Source: Department of Agriculture, Maluku Province

Before the construction of irrigation canals, rice was used only for consumption by families, while the surplus of other crops, such as maize, cassava or corn, was shipped to Ambon. In 1996, the first harvest of rice on the irrigated area took place, and the surplus was shipped to Ambon that very same year. Rice production is expected to significantly increase, in line with the development of irrigation facilities. Agricultural income is still small, estimated at Rp 2.5 to 3 million per household.

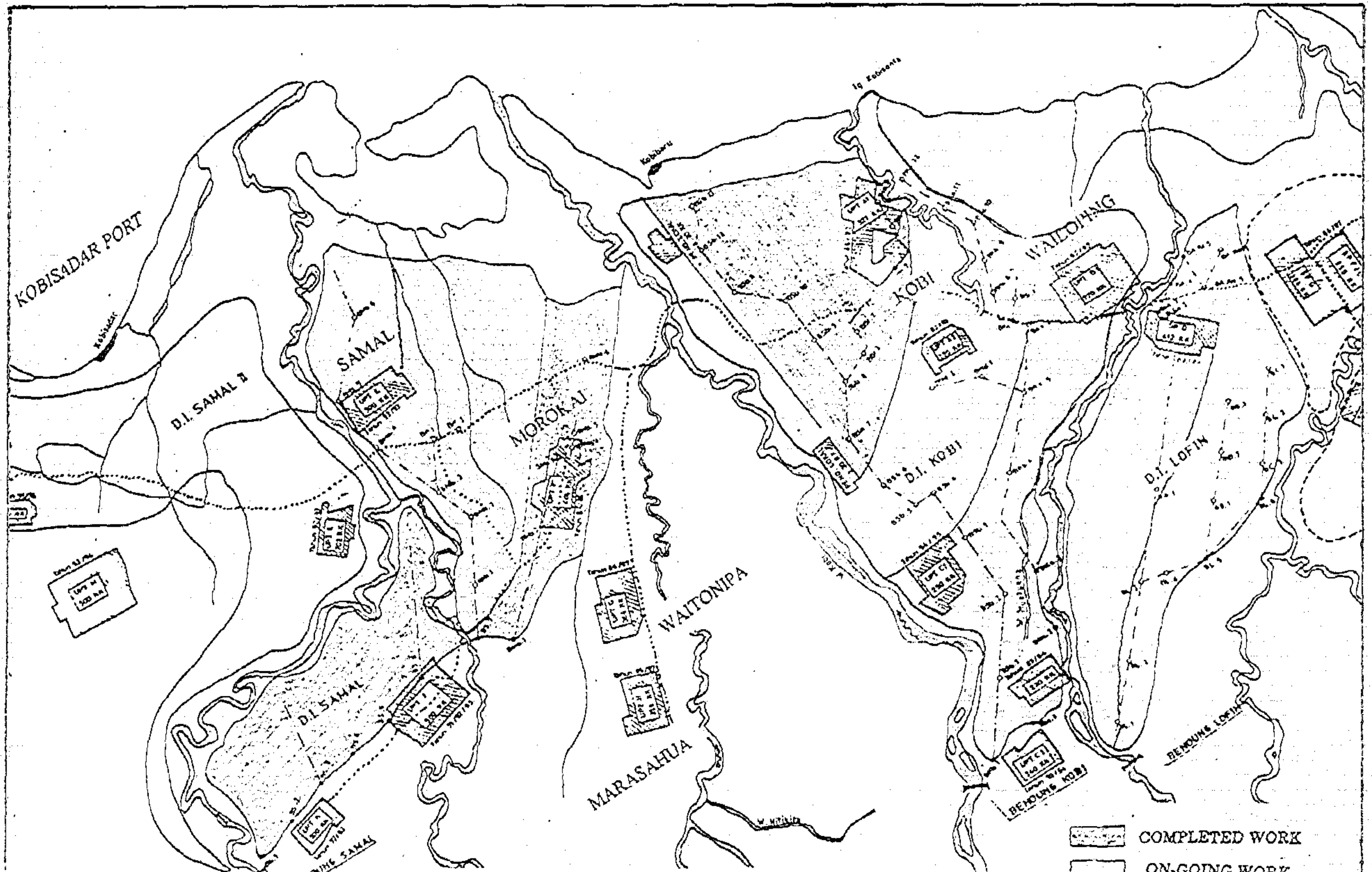

Figure-II.1.1 Irrigation Scheme in Pasahari Area

1.1.2 Future Socio-economic Conditions

(1) Future Population

The future transmigration schedule to the Study Area is shown in Table-II.1.3. According to the Transmigration Agency, 4,120 people are schedule to be newly transmigrated by the end of the fiscal year 1998/99. Since no more transmigration is currently planned by the Transmigration Agency in the Pasahari Area, this study used 1.9% as the figure for future population growth rate in this area, which is the same as the national population growth rate. The future population in the Study Area is shown in Table-II.1.4.

Table-II.1.3 Transmigration Plan

Transmigration Area	1997/98			1998/99		
	Area (ha)	No. of Household	* Population	Area (ha)	No. of Household	* Population
Samal I	260	130	520	500	250	1,000
Samal II	500	250	1,000	-	-	-
Kobi	800	400	1,600	-	-	-
TOTAL	1,560	780	3,120	500	250	1,000

Source : Transmigration Agency in Ambon, 1997

* Estimated by JICA Study Team applying the figure 4 person/household.

Table-II.1.4 Future Population in the Study Area

Year	1996	1998	2000	2005	2010	2015	2020	2025	2030
New Transmigration	-	4,120	4,278	4,700	5,164	5,674	6,233	6,849	7,524
Population Existing in 1996	15,786	16,392	17,020	18,700	20,545	22,573	24,800	27,247	29,936
Total	15,786	20,512	21,298	23,400	25,709	28,246	31,034	34,096	37,460

Source : JICA Study Team

(2) Expected Increase in Agricultural Production

It is expected that agricultural production in the Pasahari Area will increase in line with development of irrigation canals. The Seram Irrigation Project of DGWRD anticipates that the future cropping intensity in paddy will be 170% for Samal I (limited water availability will prevent the second cropping in some areas) and 200% for Kobi. Each area is expected to attain a yield of 4.5 ton/ha/harvest by the year 2001. As a result, the anticipated rice production in Samal I and Kobi from 2001 is 16,960 tons/year and 26,082 tons/year, respectively. Although there are no data available regarding water availability in Samal II, cropping intensity in paddy is expected to increase significantly also in this area when the irrigation project is realized. The following table shows the anticipated increase in cropped area and yields in Samal I and Kobi.

Table-II.1.5 Anticipated Increase in Cropped Area and Yields

Year	Samal I			Year	Kobi		
	Net Area	Cropped Area	Yield (ton/ha/harv.)		Net Area	Cropped Area	Yield (ton/ha/harv.)
1997	1,417	2,834	2.67	1997	1,900	3,800	2.96
1998	"	"	3.04	1998	"	"	3.34
1999	2,217	2,834	3.46	1999	"	"	3.73
2000	"	3,634	3.95	2000	"	"	4.11
2001	"	3,667	4.50	2001	2,898	5,796	4.50
2002	"	"	4.50	2002	"	"	4.50

Source: The Third Irrigation Sector Project (Maluku Province)

1.2 Physical Geography

1.2.1 Topography and Geology

(1) Topography

Vast alluvial lowlands are formed to the north of the center of Seram Island near the estuary. The Samal River and the Kobi River flow generally north from hilly areas to alluvial plains, where the river is very gentle in slope and meanders significantly. Flood water sometime overflows from the river course to alluvial plains, of which topography is typical flood plains (Refer to Figure-II.1.2). Flood plains form through sedimentation inside / outside of the river during flood. It is often found at the lower reaches of a river that the river bed is formed of non-consolidated sand or silt. Meandered rivers are eroded on the outer section of the curve and cause sedimentation on the inner section of the curve and thus form flood plains.

B : Backswanp
L : Natural Levee
O : Ox-bow Lake

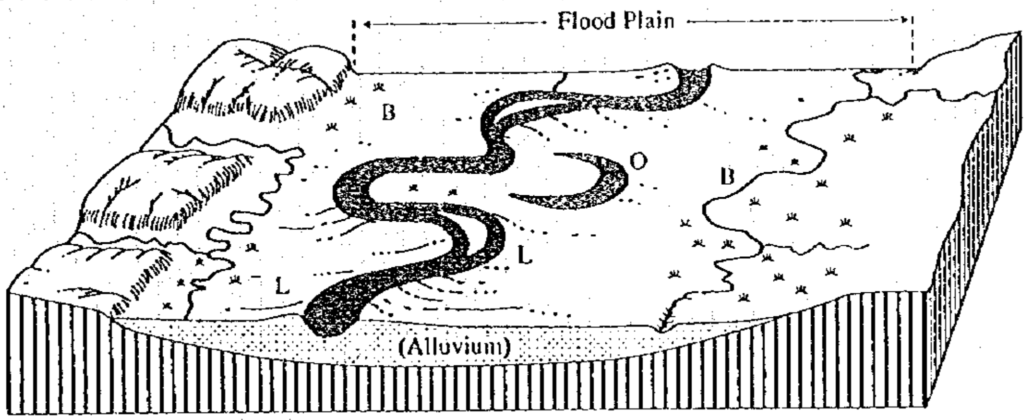

Figure-II.1.2 Schematic of Typical Flood Plain in Pasahari

(2) Geology

Geology in the vicinity of Samal River and Kobi River is shown in Figure-II.1.3. The free intake of Samal River is situated at the extreme position where the hilly area, formed from sedimentary rock of the neogene tertiary period, changes to alluvial lowlands. Non-consolidated conglomerates containing pebbles with diameters of 30 to 50 centimeters are distributed in the river bed. Further downstream, the pebbles become smaller and sand and silt are found to be superior.

