社会開発協力部報告書

No. 2

THE GOVERNMENT OF THE REPUBLIC OF INDONESIA

THE STUDY
ON
THE FLOOD CONTROL PLAN
OF
THE UPPER CITARUM BASIN

MAIN REPORT

THE GOVERNMENT OF THE REPUBLIC OF INDONESIA

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THE UPPER CITARUM BASIN

MAIN REPORT

DECEMBER 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

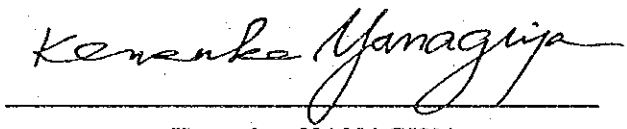
In response to a request from the Government of the Republic of Indonesia, the Government of Japan decided to conduct the Study on the Flood Control Plan of the Upper Citarum Basin and has entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Indonesia a study team headed by Mr. Naohito MURATA of Pacific Consultants International, from May 1987 to October 1987 and January 1988 to June 1988.

The team exchanged views with concerned officials of the Government of the Republic of Indonesia and conducted a field survey in Bandung City. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the development of the project and to the promotion of the friendly relations between our two countries.

I wish to express my appreciation to the officials concerned of the Government of the Republic of Indonesia for the close cooperation they extended to the team.

December, 1988



Kensuke YANAGIYA
President
Japan International Cooperation Agency

THE STUDY

ON

THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

Mr. Kensuke YANAGIYA
President
Japan International
Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit to you the final report entitled "THE STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN". This report has been prepared by the Study Team in accordance with the contract signed on 19 March 1987, 1 November 1987, and 27 April 1988 between the Japan International Cooperation Agency and Pacific Consultants International.

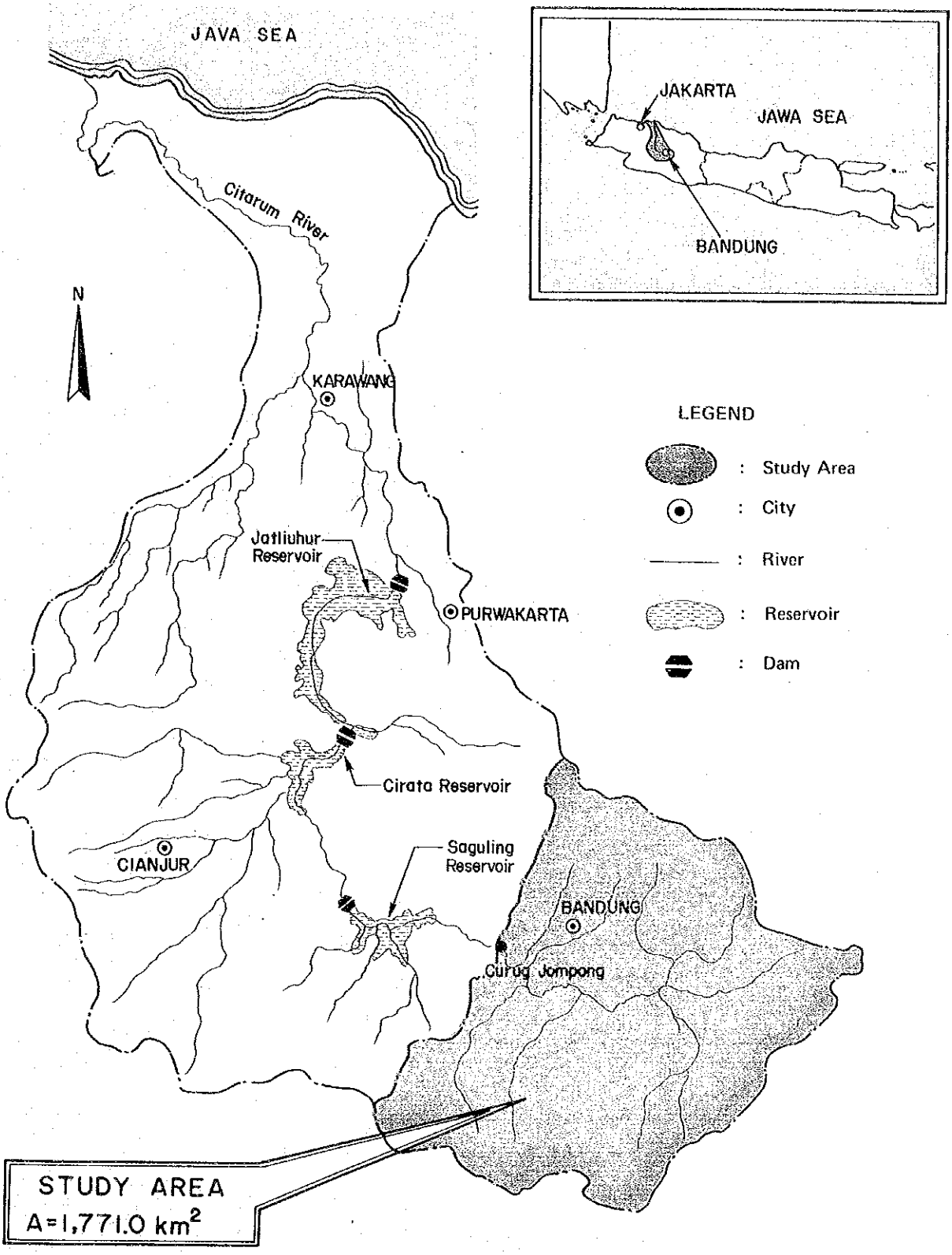
The report examines the flood control problems in the basin, presents an overall flood control plan and the results of a feasibility study on an urgent project comprising river improvement works, and the establishment of a flood forecasting and warning system.

The report consists of the Executive Summary, Main Report, and Supporting Study Reports. The Summary summarises the results of all studies. The Main Report contains background conditions, overall flood control plan, urgent flood control project, conclusions and recommendations. The Supporting Report includes data and technical details. In addition, a Data Book has been prepared and is submitted herewith.

All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, and Embassy of Japan in Indonesia also to officials and individuals of the Government of Indonesia for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the socio-economic development and well-being of the upper Citarum basin.

Yours faithfully,

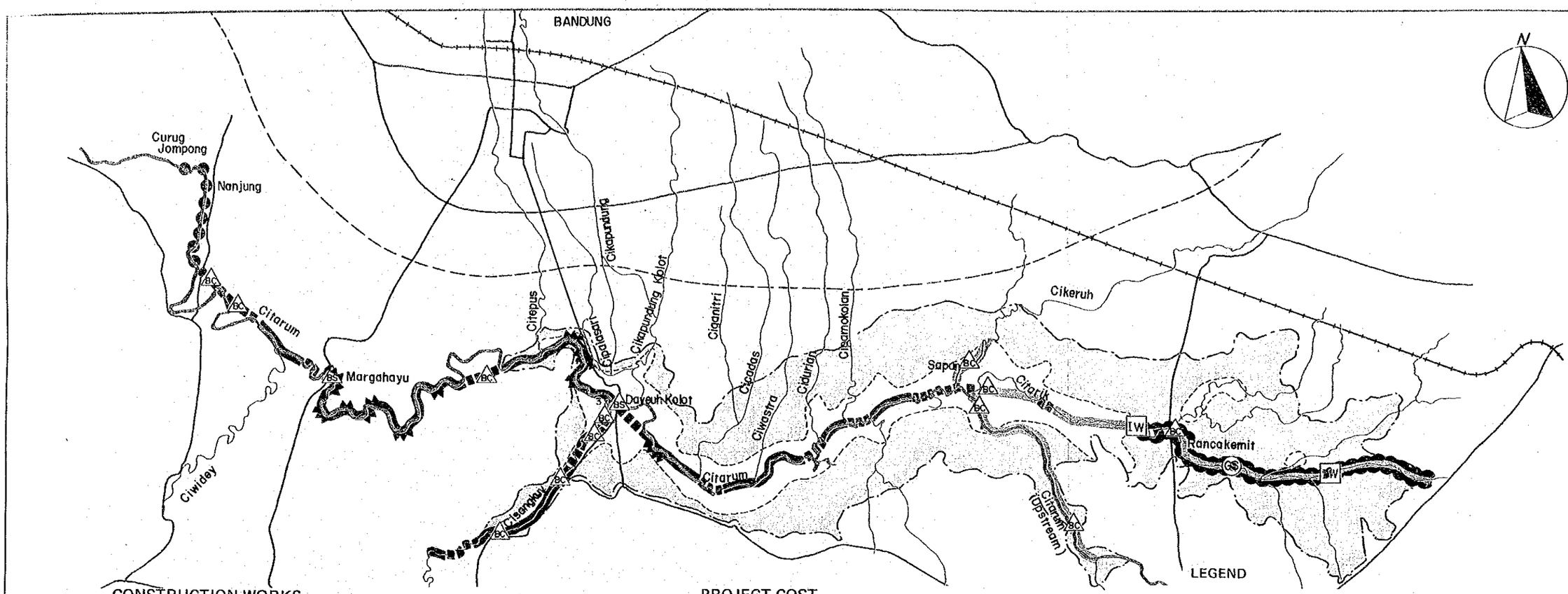
Naohito MURATA
Team Leader



LOCATION OF STUDY AREA

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA



CONSTRUCTION WORKS

Item	Unit	Long-Term Project	Urgent Project
I Civil Work			
A Existing River			
(a) Dredging			
(1) Common Soil	10^3m3	4,124	2,742
(2) Stiff Soil	10^3m3	1,123	674
(3) Soft Rock	10^3m3	1,322	935
(b) Bank Clearing / Grubbing	m2	29,750	118,800
(c) Dike	m3	54,043	-
(d) Bank Protection	m	6,100	6,100
(e) Bridge			
New Construction	m2(place)	2,424 (9)	1,024 (4)
Improvement	place	4	4
(f) Ground Sill	m(place)	7.5 (1)	-
(g) Irrigation Weir	m(place)	54 (2)	-
(h) Maintenance/ Connection Road		10,300	250
B Cut-off Channel			
(a) Dredging			
(1) Common Soil	10^3m3	1,187	1,109
(2) Stiff Soil	10^3m2	1,205	1,147
(3) Soft Rock	10^3m2	448	246
(b) New Bridge Construction	m2	2,112	2,016
	(place)	3	3
(c) Maintenance / Connection Road	m	87,000	2,150
C Flood Warning System	set	1	1
II Land Acquisition Compensation			
A Land Acquisition			
(a) Existing River	10^3m2	1,282	750
(b) Cut-off Channel	10^3m2	375	362
B House Resettlement			
(a) Existing River	house	174	137
(b) Cut-off Channel	house	80	80

PROJECT COST

Cost Item	Long-Term Project L/C (10^6 Rp)	Long-Term Project F/C (10^3 US$)	Long-Term Project Equiv.Total (10^6 Rp)	Urgent Project L/C (10^6 Rp)	Urgent Project F/C (10^3 US$)	Urgent Project Equiv.Total (10^6 Rp)
A. Direct Cost	14,205.0	43,246.8	85,778.2	9,381.3	28,784.2	57,019.2
(1) Civil Work	(13,952.6)	(42,634.8)	(84,513.0)	(9,128.9)	(28,172.2)	(55,754.0)
(2) Flood Warning System	(252.4)	(612.0)	(1,265.2)	(252.4)	(612.0)	(1,265.2)
B. Indirect Cost	13,119.0	6,487.0	23,854.9	10,970.7	3,667.3	17,040.1
(1) Land Acquisition/Compensation	(9,555.0)	(-)	(9,555.0)	(6,645.0)	(-)	(6,645.0)
(2) Administration	(3,564.0)	(6,487.0)	(14,299.9)	(3,183.2)	(-)	(3,183.2)
(3) Engineering Service				(1,142.5)	(3,667.3)	(7,211.9)
C. Physical Contingency	2,732.4	4,973.4	10,963.3	2,035.2	3,245.2	7,405.9
Total (1)	30,056.4 (24.9%)	54,707.2 (75.1%)	120,596.4 (100%)	22,387.2 (27.5%)	35,696.7 (72.5%)	81,465.2 (100%)
D. Price Escalation	-	-	-	10,324.1	6,014.0	20,277.1
Total (2)	-	-	-	32,711.3 (32.2%)	41,710.7 (67.8%)	101,742.3 (100%)

- : Bank Clearing / Grubbing (Long-Term / Urgent Project)
- : Existing River Dredging (Long-Term / Urgent Project)
- : Existing River Dredging (Long-Term Project)
- : Cut-off Channel (Long-Term / Urgent Project)
- : Cut-off Channel (Long-Term Project)
- : Dike (Long-Term Project)
- BC : New Bridge Construction (Urgent Project)
- BC : New Bridge Construction (Long-Term Project)
- BS : Bridge Strengthening (Long-Term / Urgent Project)
- GS : Ground Sill (Long-Term Project)
- IW : Irrigation Weir (Long-Term Project)
- : Bank Protection (Long-Term / Urgent Project)
- : Potential Flood Area (7,249 ha)
- : Frequent Flood Area (2,000 ha)

PROPOSED FLOOD CONTROL WORKS

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA

SUMMARY

Jan. 1988 Floods at Dayeuh Kolot of the Citarum River

SUMMARY

1. Introduction

The Upper Citarum Basin (the Study Area) is located in the central part of the West Jawa Province. The Basin is affected by recurrent floods of the Citarum River. Mitigation of the flood damages is essential for development of the Basin.