The free intake of the Kobi River is located in the alluvial lowlands formed non-consolidated conglomerates containing pebbles with diameters of 5 to 10 centimeters.

KETERANGAN
EXPLANATION

Qa	ALUVIUM *ALLUVIUM*	: Lanau, pasir dan kerikil : *Silt, sand and gravel*
Ql	BATUGAMPING KORAL *CORAL LIMESTONE*	: Batugamping koral berstruktur terumbu : *Reefal struktur of coral limestone*
Qt	ENDAPAN TERAS *TERRACE DEPOSIT*	: Konglomerat, komponennya kuarsa susu, rijang merah, sekis, filit, batupasir dengan semen lempung, lempung pasiran lateritis dan batugamping terumbu : *Conglomerate, the fragments consist of milky quartz, red chert, schist, phyllite, sandstone, cemented by lateritic sandy clay and reef limestone.*
TQf	FORMASI FUFA *FUFA FORMATION*	: Batupasir, lanau, napal, lempung, konglomerat, batugamping, gambut : *Sandstone, silt, marl, clay, conglomerate, limestone, peat*
Tpw	FORMASI WAHAI *WAHAI FORMATION*	: Napal, batugamping pasiran, batupasir, napal tufan : *Marl, sandy limestone, sandstone, tuffaceous marl*
Tpav	BATUAN GUNUNGAPI AMBON *AMBON VOLCANIC ROKS*	: Lava, breksi gunungapi, breksi tuf, tuf : *Lava, volcanic breccia, tuff breccia, tuff*
Tmps	KOMPLEK SALAS *SALAS COMPLEX*	: Bongkah-bongkah berbagai jenis batuan sedimen, beku dan malihan didalam masa dasar lempung berstruktur seperti sisik ikan. Bongkah-bongkah itu adalah konglomerat, grewake, batugamping, rijang, batulanau, batulempung, serpentinit, piroksenit, dunit, gabro, diabas, diorit, sekis, genes, filit. : *Blocks of various kinds of sedimentary, igneous and metamorphic rocks in a groundmass of scaly clay. They consist of conglomerate, greywacke, limestone, chert, siltstone, claystone, serpentinite, pyroxenite, dunite, gabbro, diabase, diorite.*
Toml	FORMASI LISA BATA *LISA BATA FORMATION*	: Batugamping, batupasir, napal, serpih : *Limestone, sandstone, marl, shale*
Tpch	FORMASI HATUOLO *HATUOLO FORMATION*	: Serpih pasiran, napal, rijang : *Sandy shale, marl, chert*
Ks	FORMASI SAWAI *SAWAI FORMATION*	: Kalsilutit, serpih merah dan rijang mengandung radiolaria : *Calcilutite, red shale, and chert containing radiolaria*
	FORMASI MANUSELA *MANUSELA FORMATION*	: Batugamping berlapis sampai masif, napal, rijang, batugamping oolitan : *Bedded-masive limestone, marl, chert and oolitic limestone*
RJk	FORMASI KANIKEH *KANIKEH FORMATION*	: Batuan sedimen tipe flis, terdiri dari grewake, arkosa, batulanau, serpih, rijang dan konglomerat : *Sedimentary rocks of flysch tipe, consist of greywacke, arkose, siltstone, shale, chert and conglomerate.*
	KOMPLEK SAKU *SAKU COMPLEX*	: Batusabak, grewakemalih, arkosamalih, batugamping, dan konglomerat : *Slate, metagreywacke, metaarkose, limestone and conglomerate*
	KOMPLEK TEHORU *TEHORU COMPLEX*	: Batuan malihan berfasies sekis hijau, terdiri dari filit, batusabak, sekis, pasmit dan batugamping terpualamkan : *Metamorphic rocks of green schist facies, consist of phyllite, slate, schist, psamite and marbleized limestone*
	KOMPLEK TAUNUSA *TAUNUSA COMPLEX*	: Batuan malihan berderajat amfibolit, terdiri dari sekis, genes, amfibol, kuarsit, filit dan pualam : *Metamorphic rocks of amphibolite facies, consist of schist, gneiss, amphibolite, quartzite, phyllite and marble*

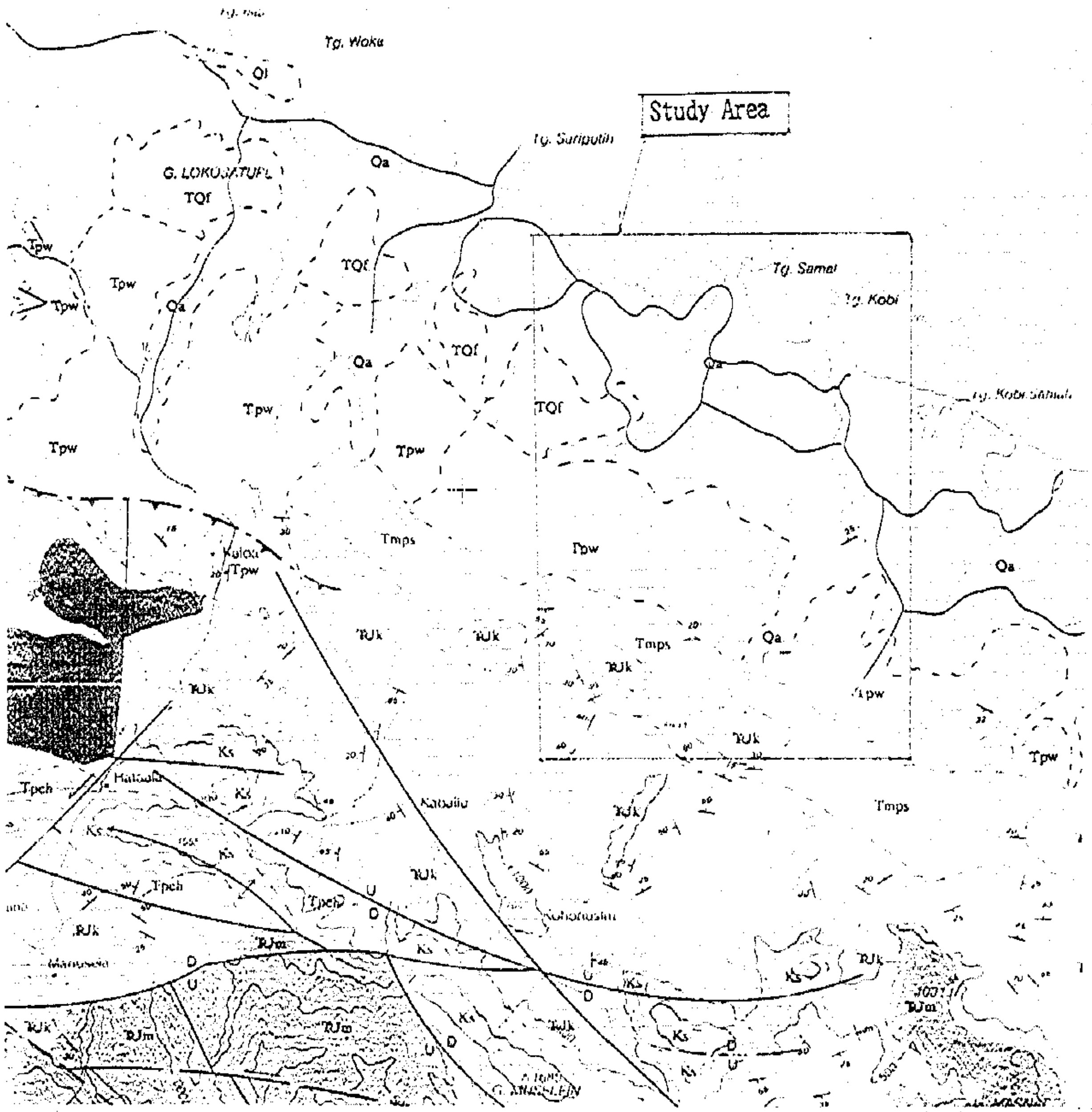

Figure-II.1.3 Geological Map of Pasahari Area

1.2.2 Land Use

(1) Current Land Use

The overall land use situation in Pasahari Area in 1988 is shown in Figure-II.1.4. This land use map was compiled by the Study Team based on the aero-photographs which were taken in 1988. The size of each land use category in the flood prone area is shown in Table-II.1.6. The Pasahari area was once covered mainly with forests and grasslands, with mangrove forests along the coast. However, since cultivation is expanding rapidly in line with the transmigration and irrigation schemes, some forest and grasslands have already been turned into farmland.

Table-II.1.6 Current Land Use in Flooded Area as of 1988

Category	Samal River Basin		Kobi River Basin	
	Area (km²)	Ratio (%)	Area (km²)	Ratio (%)
Dense Forest	29.4	51.5	30.7	40.3
Less Dense Forest	2.6	4.6	2.6	3.4
Bush	0.3	0.5	1.4	1.8
Mangrove	12.6	22.1	12.4	16.3
Plantation	0.4	0.7	1.9	2.5
Paddy Field	4.6	8.1	11.0	14.4
Pasture	5.4	9.5	10.4	13.6
Crop Field / Orchard	0.0	0.0	0.5	0.7
Marsh	0.2	0.4	0.8	1.0
Housing Settlement	1.5	2.6	4.6	6.0
Total Area	57.0	100.0	76.3	100.0

Source: JICA Study Team

(2) Future Land Use

The resettlement to the Samal and Kobi areas is scheduled to be finished in the fiscal year 1998/99, while irrigation facilities for Samal I and Kobi will be completed by the end of the fiscal year 1996/97. Except for the Samal II project, no further irrigation projects are yet scheduled.