This Study on the Flood Control Plan of the Upper Citarum Basin was carried out by the Study Team of the Japan International Cooperation Agency (JICA) in collaboration with the officials concerned of the Government of Indonesia from May 1987 to December 1988.

2. Study Area

The Study Area is 1,771 km^2 in area and bounded by mountain ridges with an altitude of about 2,000 m. The Citarum River flows through the South Bandung plateau at an elevation of about 660 m which is located in the center of the Study Area.

Average annual rainfall ranges from 1,800 mm to 2,800 mm. Rainy season extends from November to April during which approximately 70% of the annual rainfall occurs.

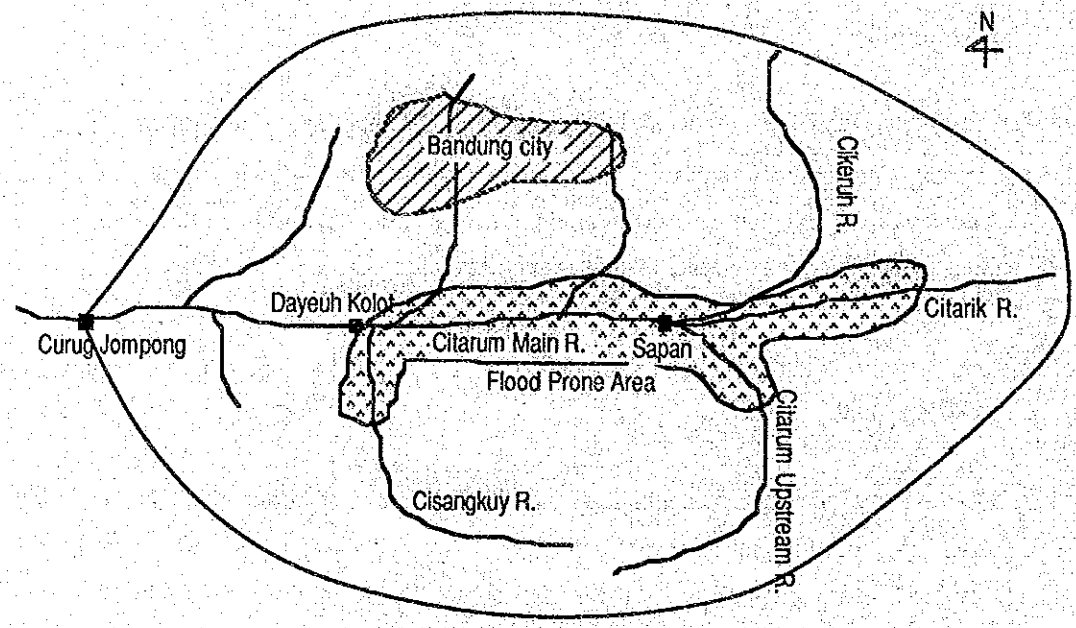
The Study Area includes the areas of three (3) administrative autonomies: the whole area of Kotamadya Bandung, about a half portion of Kabupaten Bandung and a small portion of Kabupaten Sumedang.

The population of the Study Area increased from 3.6 million in 1980 to 4.0 million in 1985. It is expected to increase further to 5.5 million in 2005. The population density in 1985 was 1,758 persons/km^2.

The present land-use distribution of the Study Area is built-up area of 7.1%, agricultural land of 68.7%, and forest and water areas of 24.2%. The built-up area is expected to increase up to 16.0% in order to accommodate the growing population in 2005.

3. River Condition and Flood Damage

The Citarum River consists of the Citarum Main River, and the tributaries, the Citarum Upstream River, Citarik River, Cikeruh River, Cisangkuy River and others. The Citarum Main River drains 755 km^2 at Sapan, 1,332 km^2 at Dayeuh Kolot and 1,771 km^2 at Curug Jompong. The Citarum River system is illustrated in the figure shown below.



Citarum River System

The discharge capacity of the Citarum River is too small, especially in its lower reaches of about 25 km in-between Dayeuh Kolot and Curug Jompong, to carry the flood run-off from the catchment area. This imbalance is the cause of flooding in the low-lying areas of the River. The potential flood prone area extends over more than 7,000 ha in the upstream of Dayeuh Kolot.

A low-lying land of 2,000 ha is inundated by frequent floods, two (2) or three (3) times a year, affecting approximately 40,000 residents and 10,000 houses.

In March 1986 floods, the Basin suffered from serious flood damages as described below.

- Total flooded area : 7,249 ha
- Number of affected residents : 112,252
- Number of damaged houses : 27,310

The expected average annual flood damage is estimated to be Rp. 17,508 million at 1987 prices.

4. Overall Flood Control Plan

An integrated approach of both structural and non-structural flood control measures is required to attain a satisfactory solution of the flood problems in the Citarum River. The proposed overall flood control plan consists of river improvement works as structural measures and flood plain management as non-structural measures.

4.1 Long-Term River Improvement Plan

The long-term river improvement is planned and designed in accordance with the following policy and criteria.

(1) The plan is prepared to meet the population and land-use condition projected in the year 2005.

(2) A 20-year frequency flood is applied for the design of river improvement works.

(3) Complete flood control of the Citarum River is not attainable. Inundation of approximately 1,000 ha in the low-lying area is allowed for the design floods.

The proposed river improvement is in the Citarum Main River and its major tributaries, Citarum Upstream, Citarik, Cikeruh and Cisangkuy. The total river improvement length is 61.4 km with the following break-down.

- Citarum Main River : 31.2 km
- Citarum Upstream River : 6.0 km

- Citarik River : 14.8 km
- Cikeruh River : 2.0 km
- Cisangkuy River : 7.4 km

The major river improvement works are river dredging including 14 cut-off channels and the construction of related river structures. No dike construction is proposed in the rivers other than the Citarik River.

The proposed construction works are as follows:

- River dredging : 9,409 x 10^3 m^3
- Bank clearing and grubbing : 1.0 km
- Dike : 12.90 km
- Bank protection : 6.1 km
- Bridge : 16 places
- Ground sill : 1 place
- Irrigation weir ; 2 places
- Maintenance/Connection road : 97.3 km
- Land acquisition : 165.7 ha
- Resettlement : 254 houses

4.2 Flood Plain Management

Flood plain management is planned to supplement structural measures of the flood control. Flood plain management will be performed for the flood risk area of a 50-year floods, after completion of the proposed long-term river improvement plan. The target area is approximately 1,300 ha. The recommended non-structural measures of flood plain management are as follows.

- Land-use regulation including relief to house damage by non-structural measures
- Establishment of flood forecasting and warning system

4.3 Economic Evaluation

The estimated project cost is Rp. 120,596 million at 1987 prices. The estimated project benefit, expected flood damage reduction, is Rp. 16,006 million per annum at 1987 prices.

The economic internal rate of return for the Project is estimated to be 11.6%.

5. Urgent Flood Control Plan

The proposed urgent flood control plan consists of urgent river improvement works and flood plain management.

5.1 Urgent River Improvement Plan

The most serious flood problems occur in the flood plain located between Sapan and Dayeuh Kolot. Hence the urgent river improvement plan is prepared to mitigate the recurrent flood damages in this area.

The urgent river improvement plan is formulated within the frame-work of the long-term plan and in conformity with it. A 5-year frequency flood is applied for the design of river improvement works. Approximately 1,000 ha of the low-lying land within the target flood plain is allowed to be inundated, since complete elimination of flood waters from the target area is not attainable.

Reaches to be improved are the Citarum Main River of 31.2 km long between Curug Jompong and Sapan, and its tributary Cisangkuy River of 7.4 km long. The major river improvement works are river dredging including eight (8) cut-off channels of the Citarum Main River and three (3) small cut-off channels of the Cisangkuy River, and the construction of related river structures.

The proposed construction works are as follows:

- River dredging	:	6,953 x 10^3 m^3
Existing channel	:	4,351 x 10^3 m^3
Cut-off channel	:	2,602 x 10^3 m^3
- Bank clearing and grubbing	:	3.0 km
- Bank protection	:	6.1 km
- Bridge improvement	:	11 places
New construction	:	7 places
Strengthening	:	4 places
- Maintenance/Connection road	:	2.15 km
- Land acquisition	:	110.6 ha
- Resettlement	:	223 houses

5.2 Flood Plain Management

Flood plain management of the urgent flood control plan consists of the land-use regulation in the flood risk area, and the establishment of a flood forecasting and warning system.

The flood risk area of 50-year flood is considered as the target area of the flood plain management. The area is approximately 5,600 ha for the period after the completion of the urgent river improvement plan in which 27 desas are included. However, it will decrease to approximately 1,300 ha after completion of the long-term river improvement plan.

The land-use regulation will include the following measures.

- Restriction of housing development in critical flood prone areas
- Guidance for flood-proof housing development
- Relief of the existing houses in the flood prone areas by non-structural measures

A flood forecasting and warning system will be established to support the flood evacuation activities. The required hydrological data collection and transmission system will be fully accomplished by improving the existing system of the Sagling Hydropower Project. The required additional facilities are as follows.

- Six (6) telemeters at the existing water level stations
- One (1) expansion of existing monitoring station at Institute of Hydraulic Engineering
- One (1) master station at Provincial Public Works

5.3 Project Cost and Implementation Schedule

The estimated project cost is Rp. 81,465.2 million (equivalent to US$49.22 million) at 1987 prices. The proposed works and facilities will be completed within five (5) years. The project cost including price contingency for five (5) years is estimated to be Rp. 101,742.3 million (equivalent to US$61.48 million).

Breakdown of the project cost is shown below.

Cost Item	L/C (10^6 Rp)	F/C (10^3 US$)	Equiv.Total (10^6 Rp)
A. Direct Cost	9,381.3	28,784.2	57,019.2
(1) Civil Work	(9,128.9)	(28,172.2)	(55,754.0)
(2) Warning System Equipment	(252.4)	(612.0)	(1,265.2)
B. Indirect Cost	10,970.7	3,667.3	17,040.1
(1) Land Acquisition/Compensation	(6,645.0)	(-)	(6,645.0)
(2) Administration	(3,183.2)	(-)	(3,183.2)
(3) Engineering Service	(1,142.5)	(3,667.3)	(7,211.9)
C. Physical Contingency	2,035.2	3,245.2	7,405.9
Total (1) without price escalation	22,387.2 (27.5%)	35,696.7 (72.5%)	81,465.2 (100%)
D. Price Escalation ($^{1990}/_{1991}$~$^{1994}/_{1995}$)	10,324.1	6,014.0	20,277.1
Total (2) with price escalation	32,711.3 (32.2%)	41,710.7 (67.8%)	101,742.3 (100%)

Note: Exchange rate: US$1.00 = Rp. 1,655 = ¥135

6. Project Evaluation

After the completion of this project, land and number of houses relieved of flood damage against 5 and 20-year floods are estimated as follows:

Flood	Relieved Area (ha)	Number of Relieved House	
		Completely Free	Free from Serious Inundation Depth (50cm)
5-year	4,090	19,300	24,100
20-year	2,550	12,300	20,300

Annual economic benefit is estimated to be Rp. 13.2 billion under the present socio-economic conditions. The estimated project economic cost at 1987 prices is Rp. 79.2 billion. The required annual operation and maintenance cost is Rp. 285 million.

The estimated investment efficiency of the Project is as follows:

Economic Internal Rate of Return (EIRR) : 14.1%
Benefit Cost Ratio (B/C) : 1.44
Net Present Value (NPV) : Rp. 26.9 billion

Taking into consideration of future conditions such as improvement of living standards and increase in crop yield in the flood area, EIRR would increase from 14.1% to 18.5%.

7. Recommendation

(1) The proposed Project is technically, economically and socially justified. Immediate implementation of the Project is recommended in consideration of the existing serious flood problems.

(2) On-going projects, watershed management and improvements of tributaries flowing through the Bandung Urban Area, are recommended to be progressed under the proposed plan by the Government of Indonesia in view of necessity for the Overall Flood Control Plan of the Upper Citarum Basin.

(3) Because of the high costs required for the implementation of the Urgent Project, foreign financial assistance may be necessary.

(4) Flood plain management consisting of land-use regulation and flood forecasting, warning, and evacuation system shall be implemented for the proposed flood risk area of approximately 5,600 ha.

(5) Some low-lying Kampungs are still flood prone even after completion of the Urgent Project. Main Drainage system in such Kampungs shall be improved to drain the stagnant flood water soon after the flood in the river recedes.

(6) Garbage disposal into rivers causes a river bed rising, resulting in decrease of the discharge capacity of the rivers. Garbage disposal shall be well controlled for maintenance of he proper river conditions.

(7) Dredged materials of good quality shall be considered to be used profitably for beneficial purposes.

PHOTOGRAPH

EXISTING WATERSHED AND RIVER CONDITION

1. FLOODS AND LAND DEVELOPMENT
2. CITARUM RIVER
3. TRIBUTARIES

FLOODS

Jan. 1984 Floods (Flooding around Dayeuh Kolot)

Jan. 1988 Floods (Flooding of Cisangkuy River near near confluence of the Citarum River)

Jan. 1988 Floods (Flooding of low-lying areas along left bank of the Citarum River at upstream of Dayeuh Kolot)

LAND DEVELOPMENT

Urbanization of flood prone areas along right bank of the Citarum River at upstrea of Dayeuh Kolot

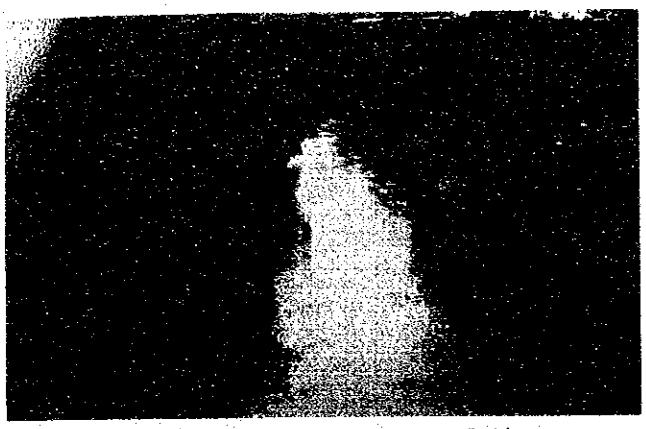
Dry field development of Citarum Basin

Tea plantation development of Citarum Basin

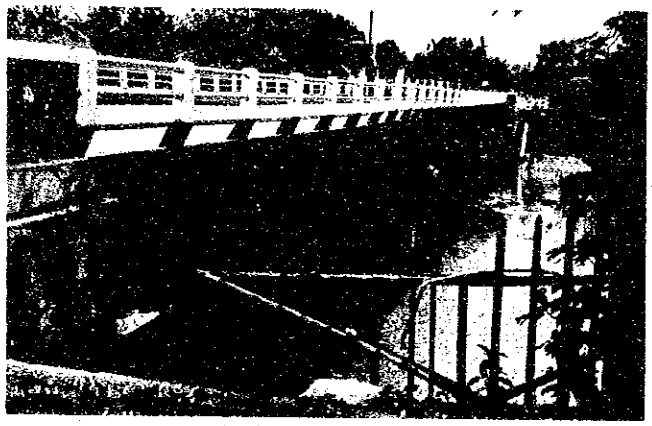
CITARUM RIVER

Curug Jompong Fall (Starting point of River Improvement Plan)

Upstream stretches of Curug Jompong

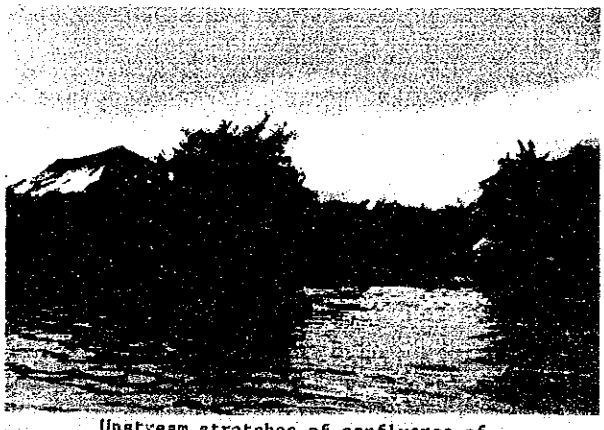


Downstream stretches of Nanjung Bridge

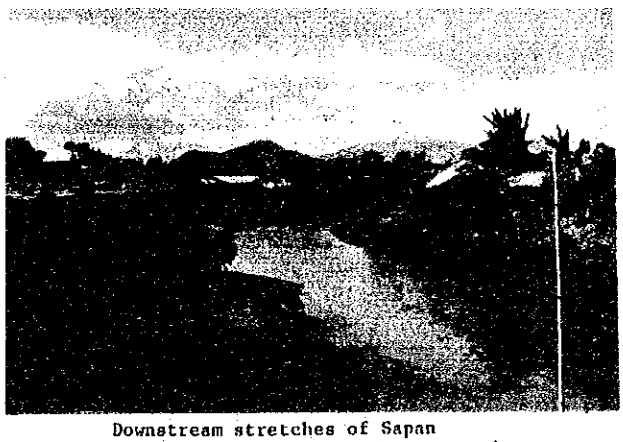


Cilampeni Bridge near Narugahayu

Dayeuh Kolot Road Bridge (See from downstrea to upstream)



Upstream stretches of confluence of the Cidurian River (See from down-stream to upstream)



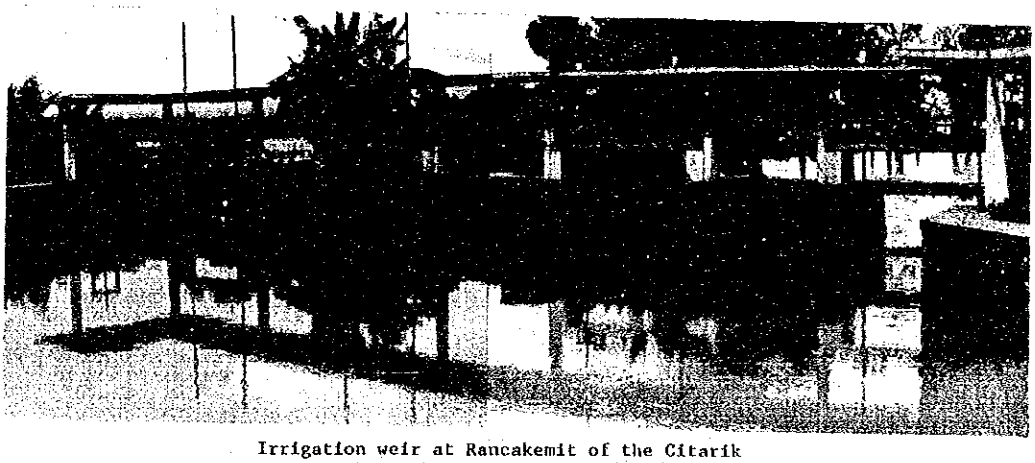
Downstream stretches of Sapan
(See from downstream to upsteram)

TRIBUTARIES

Cikapundung River, right tributary of Citarum River, in Bandung City

Cicadas River, right tributary of Citarum River, after completion of urgent river improvement project

Downstream stretches of the Cikeruh River, right tributary of the Citarum River

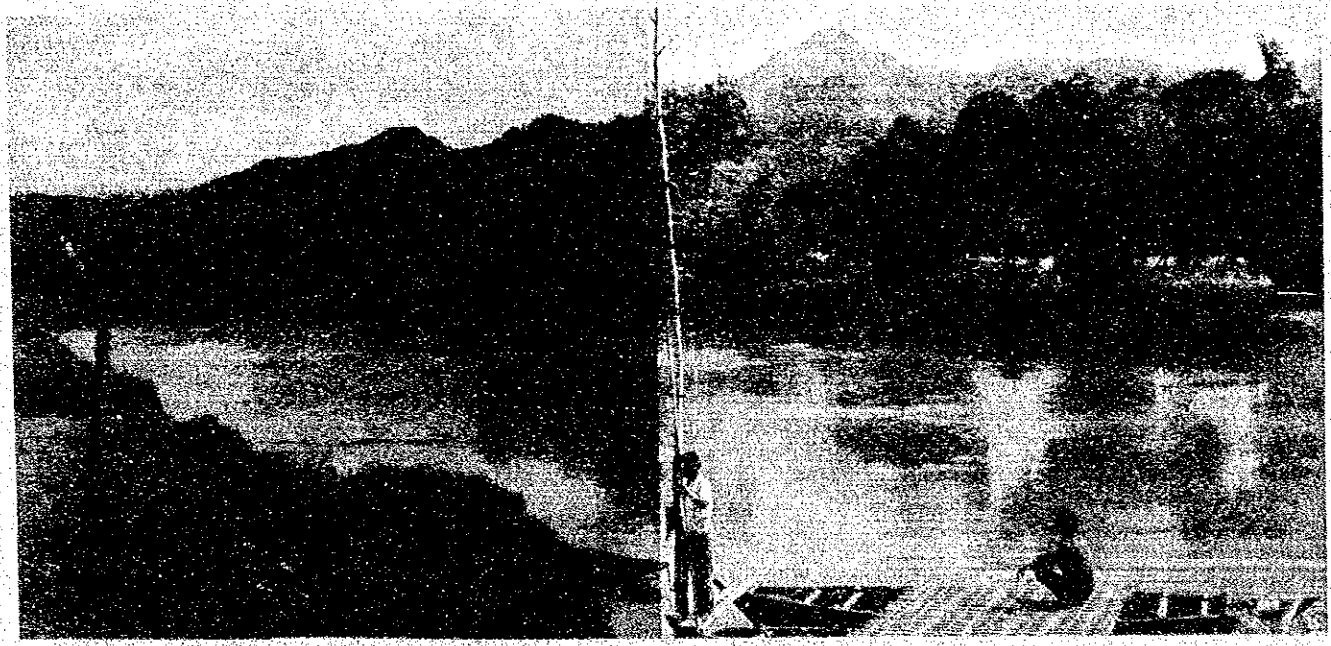


Irrigation weir at Rancakemit of the Citarik River, right tributary of the Citarum River