Paddy field has been developed on a alluvial plain of Samal and Kobi by avoiding habitually flooded areas. These areas will be turned into paddy field if flood control facilities are constructed. The area located between the mainstream of Kobi River and Tinupa River (a branch of Kobi River) has a potential to be developed into farmland in the near future. The hilly areas in the upstream of the rivers where people living on hunting reside will remain undeveloped for the time being.

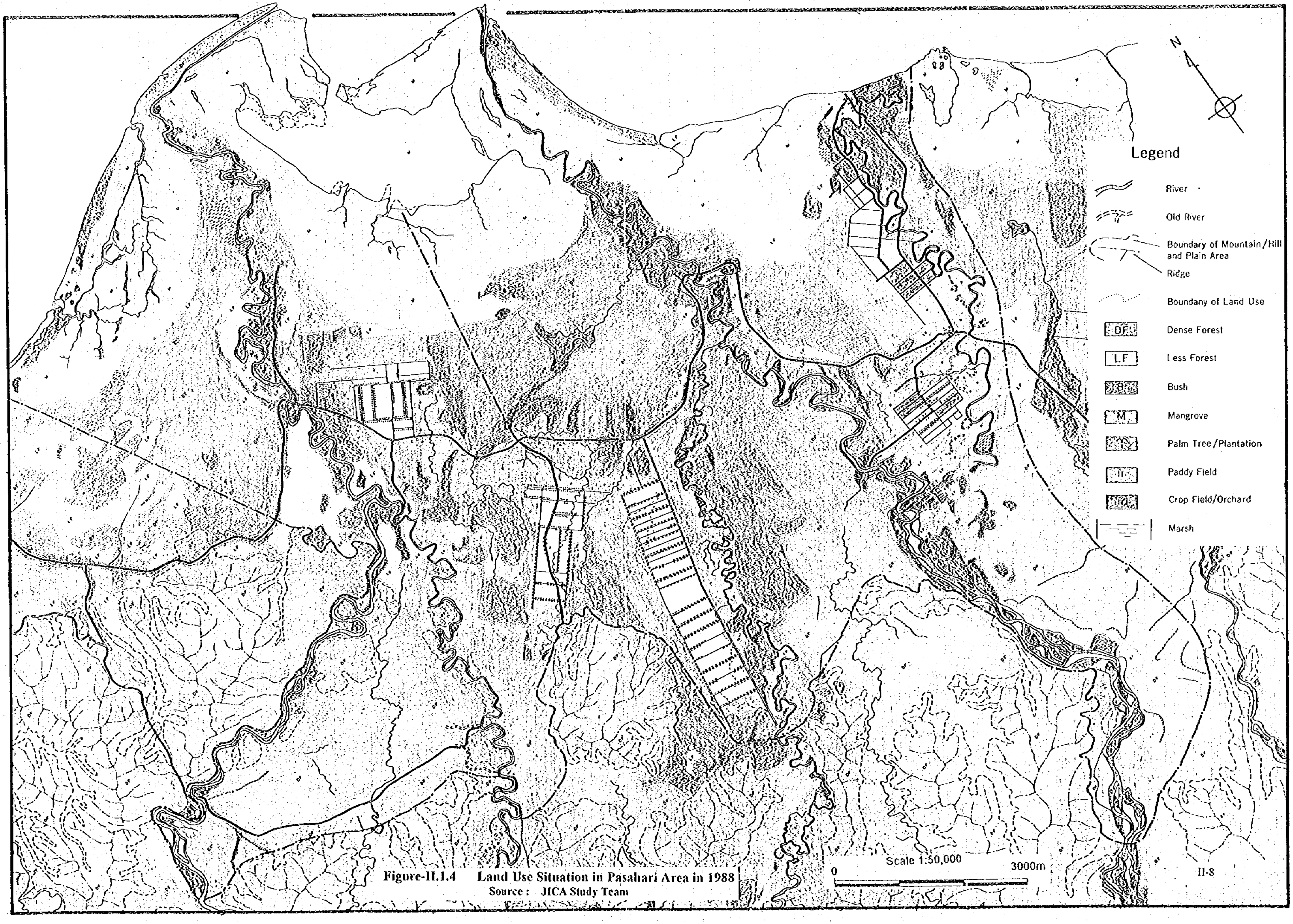

Figure-II.1.4 Land Use Situation in Pasahari Area in 1988
Source : JICA Study Team

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. The weather conditions in the Pasahari Study Area are outlined in Table-II.1.7. The average temperature and humidity are as high as 24.7 °C and 89% respectively, indicating a hot and humid climate. Figure-II.1.5 characterizes the seasonal fluctuation of weather.

Table-II.1.7 Weather Conditions in Pasahari Area (Kobisonta Station)

Month/Year	Rainfall (mm)			Fine Weather Ratio (%)	Relative Humidity (%)	Maximum Temperature (°C)	Minimum Temperature (°C)	Average Temperature (°C)
	Kairatu	Wahai	Kobi-sonta					
January	135	291	231	40	91	27.4	21.7	24.4
February	110	379	191	42	92	27.7	21.8	24.6
March	100	298	261	44	92	28.2	17.3	24.2
April	129	226	165	46	91	27.9	22.2	25.1
May	169	144	125	50	91	27.0	22.0	24.7
June	192	125	33	58	90	26.9	22.3	24.7
July	260	113	46	34	85	26.6	22.1	24.4
August	187	87	22	64	84	26.9	21.7	24.3
September	180	86	31	51	85	27.5	21.9	24.5
October	88	68	38	52	87	27.5	22.6	25.0
November	77	105	82	52	88	27.9	22.6	24.8
December	144	147	197	30	91	27.5	22.5	25.2
Total/Average	1,797	2,077	1,424	47	89	27.1	21.8	24.7

Note: Figures are average values from 7 years (1987-1995) at Kobisonta, from 18 years (1954-1993) at Wahai, from 10 years (1975-1995) at Kairatu.

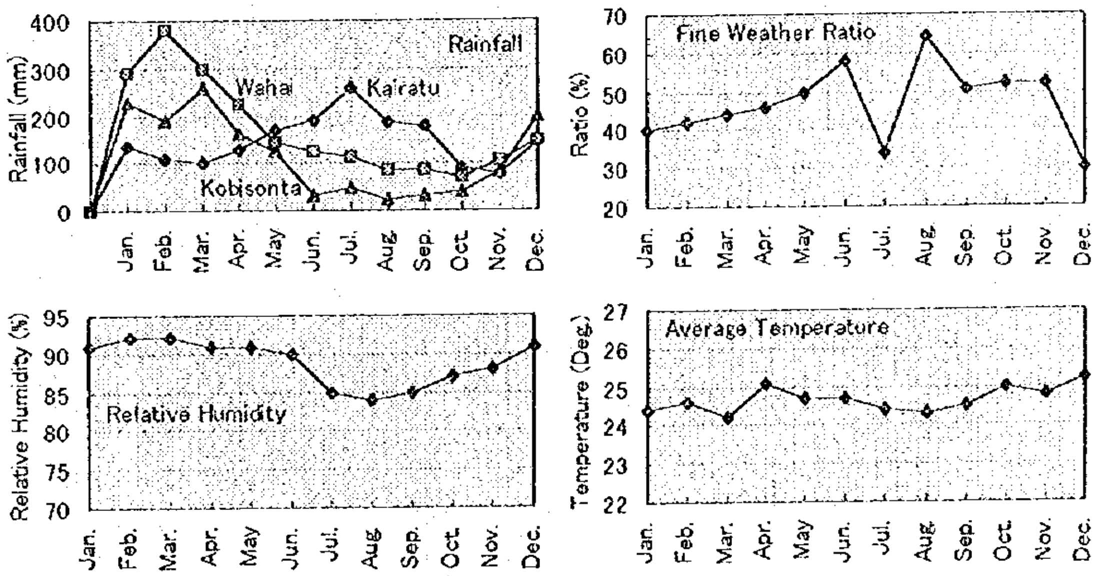

Figure-II.1.5 Seasonal Fluctuation of Weather in Kobisonta Station

1.3.2 River Systems and Hydrometric Stations

(1) River Systems

The Study area in the Pasahari area of Seram includes the two river basins, namely Samal and Kobi rivers, and their tributaries Musi and Tinupa rivers. The catchment areas and main river lengths have been measured by the Study Team using the revised 1:100,000 scale topographical map. The results are given in Table-II.1.8 and the longitudinal profiles of the two rivers are shown in Figure-II.1.6 below. The river systems are shown in Figure-II.1.7.