Upstream stretches at Rancaekek of the Citarik River (See from down stream to upstream)

Cisangkuy River, left tributary of the Citarum River, at about 4 km upstrem from the confluence of the Citarum River

MAIN REPORT



Citarum River at Cidjaruk (Flood Prone Area)

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ABBREVIATIONS

Administrative districts

Kab.	= Kabupaten	Regency
Kodya	= Kotamadya	City
Kec.	= Kecamatan	Sub-district
	Desa	Sub-district of Kecamatan
Kel.	= Kelurahan	Village (urban area)
Kp.	= Kampung	Village (rural area)
Prop.	= Propinsi	Province

Institutions

ADB	Asian Development Bank
BAPPEDA	Badan Perencanaan Pembangunan Daerah; Provincial Planning Board
Dirjen Bina Marga	Directorate General of Highways
BMG	Badan Meteorology dan Geofisika; Metearological and Geographical Agency
Dirjen Cipta Karya	Directorate General of Human Settlement
DGWRD	Derektorat Jendral Pengairan; Directorate General of Water Resources Development
DOR	Direktorat Sungai; Directorate of Rivers
DEP. PU	Departmen Pekerjaan Umum; Ministry of Public Works
DPUP	Dinas Pekerjaan Umum Propinsi; Provincial Public Works
IHE	Pusat Penelitian dan Pengmebangan Pengairan; Institute of Hydraulic Engineering
JICA	Japan International Cooperation Agency
PLN	Perusahan Listrik Negara; National Electric Coorporation
PERUMNAS	Perusahan Umum Perumahan Nasional; National Housing Development Coorporation
SATKORLAK	Satuan Kordinasi Pelaksanaan Unit Coordination Implementation

Others

BUDP	Bandung Urban Development Project

BUDS	Bandung Urban Development and Sanitation Study 1979
GDP	Gross Domestic Product
GRDP	Gross Regional Domestic Product
KIP	Kampung Improvement Project
REPELITA IV	Rencana Pembangunan Lima Tahun Fourth Five Year Development Plan
WJRDP	West Java River Development Project

Units and Conversion Factors

1) Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer

2) Area

ha	=	hectare
km^2	=	Square kilometer

3) Volume

l, ltr	=	liter = 1,000 cm3
m^3	=	cubic meter
mcm	=	million cubic meter

4) Weight

mg	=	milligram
g	=	gram
kg	=	kilogram
t, ton	=	metric ton = 1,000 kg

5) Time

s, sec.	=	second
min	=	minute
h, hr	=	hour
d	=	day
yr	=	year

6) Money

US$	=	united states dollar
Rp.	=	rupiah
ERp.	=	economic price in rupiah
¥	=	japanese yen

7) Others

Kwh	=	kilowatt hour
mkwh	=	mega kilowatt hour
%	=	per cent
ppm	=	parts per million
HP	=	horse power
°C	=	degree centigrade
10^3	=	thousand
10^6	=	million
10^9	=	billion
ø	=	diameter
max	=	maximum
min	=	minimum
m3/det	=	cubic meter/second
E	=	east
S	=	south
N	=	north
W	=	west
Fig.	=	figure

CHAPTER 1

INTRODUCTION

Chapter 1. INTRODUCTION

1.1 Background of the Study

The Citarum River flows northward to Java Sea through central part of West Java from its sources in the mountains surrounding Bandung city. Its catchment area of 6,000 km^2 is the largest among the rivers in West Java. Total length of the trunk river is more than 350 km.

The Upper Citarum River drains an area of approximately 1,800 km^2, covering the South Bandung plateau, at Curug Jompong located in the upstream end of the Saguling reservoir. The River Basin comprises approximately 70,000 ha of paddy field, 52,000 ha horticulture land, 13,000 ha urban area, and 42,000 ha forest. The river runs through the plateau with an elevation of about 700 m from east to west, meandering in its course and joining many tributaries until it reaches Curug Jompong.

The South Bandung plateau suffers from recurrent floods of the Upper Citarum River and the damages are the most serious in Dayeuh Kolot area. The major floods have occurred in the recent years, Apr. 1982, Feb. 1983, Jan. 1984 and Mar. 1986. Among these flood, the Mar. 1986 flood recorded the maximum flood area of 7,249 ha with flood depth of 0.8 to 1.5 m at Dayeuh Kolot and caused the following damages;

- damage to 27,310 houses and 480 industrial and commercial buildings
- damage to Province and Kabupaten roads of 124 km
- damage to rice crop of 6,360 ha
- evacuation of 4,300 families

These recurrent floods are mainly due to the following river conditions.

(1) The discharge capacity of the Upper Citarum River is very small compared to the flood run-off from the catchment area. This imbalance is compensated by flooding in the low-lying areas along the River.

(2) Land use developments of the watershed has increased flood peak and sediment loads of the river. These phenomena have aggravated the flood situation.

(3) Pressure of the increasing population in the Bandung Region (2.6 million in 1961, 3.2 million in 1971 and 4.1 million in 1980) has created urban sprawl into the flood prone area and it has increased flood damages.

(4) The poor discharge capacity of the river and channels are further worsened by garbage disposal into the rivers.

In addition, the rapid population growth of the Bandung Region in the future (6.4 million in 2005) will accelerate the aggravation of the flood situation in the Upper Citarum River Basin.

To cope with these circumstances, the Government of Indonesia has started a crash program in 1986 to meet an urgent requirement of flood control for Dayeuh Kolot area and also requested to the Government of Japan to undertake the Study on the Flood Control Plan of the Upper Citarum Basin. The Scope of the Study was agreed upon between the Ministry of Public Works, Government of Indonesia, and the Mission of the Japan International Cooperation Agency (JICA) on December 11, 1986.

1.2 Objectives and Area of the Study

The objectives of the Study are;

(1) to prepare an overall flood control plan of the Upper Citarum Basin,

(2) to conduct a feasibility study on an urgent project corresponding to the identified component of the flood control plan, and

(3) to perform technology transfer to the Indonesian counterpart personnel.

The Study Area will cover the Upper Citarum Basin (the catchment area of Curug Jompong) which is approximately 2,000 km^2 in the original Scope of Work but 1,771 km^2 in the actual study.

1.3 Implementation of the Study

The Directorate General of Water Resources Development (DGWRD), Ministry of Public Works, was assigned as the counterpart executing agency of the Government of Indonesia while the Japan International Cooperation Agency (JICA) was assigned as the official agency responsible for the implementation of the technical cooperation programme of the Government of Japan.

The Study was carried out by the Japanese consultant team retained by JICA and counterpart staff of DGWRD and the local engineers retained by DGWRD.

The Study was conducted from May, 1987 to December, 1988. The members involved in the Study are listed below.

(1) JICA Study Team

Mr. N. Murata	(PCI)	:	Team Leader
Mr. H. Shiraiwa	(PCI)	:	Deputy Team Leader/ Flood Control Planning
Mr. Y. Asano	(PCI)	:	Land Use Planning
Mr. T. Ishio	(PCI)	:	Hydrologic Analysis
Mr. T. Tokumasu	(PCI)	:	River Facility Planning/Design
Mr. M. Yahata	(PCI)	:	Construction Planning/Cost Estimate
Mr. S. Takada	(PCI)	:	Geology/Soil Mechanics
Mr. K. Kawamura	(AAS)	:	Topographic Analysis
Mr. K. Nakamura	(AAS)	:	Ground Survey
Mr. S. Suzuki	(PCI)	:	Flood Condition Survey
Mr. T. Tashino	(PEI)	:	Flood Damage Survey/ Project Evaluation

(2) JICA Advisory Committee

Mr. T. Yamagishi (MOC)	:	Chairman
Mr. O. Yamaguchi (MOC)	:	Member
Mr. T. Hiraoka (MOC)	:	Member
Mr. K. Yoshino (MOC)	:	Member
Mr. S. Tsuboka (MOC)	:	Member

(3) Indonesian Government

Ir. Soebandi Wirosumarto	:	Director General of Water Resources Development
Ir. Putra Duarsa	:	Inspector General, Ministry of Public Works
Ir. Kusdaryono	:	Assistant Director General of Water Resources Development
Ir. Hartono Pramudo	:	Director of Rivers, DGWRD
Ir. Sarbini Rohodibroto	:	Director of Planning and Programming, DGWRD
Ir. Sadeli Wiramihardja	:	Chief of Public Works of West Java/ West Java Regional Office, Ministry of Public works
Ir. Amir Muryadi	:	Chief of Technical Design of DOR
Ir. Siswoko, Dipl. HE	:	Chief of Section of Technical Design of DOR
Ir. Soelastri Djennoedin	:	Directress of IHE
Ir. Joesron Loebis, MSC	:	Chief of Hydrologic Investigation of IHE
Ir. Maman Gantina, Dipl. HE	:	Chief of Sub-Water Resources Services of Public Works of West Java Province
Ir. Sukanda Marga Permana	:	Chief of Sub-Urban Development Services of Public Works of West Java Province
Ir. Mugiono, Dipl. HE	:	Project Manager of Improvement and Regulation of Upper Citarum Basin Project
Ir. A. Hidayat	:	Project Manager of River Improvement and Maintenance Project of West Java Province

(4) DOR Counterparts and Local Engineers

Ir. Bambang, S. Dipl. HE	:	Team Leader
Ir. Syafrudin	:	Flood Control Planning
Mr. Tjutju Prihatna, BE	:	Land Use Planning
Mr. Tjetjen Z.A	:	Hydrologic Analysis
Ir. Tjutju Risyana	:	River Facility Planning/Design
Ir. A. Rosyid	:	Construction Planning/Cost Estimate
Mr. Amir Nazar, BE	:	Ground Survey
Mr. U. Abdurachman, BE	:	Flood Control Survey
Ir. Hambali Suraja	:	Dupty Team Leader
Ir. Andang Dwiananto	:	Flood Control Planning
Ir. Murdianto	:	Hydrologic Analysis
Drs. Yuni Moro Buwigyono	:	River Facility Planning/Design
Ir. Eddy Isnomo	:	Construction Planning/Cost Estimate
Mr. Ishak Awat, BE	:	Geology/Soil Mechanic
Mr. Komar Wiriadinata	:	Topographic Analysis
Ir. Yulianto Sarwoko	:	Flood Damage Survey/ Project Evaluation

Special Abbreviations

MOC : Ministry of Construction, Government of Japan
PCI : Pacific Consultants International
PEI : Project Economy Institute, INC.
AAS : Asia Air Survey Co., LTD

1.4 Composition of Report

This report consists of three (3) volumes: Main Report, Supporting Report, and Data Book.

The Main Report presents the summarized results of all the studies. In Chapter 2 through 5, the basic information for the Study are described. Chapter 6 deals with the overall flood control plan. In Chapter 7 through 10, the feasibility study on the urgent project corresponding to the identified component of the flood control plan is described. Chapter 11 deals with recommendation.

The Supporting Report includes the following Studies;

A	:	Topography and Geology
B	:	Socio-Economic Condition
C	:	Present Watershed and River Condition
D	:	Flood Condition
E	:	Flood Damage
F	:	On-going Project
G	:	Hydrological Analysis
H	:	Overall Flood Control Plan
I	:	Urgent Flood Control Plan
J	:	Construction Plan and Cost Estimate for Urgent Flood Control Plan
K	:	Economic Evaluation for Urgent Flood Control Plan
L	:	Topographic Survey
M	:	Scope of Works
ANNEX	:	Comprehensive Flood Disaster Prevention Measures in Japan

The Data Book is consisted of the flowing three separate volumes;

I	:	Design Drawings
II	:	Topographic Survey Drawings
III	:	Flood Condition and Hydrological Data

1.5 Acknowledgement

In undertaking the Study, the Study Team has attached great importance to the incorporation of the views of departments and agencies of the Government of Indonesia relating to the various aspects covered by the Study. The contributions to the Study by the officials of Ministry of Public Works, Directorate General of Water Resources Development, and other individuals who have provided information and data, participated in discussions, given valuable advices, and provided other forms of assistance to the Study are greatfully acknowledged.

A heartfelt gratitude is also extended to the officials of the Embassy of Japan in Indonesia, the Ministry of Foreign Affairs and Ministry of Construction of the Government of Japan who gave advice and provided various supports during the performance of the Study. In reality, the Study can be regarded as a joint effort by the Indonesian and Japanese officials and individuals concerned and the Japanese Study Team. The Study Team sincerely hopes that this effort will contribute to the future development of flood control of the Upper Citarum Basin in particular, and to its socio-economic development and well-being in general.

CHAPTER 2

STUDY AREA

Chapter 2. STUDY AREA

2.1 Natural Condition

2.1.1 Topography

The Study Area is bounded by mountain ridges with an altitude of about 2000 m. The Citarum River flows from the east to the west in the center of the Study Area with an elevation of about 660 m. The flood plain of the Citarum River was a lake during the period between about 6000 and 3000 years ago and almost flat. All the tributaries have steep slopes because of short stream length and large difference in ground elevation.

A relief of the Study Area is illustrated in Fig. 2.1.

2.1.2 Geology

(1) General Geology

Fig. 2.2 shows a general geology of the Study Area. Bandung is situated on the alluvial fan of the Citarum River. The flat area along the Citarum River consists of lacustrine and alluvial deposits, while the other areas consist mostly of volcanic deposits.

(2) Geology along the Citarum River

The geology along the Citarum River consists of flood plain deposits, lacustrine deposits and pleistocene deposits with rock intrusion.

1) Flood plain deposit

This is a secondary deposit of clayey soil of a light brown color and distributed in all the reaches of the Citarum River. Thickness of the layer is 1 - 4m. The N-value varies between 1 and 13.

2) Lacustrine deposit

This consists of clayey soil, humus soil and sandy soil. It is widely distributed in the upstream of Dayeuh Kolot. Thickness of the layer is approximately 50 m.

(a) Clayey soil

This is soft clayey soil of a dark grey color. It is distributed at an elevation between EL. 626 m and EL. 660 m. N-value is 2 - 8.

(b) Humus soil

This is soft humus soil of a black or dark grey color. It is distributed at an elevation ranging from EL. 639 m to EL. 660 m. Thickness of the layer is 4 - 15 m. N-value is 0 - 3.

(c) Sandy soil

This is distributed among the layers of clayey soil and humus soil with a layer thickness of 3 - 5 m, and also forms the base layer of lacustrine deposit. Thickness of the base layer of sandy soil is approximately 13 m. N-value is 2 - 29.

3) Pleistocene deposit

This consists of clayey soil, sandy soil, gravel and intrusive rock. It is distributed in the downstream of Dayeuh Kolot.

(a) Clayey soil

This is distributed between the river distances of 8 and 25 km, together with sandy soil layer. N-value is 7 - 60.

(b) Sandy soil

This consists of fine sand and silt. It is distributed between 0.5 and 25 km river distances from Curug Jompong, together with clayey soil layers. N-value is 21 - 60.

(c) Gravel

This is locally distributed around 17 km river distance. Thickness of the layer is approximately 3.0 m.

(d) Intrusive rock

Intrusive rocks of quartz trachyte are distributed around Curug Jompong. They are very hard.

(3) Geology of the Citarum River Bed

The geological conditions of the river bed of the Citarum River were investigated in detail by field reconnaissance, boring test and seismic exploration. The summarized results are shown in Table 2.1.

Geological map of the Citarum River is shown in Fig. 2.3 and its geological profile is shown in Supporting Report A.

2.1.3 Rainfall

The climate of the Study Area is of typical tropical type, characterized by two (2) distinct seasons: rainy and dry. Average annual rainfall ranges from 1,800 mm to 2,800 mm. Isohyetal map of the annual rainfall is shown in Fig. 2.4.

Heavy rainfall in the Study Area is caused by the east monsoon. Rainy season extends from November to April during which approximately 70% of the annual rainfall occurs.

Monthly distribution of annual rainfall in the representative stations of the Study Area is shown in Table 2.2.

2.2 Socio-economic Condition

2.2.1 Administration

The Study Area includes the areas of three (3) administrative autonomies: the whole area of Kotamadya Bandung; about a half portion of Kabupaten Bandung; and a small portion of Kabupaten Sumedang.

Areas, number of Kecamatans and number of Desas covered by each Kabupaten or Kotamadya in the Study Area are shown in Table 2.3.

2.2.2 Population

The population of the Study Area increased from 3.632 million in 1980 to 3.966 million in 1985 with an annual growth rate of 1.78%. It accounted for 2.4% and 87.9% of the population of Indonesia and the Bandung Region in 1985 respectively. The population density of the Study Area in 1985 was 1,758 persons/km^2.

The population of the Study Area in 2005 is estimated to be 5.527 million, assuming an annual growth rate of 1.67%.

Break-down of the population of the Study Area by Kabupaten or Kotamadya is shown in Table 2.4. The population of Indonesia and the Bandung Region are also shown in the same table.

2.2.3 Land-use

The land-use composition of the Study Area is classified into five (5) categories, namely, forest, paddy field, dry field and plantation (both are agricultural land-use), water, and built-up areas. The distribution of present land-use composition of the Study Area are shown in Table 2.5 and Fig. 2.5.

The future land-use of the Study Area for the year 2005 is projected in conformity to the following three (3) studies.

(1) Dirjen Cipta Karya: Master Plan of Bandung Metropolitan Area for year 2001

(2) Master Plan of Bandung for year 2005 that was made by Municipality of Bandung.

(3) Proposal of the land-use for forest area in the Citarum Basin made by the Department of Forestry.

This projected future land-use composition is shown in Table 2.5 and Fig. 2.6.

2.2.4 Gross Regional Domestic Product (GRDP)

GRDP of Kabupaten Bandung is Rp. 833 billion in 1985 at current prices. The regional economic structure in 1985 is as follows:

(1) Agricultural sector : Rp. 222 billion (26.6%)
(2) Industrial sector : Rp. 244 billion (29.3%)
(3) Services' sector : Rp. 367 billion (44.1%)

The per capita GRDP is Rp. 272,000 in 1985, which is 46.3% of the national value of Rp. 588,000.

The per capita GRDP in 2005 is estimated to be Rp. 464,000, at 1985 constant prices on the following assumptions.

(1) The national economic growth will increase at a rate of 5.0% per annum, the same rate as REPELITA IV, (4th 5 year development plan) up to the year 2000. After 2000, the growth rate will be down to 4.0%.

(2) The regional share of the per capita GRDP to the nation will remain the same as 1985 condition of 46.3%.

Then, GRDP of Kabupaten Bandung in 2005 is expected to be Rp. 2,198 billion at 1985 constant prices.

Table 2.1 GEOLOGICAL CONDITION OF RIVER BED

River Distance * (km)	Kind of Soil/Rock	N-value	Velocity of Seismic Wave (m/sec)
0.0 - 0.5	very hard quartz trachyte	-	4,000 - 4,900
0.5 - 1.8	sand / sandy soil	lager than 50 - 100	1,500 - 4,000
1.8 - 3.2	sand	30 - 50	-
4.0 - 8.0	sand / sandy soil	30 - 150	-
Around 11.0	sand / sandy soil	30 - 60	-
Around 17.0	gravel	-	-
18.0 - 21.0	hard clayey soil	61 - 100	-
22.0 - 25.0	hard clayey soil	55 - 80	-
25.0 - 34.0	hard clayey soil	16 - 42	-
34.0 - 38.0	sand / sandy soil	5 - 25	-
38.0 - 45.0	clayey soil / humus soil	1 - 4	-

*Distance along existing river from Curug Jompong

Table 2.2 AVERAGE MONTHLY RAINFALL (1950 - 1985)

Station	Month												Total
	Jan.	Feb	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.	
Cimahi	240	186	247	183	102	45	73	54	84	144	218	228	1804
Pakar	238	223	233	213	148	65	55	59	85	176	256	260	2011
Cisondari	254	211	258	247	255	91	95	68	117	171	309	314	2390
Majalaya	269	211	319	215	137	79	59	44	68	121	242	287	2048
Cinyiruan	407	317	323	316	189	107	79	79	109	199	304	361	2790

Source : Pre-feasibility Study 21 Lokasi : Paket III Dalam Bidang, Water Resources Studies and Hydrologic Analysis, (Appendix III-2) Rainfall Data, August 1986

Table 2.3 STUDY AREA

KABUPATEN KOTAMADYA	Area (km 2)	RATE TO TOTAL AREA (%)	RATE TO WHOLE SUB-DISTRICT (%)	NUMBER OF KECAMATANS	NUMBER OF DESAS
Kab. Bandung	1525.9	86.2	50.2	26	327
Kab. Sumedang	164.1	9.3	11.5	2	49
Kodya Bandung	81.0	4.6	100.0	16	91
Total	1771.0	100.0	-	44	467

Table 2.4 POPULATION OF STUDY AREA

	AREA (km2)	1980 (Million)	1985 (Million)	2005 (Million)	GROWTH RATE (%) 1980/1985	GROWTH RATE (%) 1985/2005	DENSITY 1985 (person/km2)
Indonesia	1,919,443	147,490	164,047	244,734	2.15	2.02	85
Bandung Region	3,122	4,130	4,513	6,440	1.79	1.79	1,445
Kab. Bandung	3,041	2,669	2,999	4,735	2.35	2.31	986
Kodya Bandung	81	1,461	1,514	1,705	0.71	0.60	18,700
Study Area *1	2,256	3,632	3,966	5,527	1.78	1.67	1,758
Kab. Bandung	2,012	2,023	2,295	3,623	2.55	2.31	1,140
Kab. Sumedang	163	148	157	199	1.20	1.20	960
Kodya Bandung	81	1,461	1,514	1,705	0.71	0.60	18,700

Note *1: Since the area adopts the administrative district, it is different from the physical basin area.