Table-II.1.8 Study River Basins - Pasahari Area

River Name	Catchment Area (km^2)	Length of Main River (km)
Samal River	268.9	56.8
Kobi River	271.8	50.6

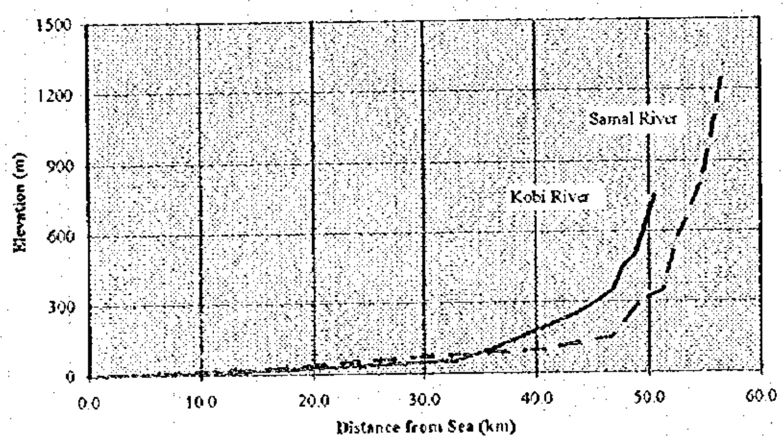

Figure-II.1.6 Longitudinal Profiles of Samal and Kobi Rivers

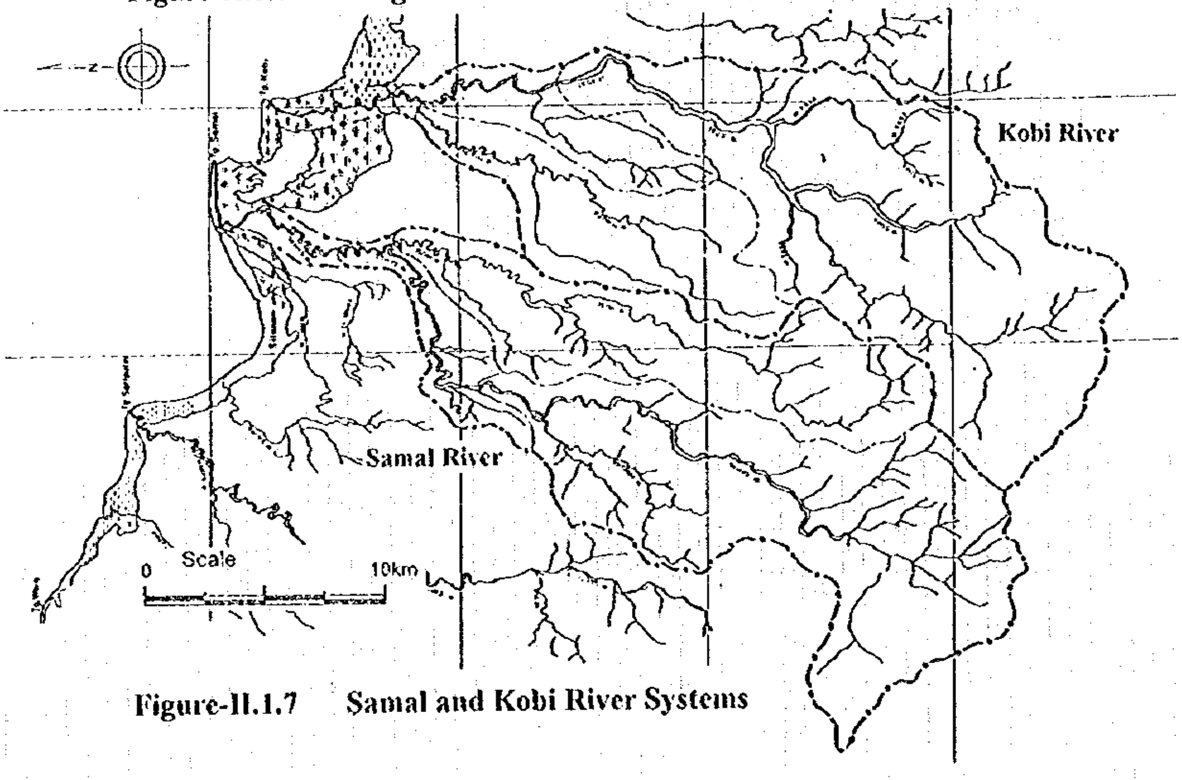

Figure-II.1.7 Samal and Kobi River Systems

(2) Hydrometric Stations

In Seram Island, there are eight meteorological (rainfall) stations, two of which are located in the vicinity of the Study Area (Wahai and Kobisonta in Pasahari). Of the seven hydrological stations, two stations are located in Samal River and Kobi River, but no data available. The condition of hydrometric stations are shown in Table-II.1.9 and II.1.10.

Table-II.1.9 Condition of Meteorological (Rainfall) Stations

Station Name	Elevation (EL.m)	Organization	Available Period		Type of Rainfall Gauge	Observation Period	
			Daily Rainfall	Hourly Rainfall		From	Current Condition
Kobisonta	20	PUSLITBANG	8 years	-	A, O	1984	Operated*
Wahai	5	BMG	14 years	-	O	1953	Operated

Note - PUSLITBANG: Pusat Penelitian dan Pengenabangan Pengairam in Bandung)
- BMG : Departmen Perhubungan, Badan Meteorologi dan Geofisika
- Others : Temperature, Relative Humidity, Sunshine Hours, Wind Speed, etc.
- A : Automatic Rainfall Gauge - O : Ordinary Rainfall Gauge

Table-II.1.10 Condition of Hydrological Stations

Station Name (River Name)	Organization	Type of Gauge	Available Period		Observation Period	
			Daily Water Level	Peak Discharge of Flood	From	Current Condition
Samal River	PUSLITBANG	Staff Gauge	4 months	-	1992	Closed
Kobi River	PUSLITBANG	Staff Gauge	5 months	-	1989	Closed

Note - PUSLITBANG : Pusat Penelitian dan Pengenabangan Pengairam in Bandung)

In order to verify meteorological and hydrological data in the target river basins, an automatic rainfall recorder (ARR), an automatic water level recorders (AWLR) and two water level staff gauges have been installed as part of this Study as shown in Table-II.1.11. The location of these observation stations are shown in Figure-II.1.8.

Table-II.1.11 List of Installed Observation Stations

Item	Station Code	River or Basin	Catchment Area (km^2)	
			Station	Total
Staff Gauge	S-SM-1	Samal River	260.4	269
	S-KB-1	Kobi River	264.0	272
AWLR	AW-SM-1	Samal River	260.4	269
ARR	AR-PH-1	Samal River	-	269

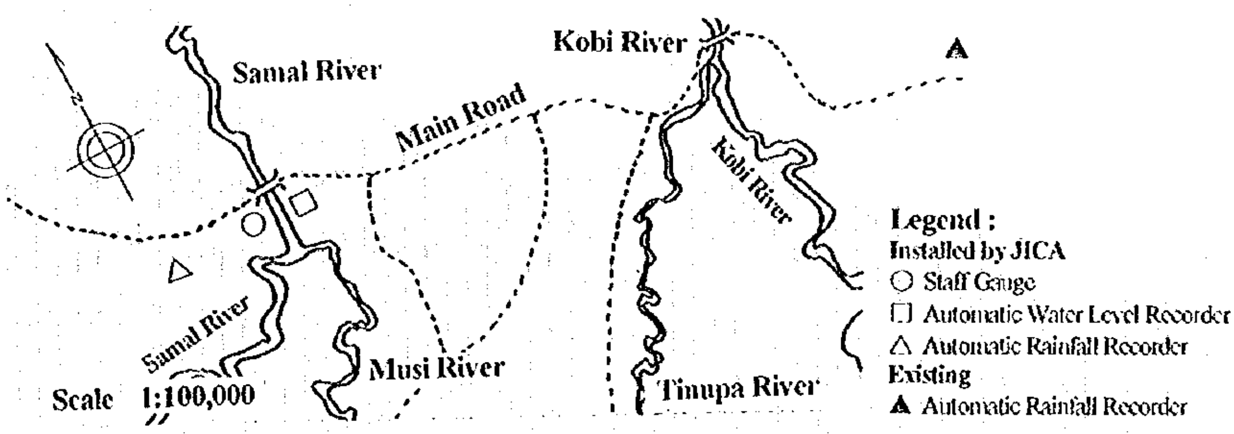

Figure-II.1.8 Location of Observation Stations

1.3.3 Flood Damage

(1) Experienced Flood Damage

Based on the flood damage survey, inundation area of each flood and each river were drawn in Figure-II.1.9. Inundation area, inundation flood water depth, and inundation hours of damaged houses are summarized in Table-II.1.12.

Table-II.1.12 Features of Past Flood Damage

Item	Flood	Samal River		Kobi River	
		Ave.	Max.	Ave.	Max.
Flooded Area (ha)	1988/01/27	1048	-	607	-
	1989/04/03	912	-	482	-
	1996/02/19	117	-	160	-
	Annual	75	-	9	-
Flood Water Depth (cm)	1988/01/27	73	100	73	100
	1989/04/03	69	100	63	100
	1996/02/19	45	100	50	100
	Annual	25	80	43	50
Inundation Hours (hour)	1988/01/27	19	24	19	28
	1989/04/03	13	24	15	24
	1996/02/19	3	12	5	8
	Annual	2	6	9	12

(2) Flood Forecasting and Warning System

(a) Flood Forecasting System

Floods, as one of the disasters facing human life in traditional society, can be forecast by interpreting natural indicators such as rainfall. For inhabitants in Pasahari, flood forecasting is only based upon experienced rainy season in December, January and February. Simple methods of flood forecasting by the indigenous people include the observation of very dark rain clouds in the mountainous upstream regions and the fact that large floods tend to occur every four years, usually after the long period of the dry season. Although there are government offices in Masohi and Wahai, there is no government office in Pasahari and actually no formal methods of flood forecasting.

(b) Flood Warning System

As mentioned above, there are no government offices in the Pasahari area and those at Wahai or Masohi are too far from the flood prone area to provide any flood forecasting or flood warning facilities. For the people living in the study area, generally they do not have any flood warning system and the only warning method is by shouting on the river banks.

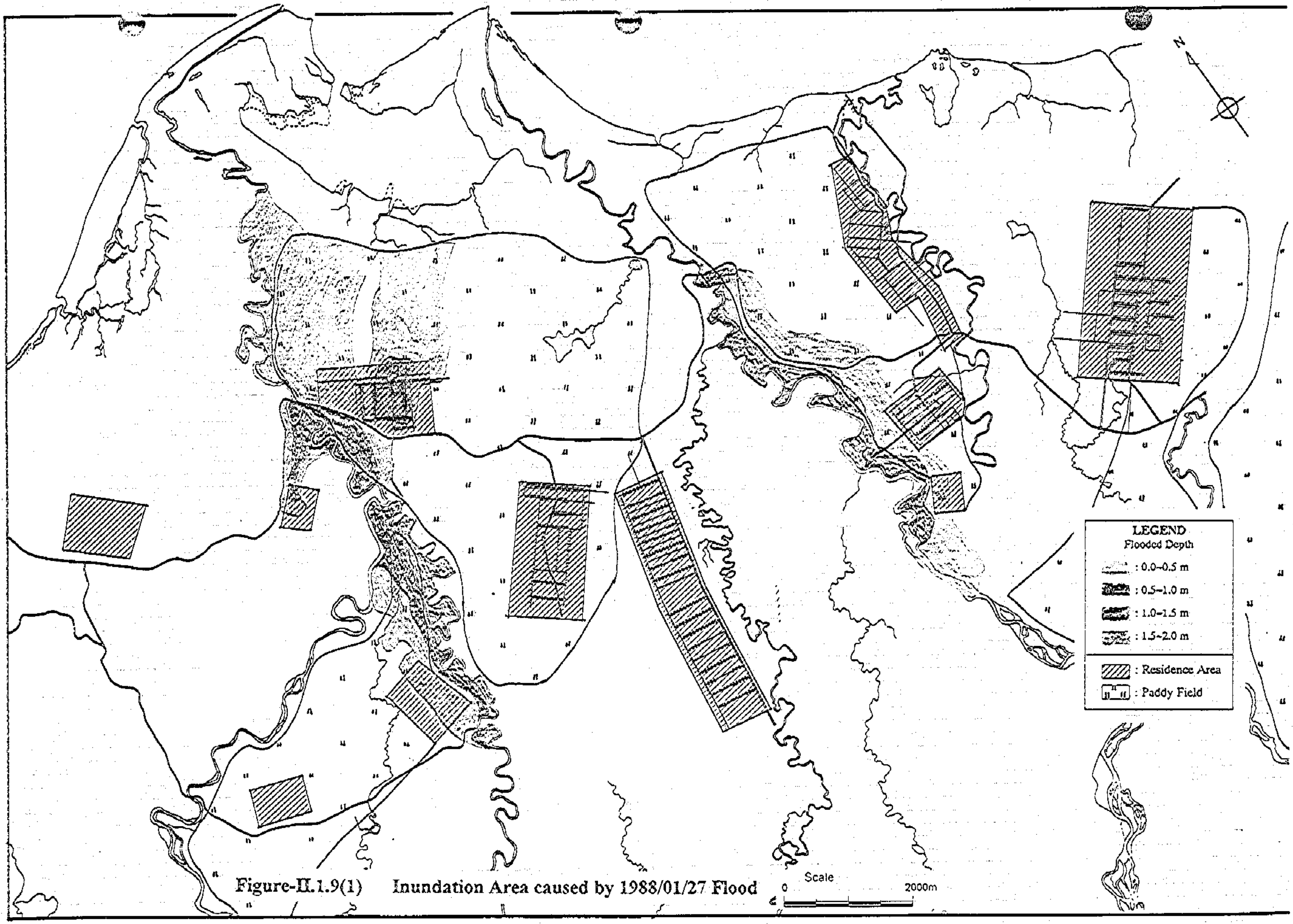

Figure-II.1.9(1) Inundation Area caused by 1988/01/27 Flood

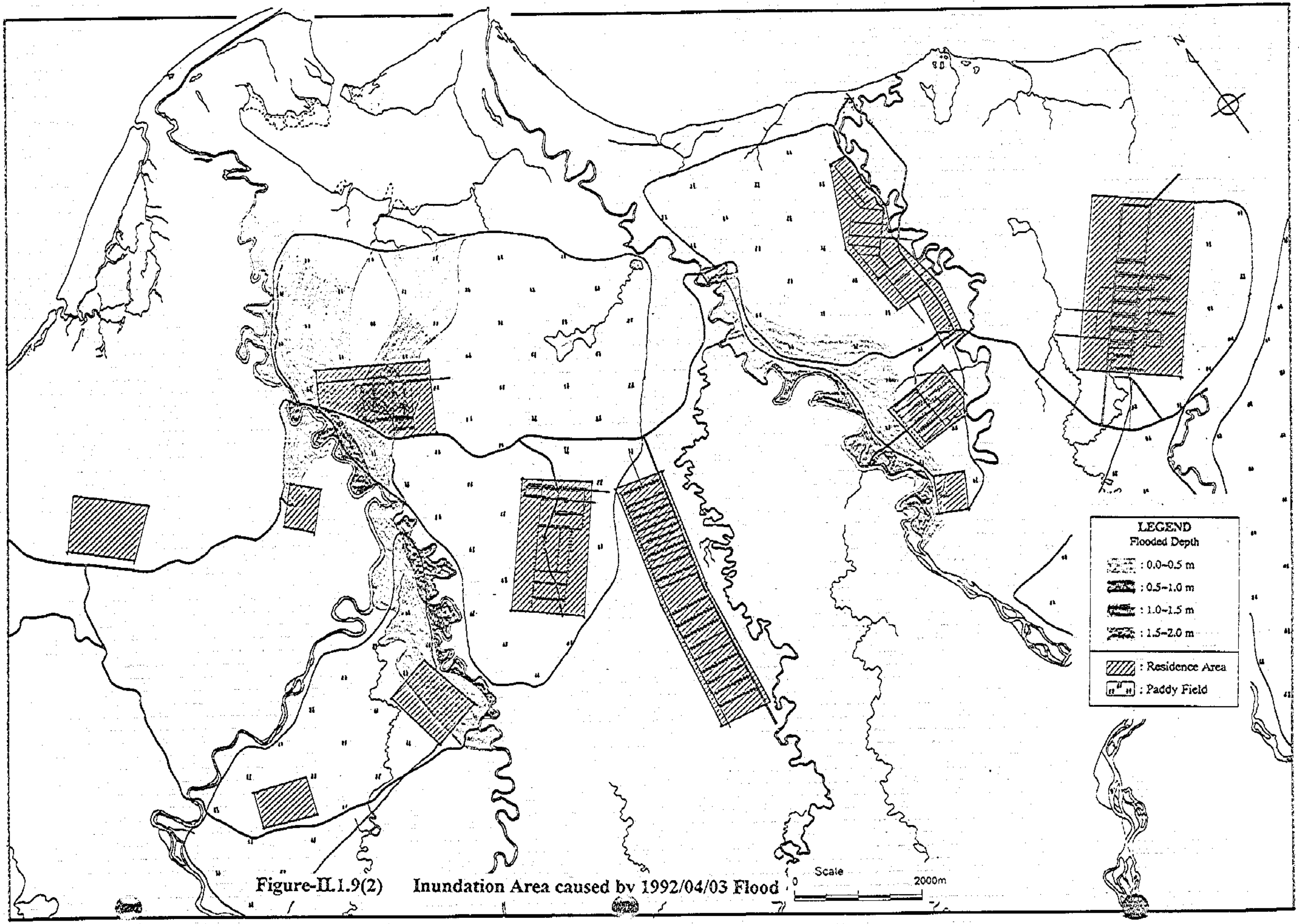

Figure-II.1.9(2)   Inundation Area caused by 1992/04/03 Flood

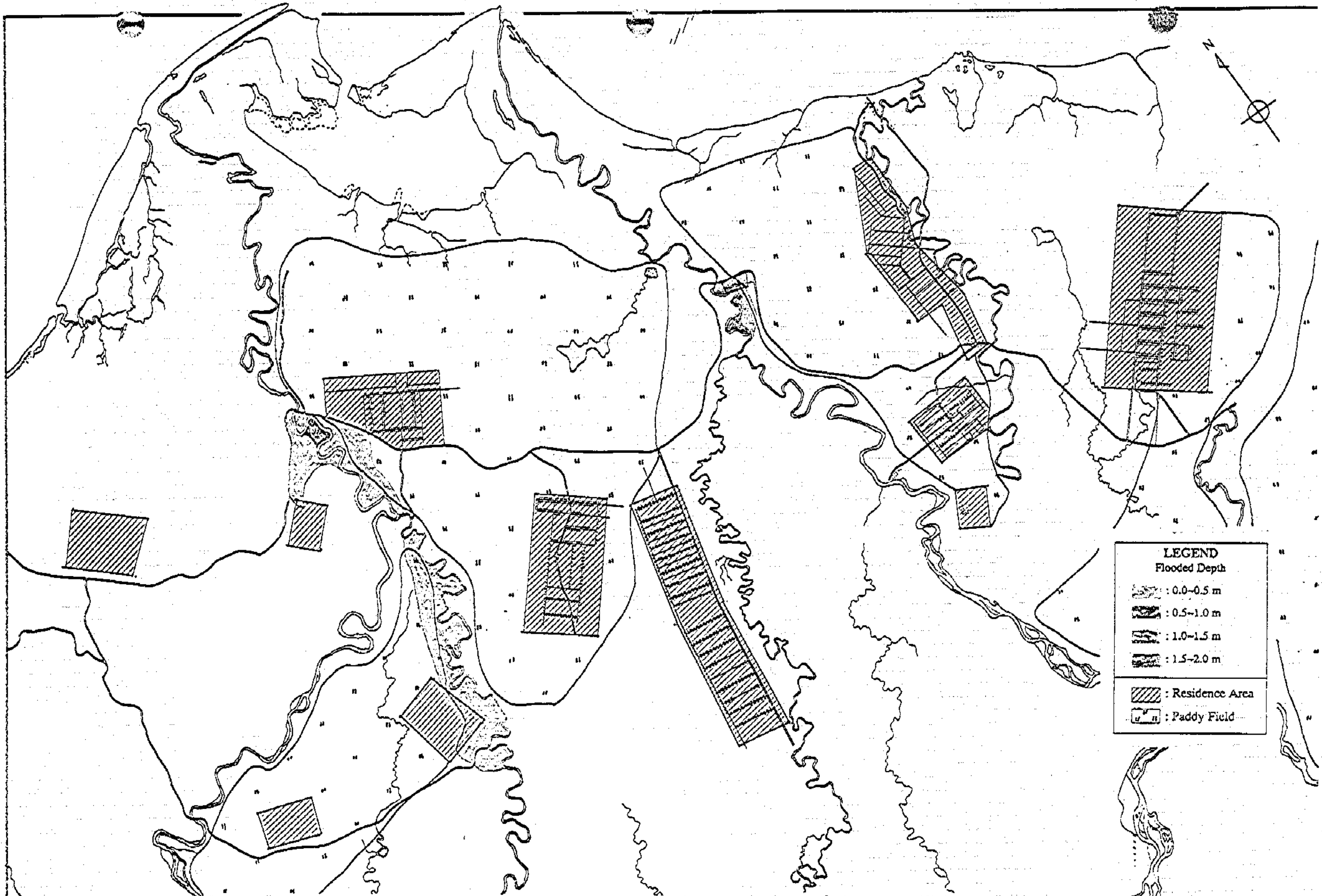

Figure-II.1.9(3) Inundation Area caused by 1996/02/19 Flood

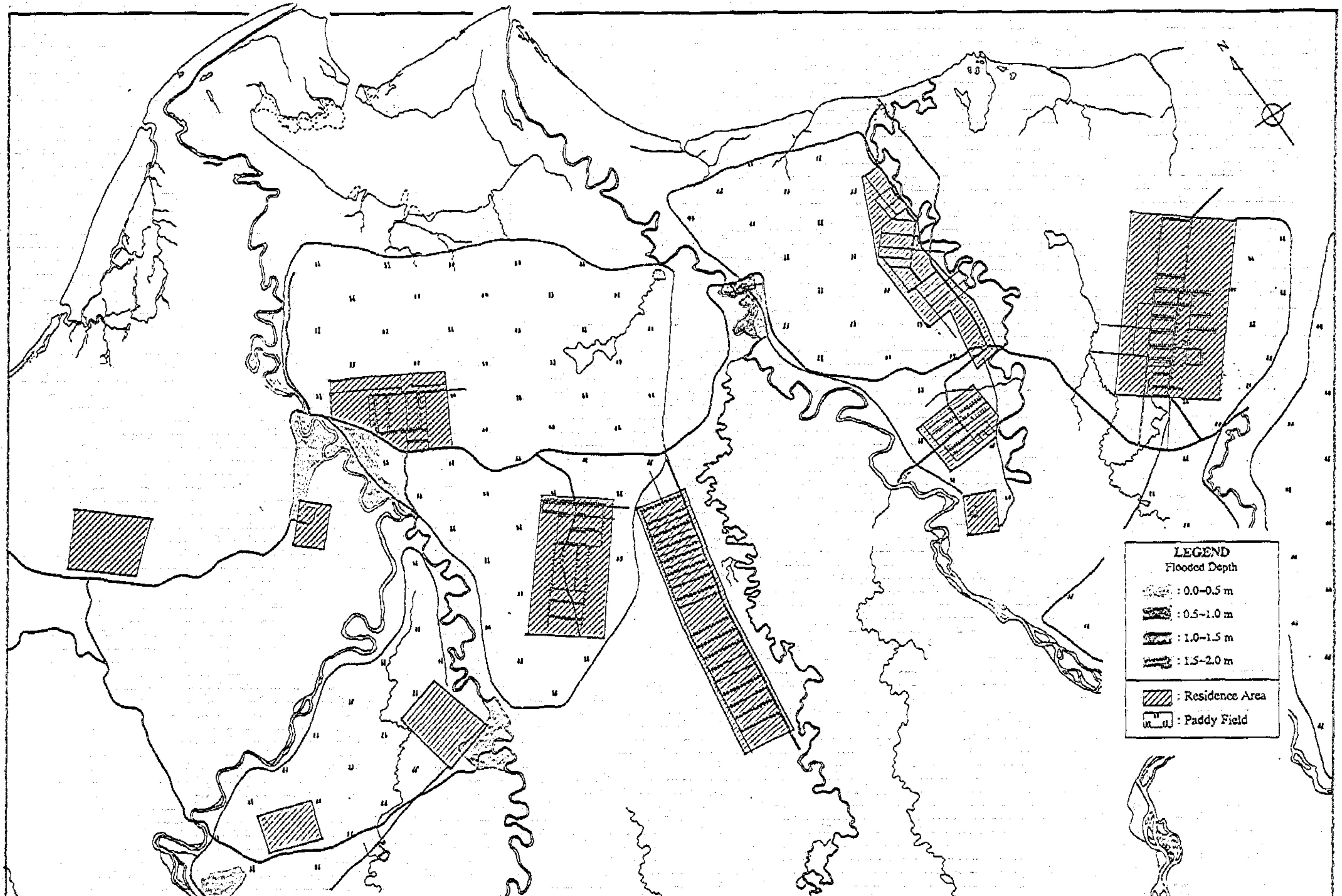

Figure-II.1.9(4) Inundation Area caused by Annual Flood

1.4 Environment

1.4.1 Social Environment

(1) Resettlement and Land Acquisition

Pasahari is a newly developed agricultural area where most of the population are transmigrated from Java under the Government's Transmigration Program. Therefore, resettlement is a common practice in this area. Besides transmigration from Java, 23 households in Tihauna Village came from Ambon after a fire incident in 1995. Resettlement happened even within the Pasahari area - 36 household left a village near Kobi River and built their new homes in Mobomet about 5 km upstream because of the flood damage in 1990. However, there has been no experience of resettlement due to industrial or any infrastructure development activity.

Since Pasahari is still an underdeveloped area and lands are allocated by the Government to the resettled people for housing and farming, and to other developments such as the construction of the irrigation systems etc., land acquisition has not become a problem so far.

(2) Transportation and Public Facilities

Infrastructure has not yet been well constructed in Pasahari area - most of the roads are unpaved, electricity is not available in most of the villages and there is almost no public telecommunication service. No public transport is yet available.

The public facilities in Pasahari area are limited to schools (one junior high school and one senior high school at Kobisonta and primary schools at most of the villages), health centers , one post office (at Kobisonta) and mosques (at each village).

(3) Historical Site and Protected Area

With a short history of human settlement in Pasahari area, there is not any historical nor archaeological sites.

In the Seram Island, there are protected forest areas designated by Maluku Province Government, but most of them are in the western part far away from the Study Area.

(4) Public Health

As for public health service, there is one community health center in Samal area with 2 doctors and one in Kobi area with 1 doctor. There are sub-health centers in most of the villages each with one person for simple medical care. The medical services are provided by the Government under the transmigration scheme. Malaria, skin infection, diarrhea and influenza are the main diseases in this area, and death from diarrhea happens occasionally.

(5) Environmental Sanitation