Table 2.5 PRESENT AND FUTURE LAND-USE IN STUDY AREA

Item	Present (1986)		Future (2005)	
	Area (km2)	Percentage (%)	Area (km2)	Persentage (%)
Built-up Area	125.4	7.1	284.0	16.0
Paddy Field	694.9	39.2	578.3	32.6
Forest	419.6	23.7	419.2	23.7
Water	8.1	0.5	6.5	0.4
Dry Field, Plantation	523.0	29.5	484.0	27.3
Total	1,771.0	100.0	1,771.0	100.0

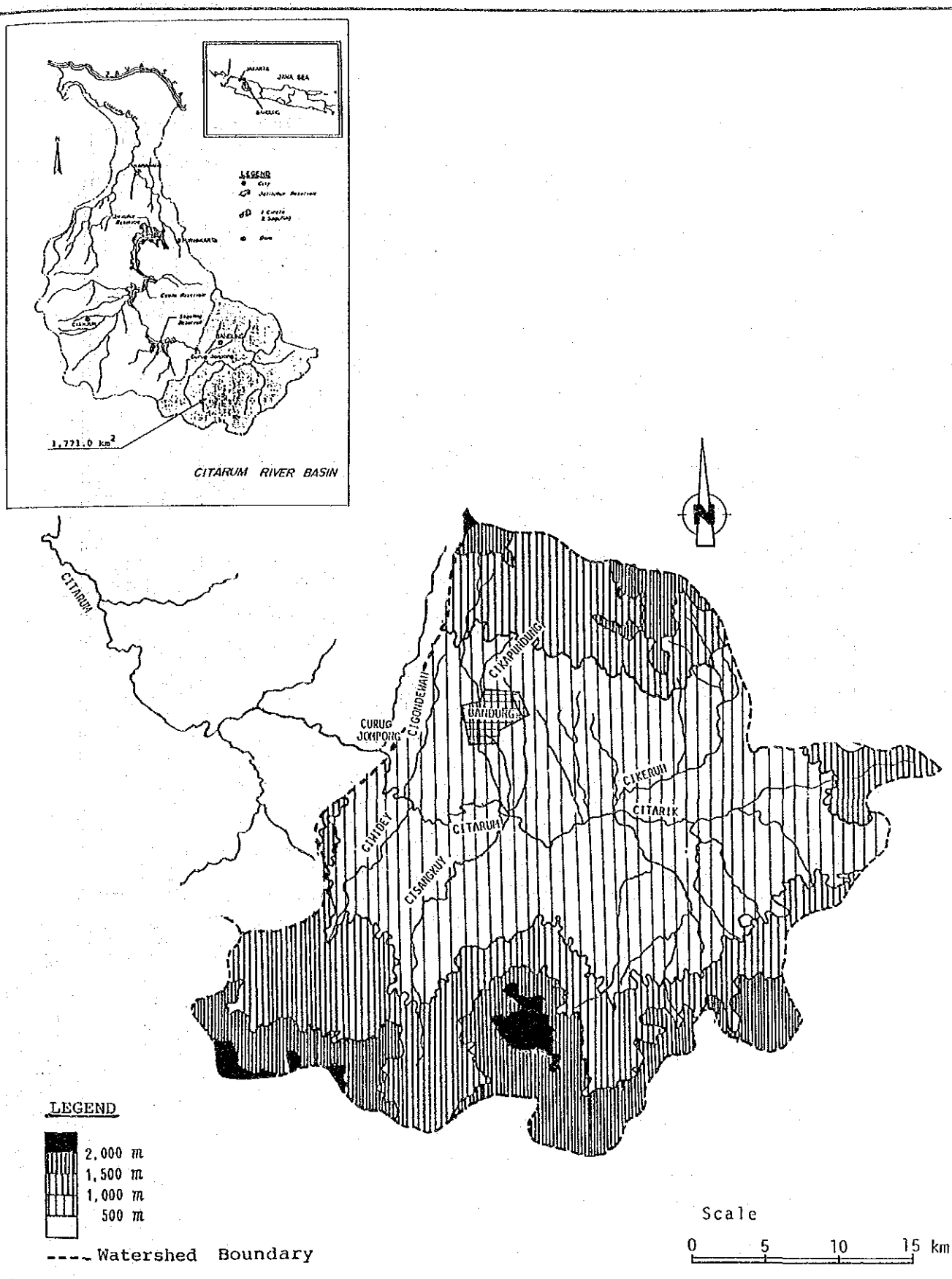

FIG. 2.1 RELIEF MAP OF STUDY AREA

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA

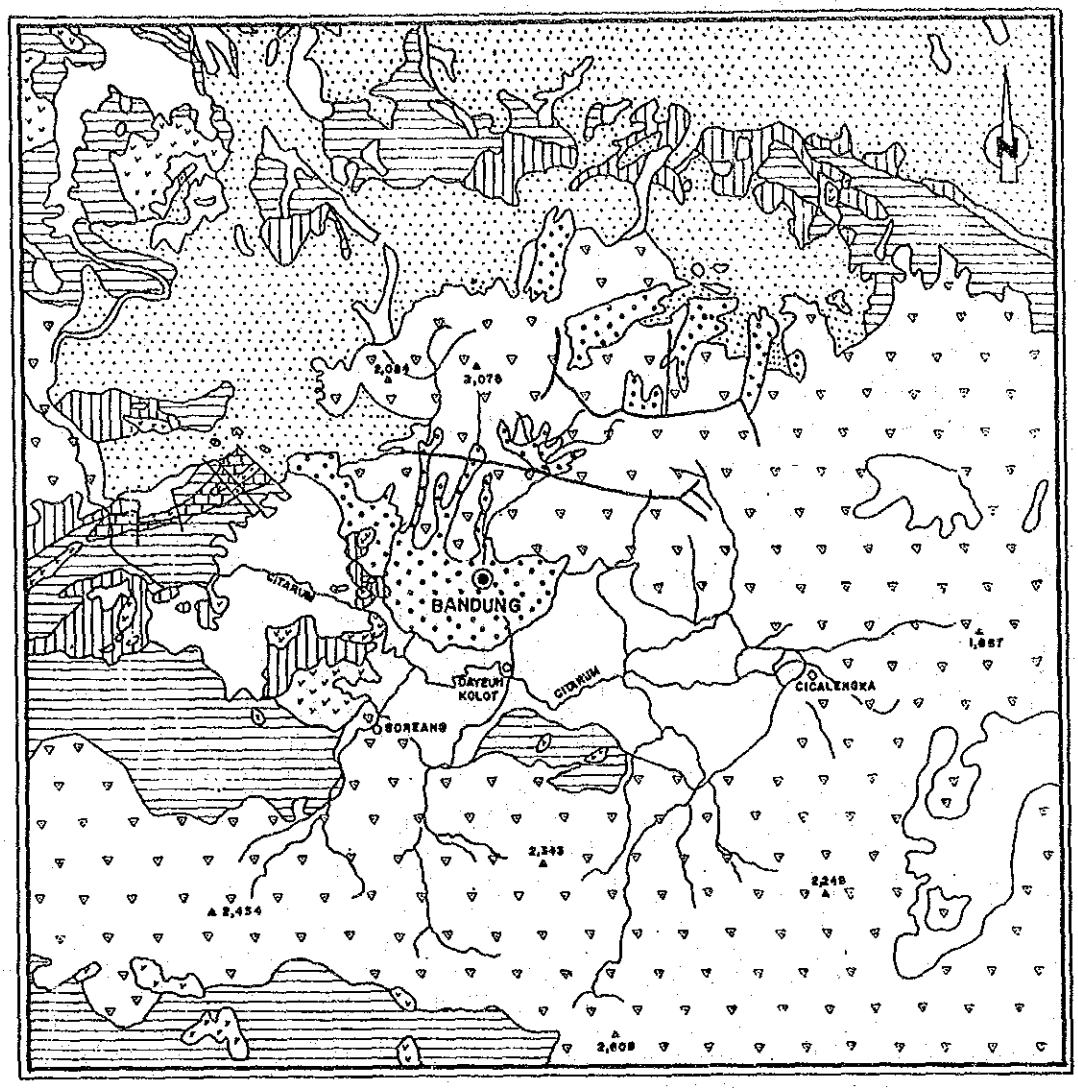

FIG. 2.2 GEOLOGICAL MAP AROUND BANDUNG AREA

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA

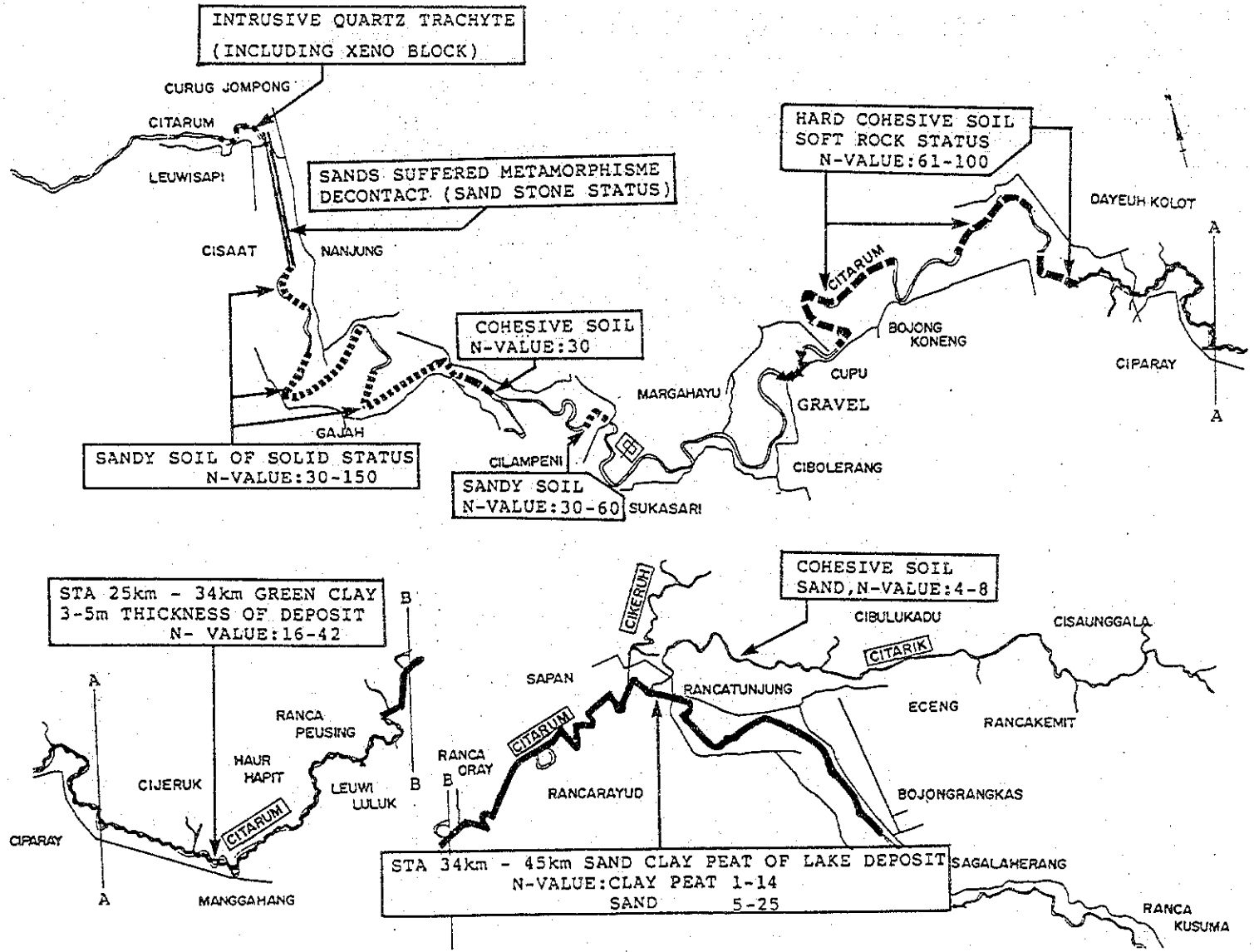

FIG. 2.3 GEOLOGY ALONG CITARUM RIVER

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

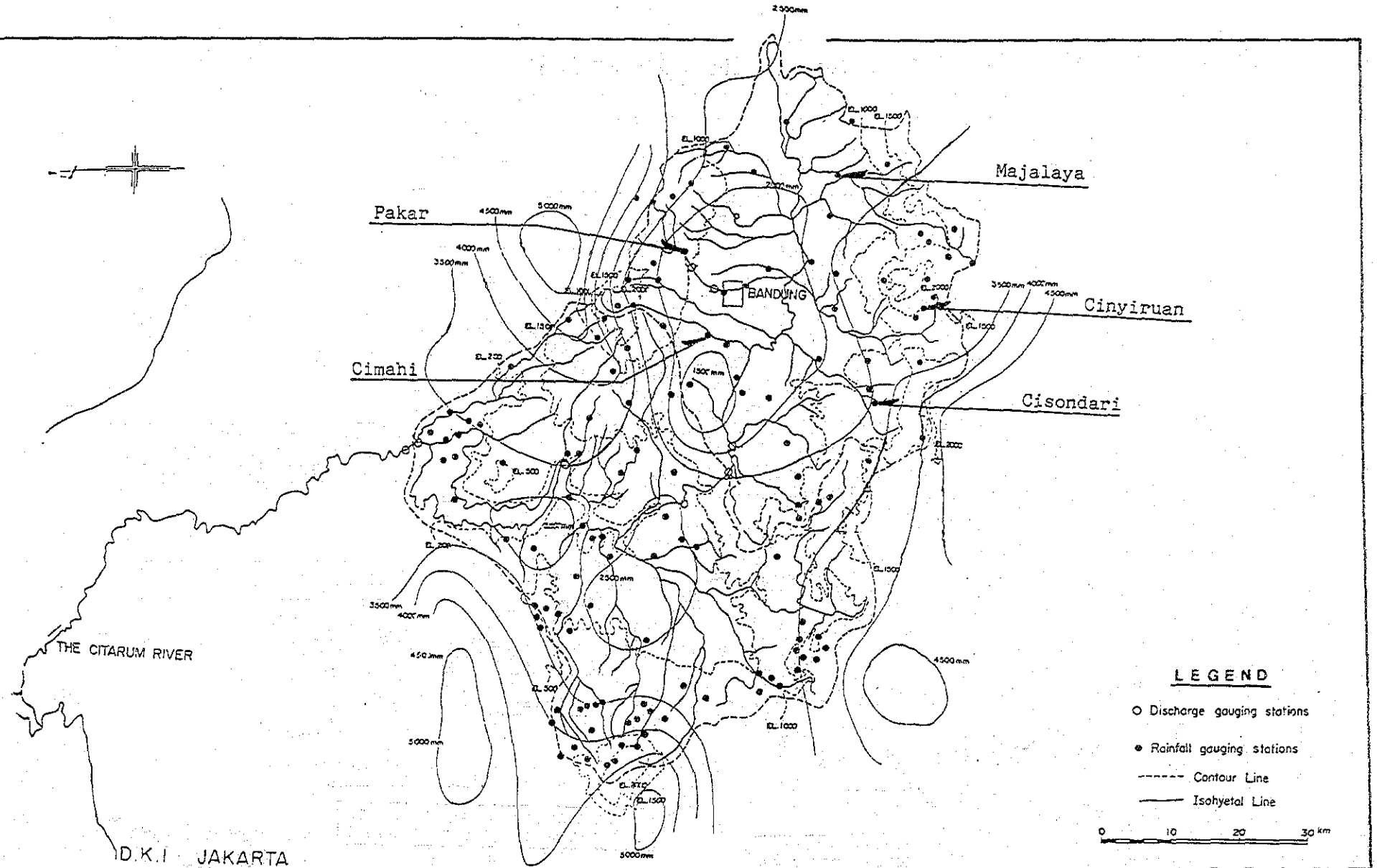

FIG. 2.4 ISOHYETAL MAP OF ANNUAL RAINFALL FOR STUDY AREA

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA

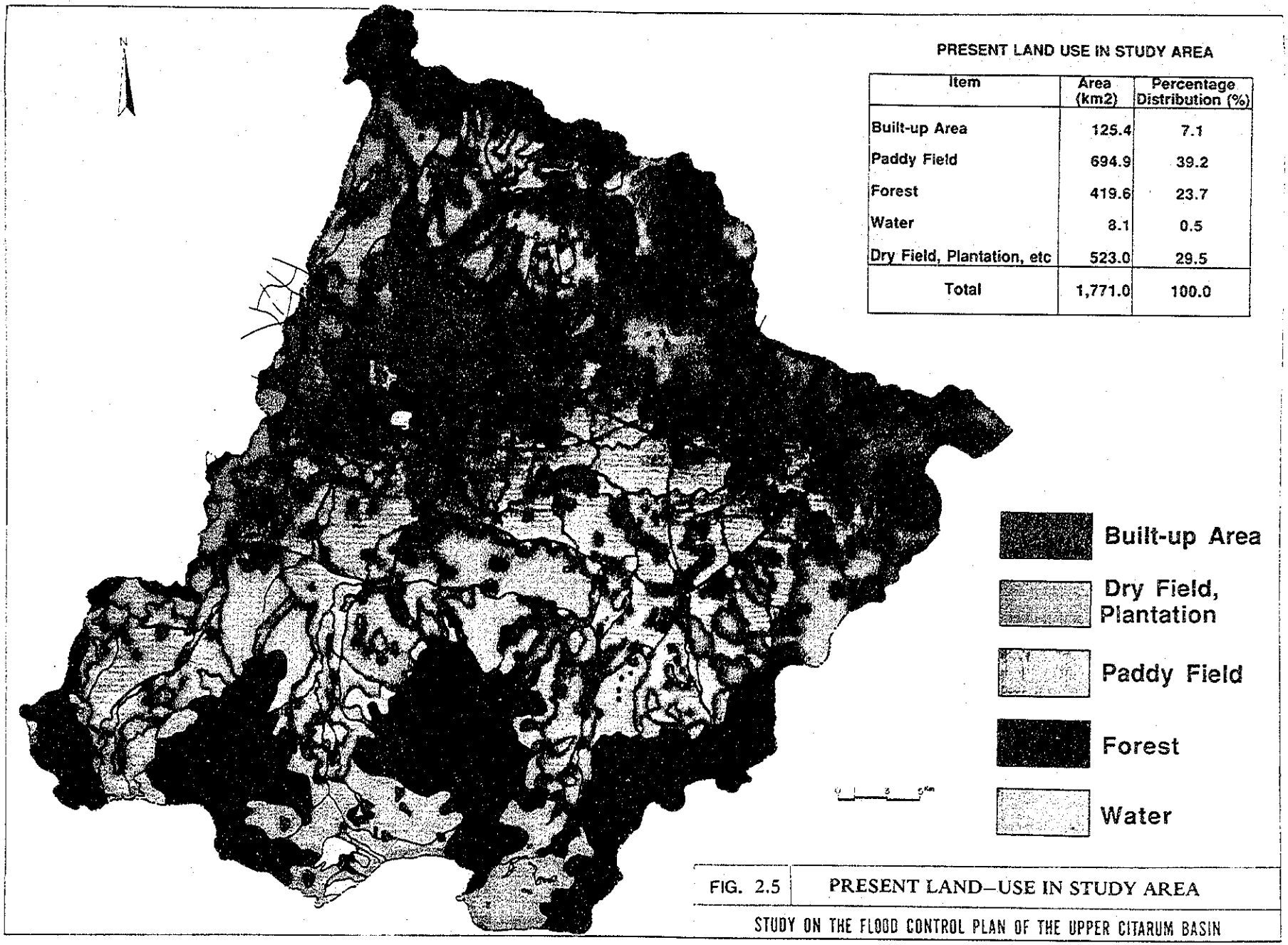