In Pasahari area, domestic water supply mainly depends on groundwater from dug-wells. In the rainy season well water is sufficient, but in the dry season people in some villages have to get water from the Samal and Kobi Rivers at their upstream side. There are not any water quality data available but villagers have complained salinity, high iron concentration and turbidity problems. To improve water supply, the Transmigration Agency planned to construct water pipes to transfer clean river water to the transmigration villages and piping work has already started at some villages in Samal area.

Only traditional toilets are available in the villages and no septic tanks have been built. The domestic sewage, night soil and garbage are discharged to the river or irrigation canals where people often do washing, bathing and swimming. Doctors in the health centers have pointed out that direct use of irrigation water may cause eye disease and skin infection and advise people to accumulate rain water for washing and bathing. This is based on a consideration of the high salinity and mud content of the irrigation water, and also the pollution by human wastes.

1.4.2 Natural Environment

(1) Flora and Fauna

Although there are no data available on the vegetation in Pasahari area, it is said that the main flora species, especially those in the forests, are about the same as those in Ambon area (refer to Supporting Report Part-G, Master Plan and Feasibility Study for Ambon Area). As for wildlife, wild boar, deer and some species of birds are dominant in the forest area.

(2) River and Coastal Environment

In the estuaries of the Samal and Kobi Rivers, there are large areas of mangrove forests which extend 2 or 3 km to the upstream direction and protect the river bank well. Bank erosion is found to be serious from the end of mangrove forest to the middle stream part of the river. The upstream part of the river flows through the forest and grassland area where river course is broad and shallow and bank erosion is less serious. Situations are similar for the 2 rivers.

In rainy season, sediment runoff is the main problem for the rivers and estuaries. Sea water turns yellowish in a broad coastal area. Through a survey from the estuary to the upstream part of Kobi River, it was found that most of the sediment was from the middle stream part of the river. The influence of sediment runoff on the coastal environment is significant.

No coral reefs exist in the estuary area. This may be because of, but not limited to, the sediment runoff that shut down the sunlight penetration - a necessary condition for the corals to grow.

1.4.3 Environmental Pollution

No environmental monitoring has ever been conducted in Pasahari area. However, considering its low population density and limited development activity, it can be said environmental pollution is not significant presently from man-made pollution sources. Some environmental problems mentioned above are mainly caused by natural reasons. For example, sea water intrusion may be the main reason for the salinity problem with the groundwater and river water quality.