FIG. 2.5 PRESENT LAND–USE IN STUDY AREA

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA

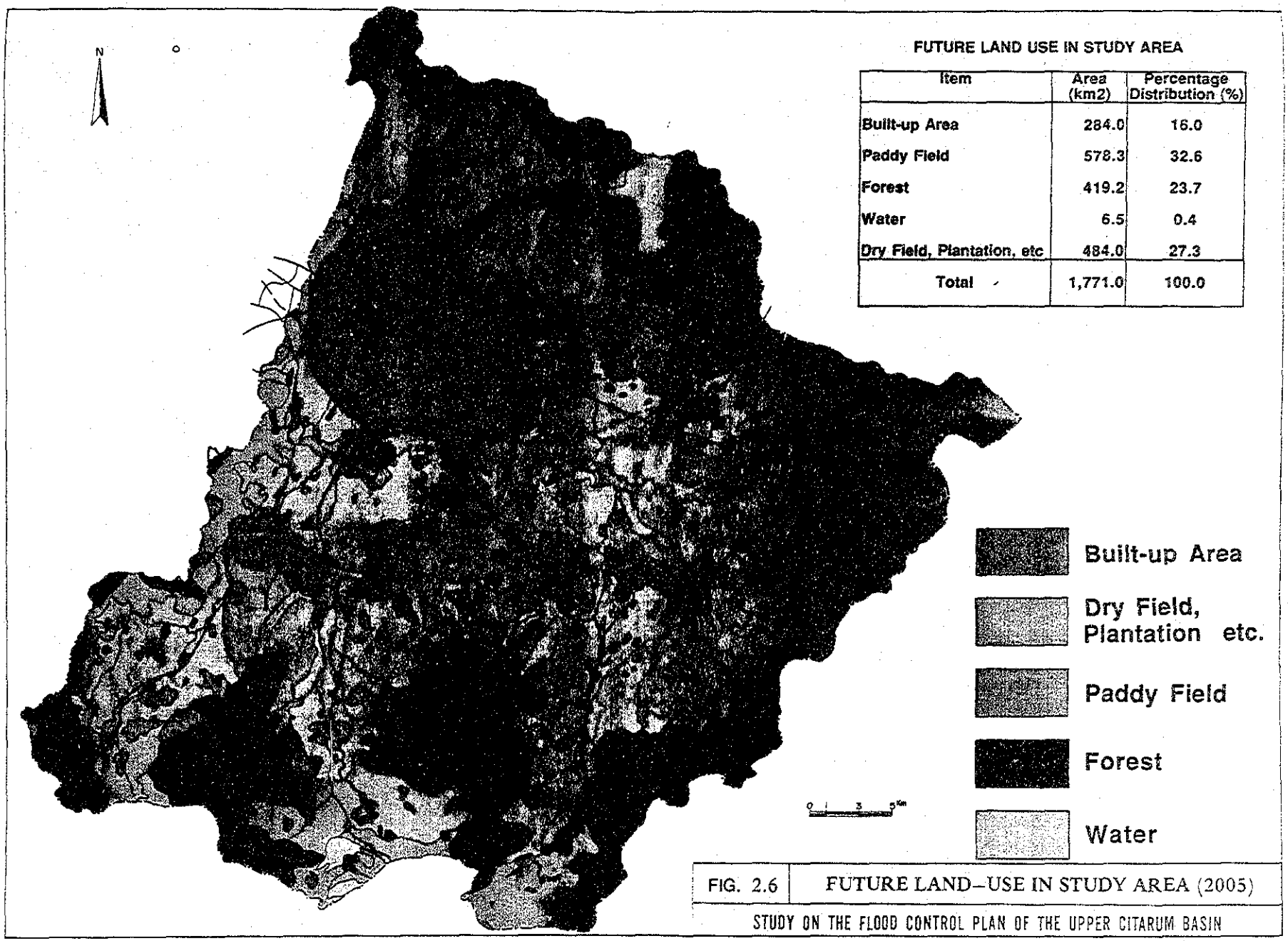

FIG. 2.6 FUTURE LAND–USE IN STUDY AREA (2005)

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

CHAPTER 3

PRESENT WATERSHED AND RIVER CONDITION

Chapter 3. PRESENT WATERSHED AND RIVER CONDITION

3.1 Watershed Condition

3.1.1 Drainage Basin

The Upper Citarum Basin (1,771 km^2) is divided into 15 major sub-basins (see Fig. 3.1).

The covered drainage areas are:

- 754.7 km^2 at Sapan
- 1,332.1 km^2 at Dayeuh Kolot
- 1,718.0 km^2 at Nanjung
- 1,771.0 km^2 at Curug Jompong

The land-use of the Basin can be roughly classified into five (5) categories: water, forest, paddy field, field (dry field, plantation, etc.) and built-up area.

The existing and future (year 2005) land-uses of the Basin are classified into these five (5) categories on a sub-basin basis.