CHAPTER 2 FLOOD ANALYSIS

2.1 Rainfall Analysis

2.1.1 Representative Rainfall Stations and Basin Rainfall

(1) Representative Rainfall Stations

In Pasahari area, since the station at Kobisonta is within the Study Area and possesses eight years of daily rainfall data, it can be taken as a representative station for both of the target river basins. However, the station at Kairatu is the only station to provide hourly rainfall data in Seram, but is 160 km from Kobisonta and located on the opposite side of the island where the rainy season and dry season are reversed. However, a comparison of the data from Kairatu and Kobisonta shows the similarity of the two stations in terms of probable daily rainfall. This indicates that although the seasonal rainfall characteristics differ greatly between Kairatu and Kobisonta, their hourly rainfalls may not be so different from each other since their daily rainfalls are roughly equal. Therefore, the daily rainfall in Pasahari Area is estimated by using the data from Kobisonta and the hourly rainfall in the Pasahari Area is estimated by using the data from Kairatu. For the above mentioned reasons, the representative rainfall observation stations in the Pasahari Area are chosen as follows:

- Daily Rainfall : Kobisonta
- Hourly Rainfall : Kairatu

(2) Basin Mean Rainfall

The rainfall data to be used in the discharge analysis need to be set with attention paid to the basin characteristics of each target river. In Pasahari area, the representative rainfall stations of Kobisonta and Kairatu are at low altitude (El. 2m and 20m, respectively). However, because the basins of the two target rivers cover a wide area of approximately 250 km^2 and reach an altitude about 1,000 m in the upstream mountainous area, it is necessary to take into account the altitude difference. Manusela rainfall station is located in the mountainous area, and mean annual rainfall data is about two times as that of Kobisonta. From rough Tiesen division based on the location of Kobisonta and Manusela in the river basin, it is decided that the basin mean rainfall can be taken as the arithmetic average of the data from the two stations, i.e. 1.5 times the mean annual rainfall recorded at Kobisonta.

2.1.2 Rainfall Probability Analysis

(1) Probable Daily and Hourly Rainfall

Table-II.2.1 and Figure-II.2.1 show the probable daily and hourly rainfall calculated based on the representative rainfall station data. The Non Annual Probability Method is applied since daily and hourly rainfall data are only available for 7 years at Kobisonta station and 8 years at Kairatu station.

Table-II.2.1 Probable Daily Rainfall [Pasahari Area]

Return Period	year	2	3	5	10	20	30	50	100	200
Probable Daily Rainfall	mm	99.3	109.8	122.9	140.7	158.5	169.0	182.1	199.9	217.7
Probable Hourly Rainfall	mm	41.8	43.9	46.6	50.3	54.0	56.1	58.8	62.5	66.2

Note : - Calculated by Non Annual Probability Method
- Non Annual Daily Rainfall Data more than 50mm/day for 7 years at Kabisonta
- Non Annual Hourly Rainfall Data more than 30mm/hour for 8 years at Kairatu

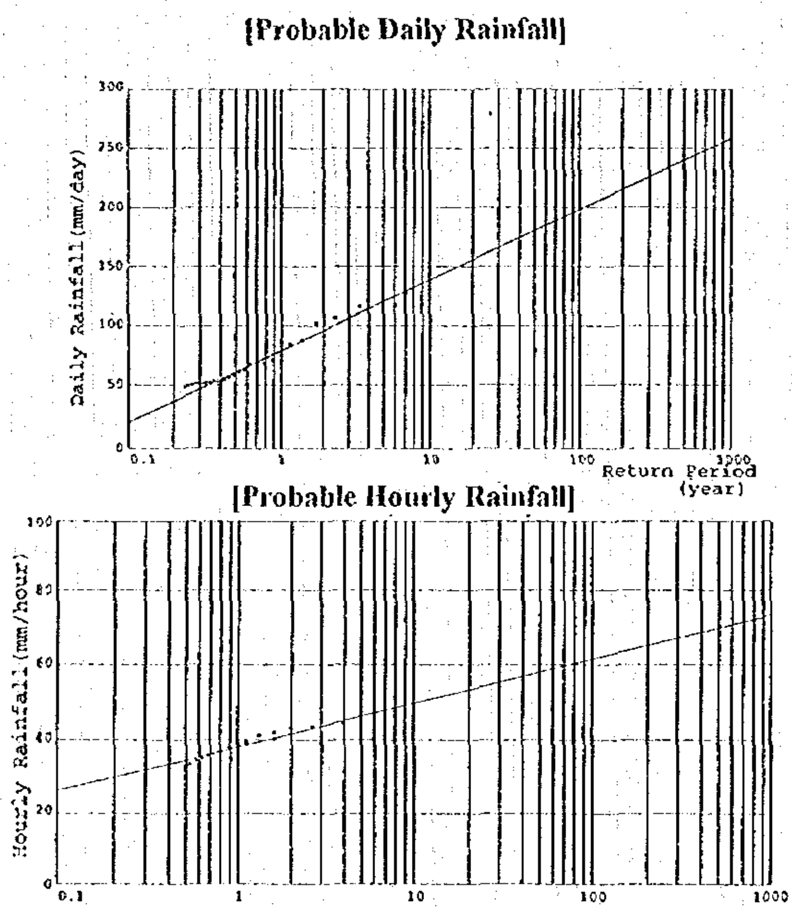

Figure-II.2.1 Plotting Position of Probable Daily and Hourly Rainfall

(2) Rainfall Intensity Curve

The rainfall intensity curves are calculated by the Talbot Formula using the probable daily rainfall from Kobisonta and probable hourly rainfall from Kairatu. The calculation results are shown in Table-II.2.2.

2.1.3 Flood Rainfall

The flood daily rainfall levels in the Study Area are shown in Table-II.2.3. The maximum daily rainfall recorded in Pasahari is 145.8 mm/day (January 27, 1988). Taking into account an occurrence probability of 1/10, the corresponding daily rainfall in Pasahari is 145.8 mm/day (probability 1/11~1/10).

Table-II.2.2 Rainfall Intensity [Kairatu]

Return Period (year)		2	5	10	15	20	25	30	50	70	100	200
Rn(24)		106.2	129.4	146.9	157.1	164.4	170.1	174.7	187.6	196.0	205.1	222.7
Rn(1)		41.8	46.6	50.3	52.5	54.0	55.2	56.1	58.8	60.6	62.5	66.2
b		1.7	2.0	2.2	2.3	2.3	2.4	2.4	2.5	2.6	2.6	2.7
a		113.8	140.2	160.3	172.0	180.4	187.0	192.4	207.3	217.1	227.7	248.2
In=a/(t+b)	0.2	59.2	63.5	67.2	69.5	71.0	72.3	73.2	76.1	78.0	80.1	84.2
[mm/hr]	0.5	51.2	55.9	59.7	62.0	63.5	64.8	65.7	68.5	70.4	72.4	76.4
t(hour)	1	41.8	46.6	50.3	52.5	54.0	55.2	56.1	58.8	60.6	62.5	66.2
	2	30.6	35.0	38.3	40.2	41.6	42.6	43.4	45.8	47.4	49.0	52.3
	4	19.9	23.3	25.9	27.4	28.5	29.3	29.9	31.8	33.0	34.3	36.8
	6	14.7	17.5	19.6	20.8	21.6	22.3	22.8	24.3	25.3	26.3	28.4
	8	11.7	14.0	15.7	16.7	17.4	18.0	18.4	19.7	20.5	21.4	23.1
	10	9.7	11.7	13.2	14.0	14.6	15.1	15.5	16.6	17.3	18.0	19.5
	12	8.3	10.0	11.3	12.0	12.6	13.0	13.3	14.3	14.9	15.5	16.8
	14	7.2	8.8	9.9	10.6	11.0	11.4	11.7	12.5	13.1	13.7	14.8
	16	6.4	7.8	8.8	9.4	9.8	10.2	10.4	11.2	11.7	12.2	13.2
	18	5.8	7.0	7.9	8.5	8.9	9.2	9.4	10.1	10.5	11.0	12.0
	20	5.2	6.4	7.2	7.7	8.1	8.4	8.6	9.2	9.6	10.1	10.9
	22	4.8	5.8	6.6	7.1	7.4	7.7	7.9	8.5	8.8	9.2	10.0
	24	4.4	5.4	6.1	6.5	6.9	7.1	7.3	7.8	8.2	8.5	9.3

Note : Talbot Formula : $I_n = \dfrac{a}{(t+b)}$

I_n : Rainfall Intensity (mm/hr)

t : Rainfall Duration (hour) a, b : Constants

Table-II.2.3 Flood Daily Rainfall in Pasahari

Rank	Pasahari [Kobisonta Station]		Reference [Wahai Station]	
	Date	Daily Rainfall (mm/day)	Date	Daily Rainfall (mm/day)
1	1988/Jan/27	145.8	1970/Feb/09	200
2	1993/Feb/07	129.5	1970/Feb/02	174
3	1993/Jan/09	117.8	1973/Feb/19	164
4	1992/Apr/03	108.9	1978/Feb/19	135
5	1986/Apr/16	104.0	1975/Feb/10	128
6	1992/Mar/05	102.8	1969/Mar/14	118
7	1989/Jul/16	101.9	1960/Jan/18	116
8	1986/Mar/27	94.2	1977/Mar/07	116
9	1989/Feb/13	93.1	1969/Apr/09	115
10	1986/Jan/29	90.8	1969/Feb/01	114

Note : Kobisonta - 11 years [1985-1995], Wahai - 14 years [1959-1993]

2.2 Flood Runoff Analysis

2.2.1 Division of Catchment Areas

The division of the Samal and Kobi rivers' catchment areas is shown in Figure-II.2.2. The main discharge reference points were chosen as the existing road bridges near the downstream of both rivers. In addition, the confluence of the tributaries of Musi and Tinupa rivers were taken as discharge reference points. The catchment area, river length and average slope associated with each of the reference points are given in Table-II.2.4.

Table-II.2.4 Division of Samal and Kobi Catchment Areas

River	Catchment Area (km²)	River Length (km)	Max. Elev. (m)	Min. Elev. (m)	Slope
Samal - Total to Bridge	260.4	45.1	1300	16	1/35
Samal Free Intake	152.7	30.4	1300	40	1/24
Intake - Bridge	20.4	14.7	40	16	1/612
Wai Musi	87.3	35.5	500	20	1/74
Kobi - Total to Bridge	264.0	42.5	800	3	1/53
Kobi Free Intake	177.8	32.1	800	20	1/41
Intake - Bridge	28.1	10.4	20	3	1/612
Wai Tinupa	58.1	24.2	350	5	1/70

2.2.2 Estimation of Peak Discharge by Rational Formula

(1) Runoff Coefficient

The runoff coefficient used in the Rational Formula is determined based on the topography, ground cover, vegetation and land use in the catchment area. As explained previously, the value of runoff coefficient adopted can vary between 0.5 and 0.9, depending on the condition of the catchment area. Typical values for different types of land use for rivers in Japan are presented in Table-II.2.5. Referring to the values of runoff coefficient proposed for "Irrigated paddy field : 0.7 - 0.8", "Mountainous land : 0.7" and "Rugged land and forests : 0.50 - 0.75", a value of runoff coefficient f = 0.7 is adopted for the rivers in the Pasahari study area.

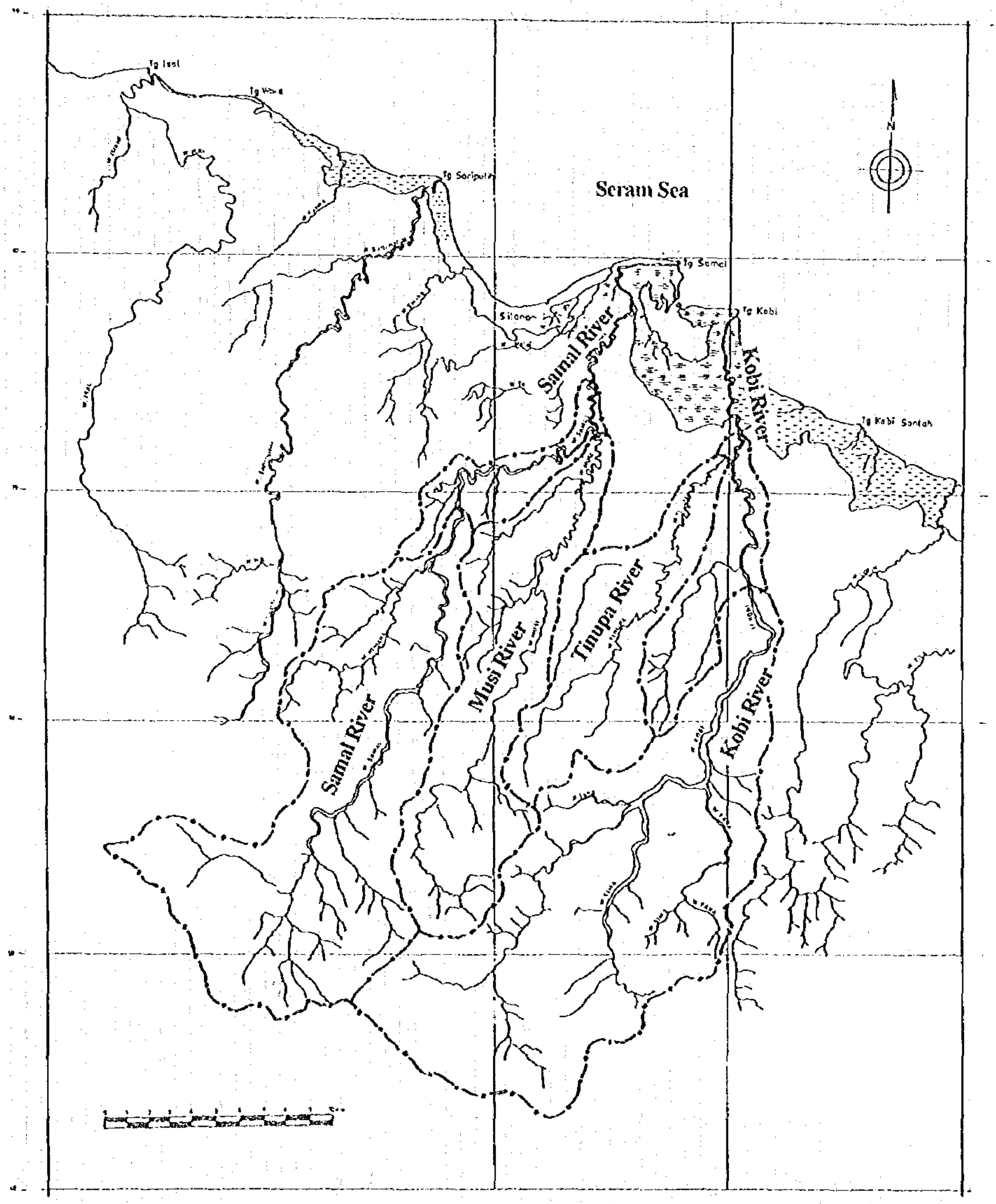

Figure-II.2.2 Division of Samal and Kobi Catchment Areas

Table-II.2.5 Proposed Values of Runoff Coefficient

Planning Value Proposed by "Manual for River Works in Japan, Planning"		Rivers in Japan proposed by Monobe	
Land Use	Runoff Coefficient	Land Use	Runoff Coefficient
Dense urban area	0.9	Steep mountainous region	0.75 - 0.90
General urban area	0.8	Mountains of Tertiary strata	0.70 - 0.80
Farm land and field	0.6	Rugged land and forests	0.50 - 0.75
Paddy field	0.7	Flat cultivated land	0.45 - 0.60
Mountainous land	0.7	Irrigated paddy field	0.70 - 0.80
		Rivers in mountainous region	0.75 - 0.85
		Small rivers in level land	0.45 - 0.75
		Large rivers with over half of the catchment in flat land	0.50 - 0.75

Source : Manual for River Works in Japan, Survey

(2) Time of Flood Concentration

The time of flood concentration is estimated by Kraven's formula, given below, and the results are shown in Table-II.2.6.

Kraven's Formula $Tp = L1 / W$

where:

Tp : Time of Flood Concentration (sec)
L 1 : Length of main water course (m)
I 1 : Slope of main water course
W : Flood runoff velocity (m/sec)

I	over 1/100	1/100 - 1/200	below 1/200
W	3.5 m/sec	3.0 m/sec	2.1 m/sec

Table-II.2.6 Time of Flood Concentration (Kraven's Formula)

River Basin	C.A. (km^2)	Elevation (m) Highest	Elevation (m) Lowest	Length L 1 (m)	Slope I 1	W (m/sec)	Tp (min)
Wai Samal	173.1	1300	16	45100	1/35	3.5	215
Wai Musi	87.3	500	20	35500	1/74	3.5	169
Wai Kobi	205.9	800	3	42500	1/53	3.5	202
Wai Tinupa	58.1	350	5	24200	1/70	3.5	115

(3) Peak Discharge by Rational Formula

The peak flood discharge was calculated for various return periods using the Rational Formula, as shown below :

Rational Formula $Qp = (1/3.6) . f . R . A$

where:

- Qp : Peak flood discharge (m^3/sec)
- f : Dimensionless runoff coefficient (f = 0.7 for Pasahari)
- R : Rainfall intensity during time of flood concentration (mm/hr)
- Tp : Time of flood concentration (hrs)
- A : Catchment area (km^2)

The rainfall intensity R is estimated using the Talbot Formula with coefficients calculated from the daily and hourly rainfall data.

Talbot Formula $R = a / (Tp + b)$

where:

- R : Rainfall intensity during time of flood concentration (mm/hr)
- Tp : Time of flood concentration (hrs)
- a, b : Coefficients determined from hourly and daily rainfall data

The results of the peak discharge calculation, and the corresponding specific discharge for each return period, are given in Table-II.2.7.

Table-II.2.7 Peak Flood and Specific Discharge by Rational Formula

Discharge Ref. Point	C.A. (km2)	Tp (min)	Peak Discharge (m3/sec) 2	5	10	15	20	25	30	50	70	100	200
Talbot Formula Coeff (a)			170.7	210.4	240.4	258	270.7	280.5	288.6	311	325.6	341.5	372.3
Talbot Formula Coeff (b)			1.723	2.009	2.187	2.276	2.341	2.388	2.429	2.526	2.582	2.643	2.749
SAMAL RVER													
Free Intake	152.7	215	955	1117	1237	1307	1356	1395	1425	1511	1568	1629	1746
Before Confl.	171.0		1070	1251	1385	1464	1519	1562	1596	1693	1756	1824	1955
Wai Musi	87.3	169	638	740	816	860	891	915	934	988	1024	1062	1135
After Conf.	258.3		1708	1990	2201	2324	2410	2477	2530	2681	2780	2886	3090
Road Bridge	260.4		1721	2006	2218	2342	2428	2496	2549	2702	2801	2908	3114
Specific Discharge (m3/sec/km2)			6.61	7.70	8.52	8.99	9.33	9.59	9.79	10.37	10.76	11.17	11.96
KOBI RIVER													
Free Intake	177.8	202	1160	1353	1497	1581	1639	1685	1721	1825	1892	1965	2105
Before Confl.	204.5		1334	1556	1722	1818	1885	1938	1980	2099	2177	2260	2421
Wai Tinupa	58.1	115	530	605	662	695	718	736	750	791	818	846	901
After Conf.	262.6		1864	2161	2384	2513	2604	2675	2730	2890	2994	3106	3322
Road Bridge	264.0		1873	2172	2395	2526	2616	2688	2744	2904	3009	3121	3339
Specific Discharge (m3/sec/km2)			7.09	8.23	9.07	9.57	9.91	10.18	10.39	11.00	11.40	11.82	12.65