The results are shown in Table 3.1.

3.1.2 Land Erosion

The Basin is affected by serious land erosion. An average erosion depth of the Basin is estimated to be 2.1 mm/year. According to the suspended load data at stream gauge stations measured by IHE, high concentration of suspended solids are recognized in the following rivers:

River (Station)	Concentration (mg/l)	Date
- Citarum (Majalaya)	1,782	Dec. 5, 1984
- Cipamokolan (Lio)	7,238	Sep. 12, 198
- Citarum, Cirasea (Andir)	2,579	Oct. 4, 1984
- Citarik, Cijalupang (Peundeuy)	3,128	Dec. 6, 1984
- Cibodas (Jatisari)	2,124	Sep. 15, 1984

Average suspended loads at Dayeuh Kolot during the flood season is estimated to be 200 - 400 mg/l.
The serious land erosion areas are illustrated in Fig. 3.2.

3.2 River Condition

3.2.1 River Profile and Cross Section

The existing average bed and bank slopes of the Citarum River and its major tributaries in the flood prone stretches are as follows:

Citarum River

Citarum Main: For 40 km stretches between Curug Jompong and Sapan,

Bed slope : 1/6,000 (0.00017)
Bank slope : 1/6,800 (0.00015)

Citarum Upstream: For 6 km stretches upstream from Sapan,

Bed slope : 1/3,600 (0.00028)
Bank slope : 1/3,600 - 1/1,000 (0.00028 - 0.001)

Citarik River: For 15 km stretches upstream from the confluence with the Citarum River at Sapan,

Bed slope : 1/4,500 - 1/1,100 (0.00022 - 0.00091)

Bank slope : 1/4,500 - 1/1,100
(0.00022 - 0.00091)

Cikeruh River: For 5 km stretches upstream from the confluence with the Citarum River at Sapan,

Bed slope : 1/2,250 (0.00044)
Bank slope : 1/4,500 (0.00022)

Cisangkuy River: For 9 km stretches upstream from the confluence with the Citarum River at Dayeuh Kolot,

Bed slope : 1/2,800 (0.00036)
Bank slope : 1/2,800 (0.00036)

The existing river profiles of the Citarum, Citarik, Cikeruh and Cisangkuy Rivers are shown in Supporting Report C.

The cross sections of the Citarum, Citarik, Cikeruh and Cisangkuy Rivers are of single section with no major embankments. The river width and depth are shown below.

Name of River	Width (m)	Depth (m)	Remarks
Citarum			
Citarum Main	30 - 70	3 - 6	Downstream of Sapan
Citarum Upstream	25 - 30	3 - 6	Upstream of Sapan
Citarik	10 - 25	2 - 4	
Cikeruh	10 - 20	2 - 3	
Cisangkuy	15 - 30	3 - 6	

The typical cross sections of the Citarum, Citarik, Cikeruh and Cisangkuy Rivers are shown in Supporting Report C.

3.2.2 Roughness Coefficient

Manning's roughness coefficient of the Citarum River was estimated by collating the water level profile of the 1986 flood obtained by non-uniform flow computation with the actual water level trace.

The estimated roughness coefficients under the existing river conditions are:

0.040: For the stretches between Curug Jompong and the confluence of the Ciwidey River.

0.035: For the stretches between the confluence of the Ciwidey River and the Cisangkuy River.

0.030: For the stretches upstream from the confluence of the Cisangkuy River.

3.2.3 Hydraulic Characteristics

Hydraulic characteristics of the Citarum, Citarik, Cikeruh and Cisangkuy Rivers are expressed in terms of flow area, ratio of river width and depth, discharge capacity and mean flow velocity.

Those are summarized in Table 3.2. Longitudinal change of the hydraulic characteristics of the river is shown in Supporting Report C.

The main stream of the Citarum River, the distance expressed in km from Curug Jompong, (0 - 40 km) undergoes a clear change in its hydraulic characteristics at sections between 20 km and 25 km distances at mid stream. The discharge capacity of the downstream stretches (0 - 20 km) is approximately two (2) times larger than that of the upstream stretches (20 - 40 km). The river width to depth ratio varies from 8 to 20 in the downstream stretches (0 - 20 km), while it remains rather constant at 8 - 10 in the upstream stretches (25 - 40 km).

Mean velocity of the bankful discharge is 1.0 m/s or less in all the stretches (0 - 40 km).

3.2.4 River Facilities

The existing river facilities related to the Project are 12 bridges, 13 irrigation weirs, dike of 10,720 m length and revetment of 250 m length.

Location of the facilities are shown in Fig. 3.3.

3.2.5 River Bed Material

Sampling tests of river bed materials of the Citarum River were conducted by the Study Team (see Supporting Report C).

Mean diameters of the river bed materials are 8.67 - 28.4 mm at Pameuntasan (just downstream of the confluence with the Ciwidey River), 0.52 - 2.62 mm at Dayeuh Kolot (just downstream of the confluence with the Cisangkuy River), 0.37 - 0.72 mm at Haurhapit (mid point between Dayeuh Kolot and Sapan), and 0.86 - 1.01 mm at Bojong Angkas (mid point between Sapan and Majalaya).

The river bed material is the minimum in size at Haurhapit located in the middle of the flood area. This fact shows that tractive force on sediment is decreased due to flood retarding effects in this location.

Specific gravity of the river bed materials is 2.73 - 2.80.

3.2.6 Sedimentation of River Bed

There exist a large mixed accumlation of sediments and garbages in the downstream of the confluence with the Cikapundung River extending over approximately 8 km. As a consequence the flood water level at Dayeuh Kolot has undergone a rapid rise in recent years.

Table 3.1 LAND-USE OF BASIN

Name of Drainage basion	Area (km2)	Land Use (Existing)										Land Use (Year : 2005)									
		Water		Forest		Paddy Field		Dry Field Plantation etc		Built-up Area		Water		Forest		Paddy Field		Dry Field Plantation etc		Built-up Area	
		Area (km2)	Percent (%)	Area (km2)	Percent (%)	Area (km2)	Percent (%)	Area (km2)	Percent (%)	Area (km2)	Percent (%)	Area (km2)	Percent (%)	Area (km2)	Percent (%)	Area (km2)	Percent (%)	Area (km2)	Percent (%)	Area (km2)	Percent (%)
1. Citarum	197.0	0.5	0.2	88.7	45.0	49.0	249.0	55.7	28.3	3.1	1.6	0.5	0.3	88.7	45.0	47.1	23.9	55.7	28.3	5.0	2.5
2. Cirasea	93.1	0.0	0.0	20.1	21.6	42.7	45.8	26.8	28.8	3.5	3.8	0.0	0.0	20.1	21.6	34.7	37.2	25.1	27.0	13.2	14.2
3. Citarik	281.4	0.8	0.3	35.0	12.4	137.5	48.9	99.0	35.2	9.1	3.2	0.8	0.3	35.0	12.4	134.2	47.7	96.5	34.3	14.9	5.3
4. Cikeruh	204.6	0.0	0.0	43.6	21.3	90.9	44.5	62.5	30.5	7.6	3.7	0.0	0.0	43.6	21.3	77.9	38.1	48.7	23.8	34.4	16.8
5. Kopo	53.7	0.0	0.0	0.8	1.5	33.6	62.6	18.2	33.9	1.1	2.0	0.0	0.0	0.8	1.5	33.6	62.6	18.2	33.9	1.1	2.0
6. Cibodas	29.7	0.0	0.0	0.0	0.0	16.3	54.8	10.5	35.4	2.9	9.8	0.0	0.0	0.0	0.0	14.3	48.2	4.6	32.3	5.8	14.5
7. Cidurian	51.8	0.0	0.0	1.5	2.9	33.6	64.9	5.4	10.4	11.3	21.8	0.0	0.0	1.5	2.8	26.4	51.0	4.5	8.7	19.4	37.5
8. Cikapundung	144.3	0.0	0.0	38.7	26.8	13.8	9.6	48.0	33.3	43.8	30.3	0.0	0.0	38.7	26.8	4.2	2.9	45.6	31.6	55.8	38.7
9. Cisangkuy	276.5	4.9	1.8	92.6	33.5	77.2	27.9	98.3	35.5	3.5	1.3	4.9	1.8	92.2	33.3	68.2	24.7	96.8	35.0	14.4	5.2
Dayeuh Koloc	1332.1	6.2	0.5	321.0	24.1	494.5	37.1	424.5	31.9	85.9	6.4	6.2	0.5	320.6	24.1	440.6	33.0	400.7	30.1	164.0	12.3
10. Cijalupang	60.1	0.0	0.0	0.0	0.0	44.4	73.9	14.5	24.1	1.2	2.0	0.0	0.0	0.0	0.0	34.6	57.6	13.1	21.8	12.4	20.6
11. Ciwidey	200.6	0.0	0.0	73.9	36.8	78.4	39.2	48.0	23.9	0.3	0.1	0.0	0.0	73.9	36.8	73.9	36.8	45.3	22.6	7.5	3.8
12. Cibaeureum	117.2	1.6	1.4	7.9	6.7	51.6	44.0	19.1	16.3	37.0	31.6	0.0	0.0	7.9	6.7	11.5	9.8	12.0	10.2	85.5	73.3
13. The basin of the rest	8.0	0.0	0.0	0.0	0.0	5.1	63.7	2.7	33.8	0.2	2.5	0.0	0.0	0.0	0.0	5.1	63.8	2.7	33.8	0.2	2.4
Nanjung	1710.0	7.8	0.4	402.8	23.4	674.0	39.2	508.8	29.7	124.6	7.3	6.2	0.4	402.4	23.4	565.7	32.9	473.8	27.6	269.9	15.7
14. Cimahi	48.0	0.3	0.6	16.8	35.0	18.8	39.2	10.7	22.3	1.4	2.9	0.3	0.6	16.8	35.0	10.5	21.9	6.7	14.0	13.7	28.5
15. The basin of the rest	6.0	0.0	0.0	0.0	0.0	2.1	35.0	3.5	58.3	0.4	6.7	0.0	0.0	0.0	0.0	2.1	35.0	3.5	58.3	0.4	6.7
Curug Jompong	1771.0	8.1	0.5	419.6	23.7	694.9	39.2	523.0	29.5	126.4	7.1	6.5	0.4	419.2	23.7	578.3	32.6	484.0	27.3	284.0	16.0

Table 3.2 HYDRAULIC CHARACTERISTICS OF RIVER

	Flow Area (m2)	Width/Depth	Discharge Capacity (m3/s)	Mean Velocity (m/s)
Citarum River				
Main (0 - 20 km)	200 - 320	8 - 20	170 - 320	0.7 - 1.0
Main (20 - 25 km)	100 - 170	10 - 20	100 - 130	0.8
Main (25 - 40 km)	100 - 130	8 - 10	100 - 130	0.9
Upstream	60 - 130	6 - 12	50 - 350	0.8 - 2.5
Citarik River	15 - 60	4 - 10	15 - 55	0.8 - 1.3
Cikeruh River	5 - 40	6 - 15	2 - 30	0.2 - 0.7
Cisangkuy River	60 - 100	4 - 10	50 - 110	0.9 - 1.2

Name of Drainage basin	Area (km2)
1. Citarum	197.0
2. Cirasea	93.1
3. Citarik	281.4
4. Cikeruh	204.6
5. Kopo	53.7
6. Cibodas	29.7
7. Cidurian	51.8
8. Cikapundung	144.3
9. Cisangkuy	276.5
Dayeuh Kolot	1,332.1
10. Cijalupang	60.1
11. Ciwidey	200.6
12. Cibeureum	117.2
13. The basin of the rest	8.0
Nanjung	1,718.0
14. Cimahi	48.0
15. The basin of the rest	6.0
Curug Jompong	1,771.0

SOURCE: STUDY TEAM

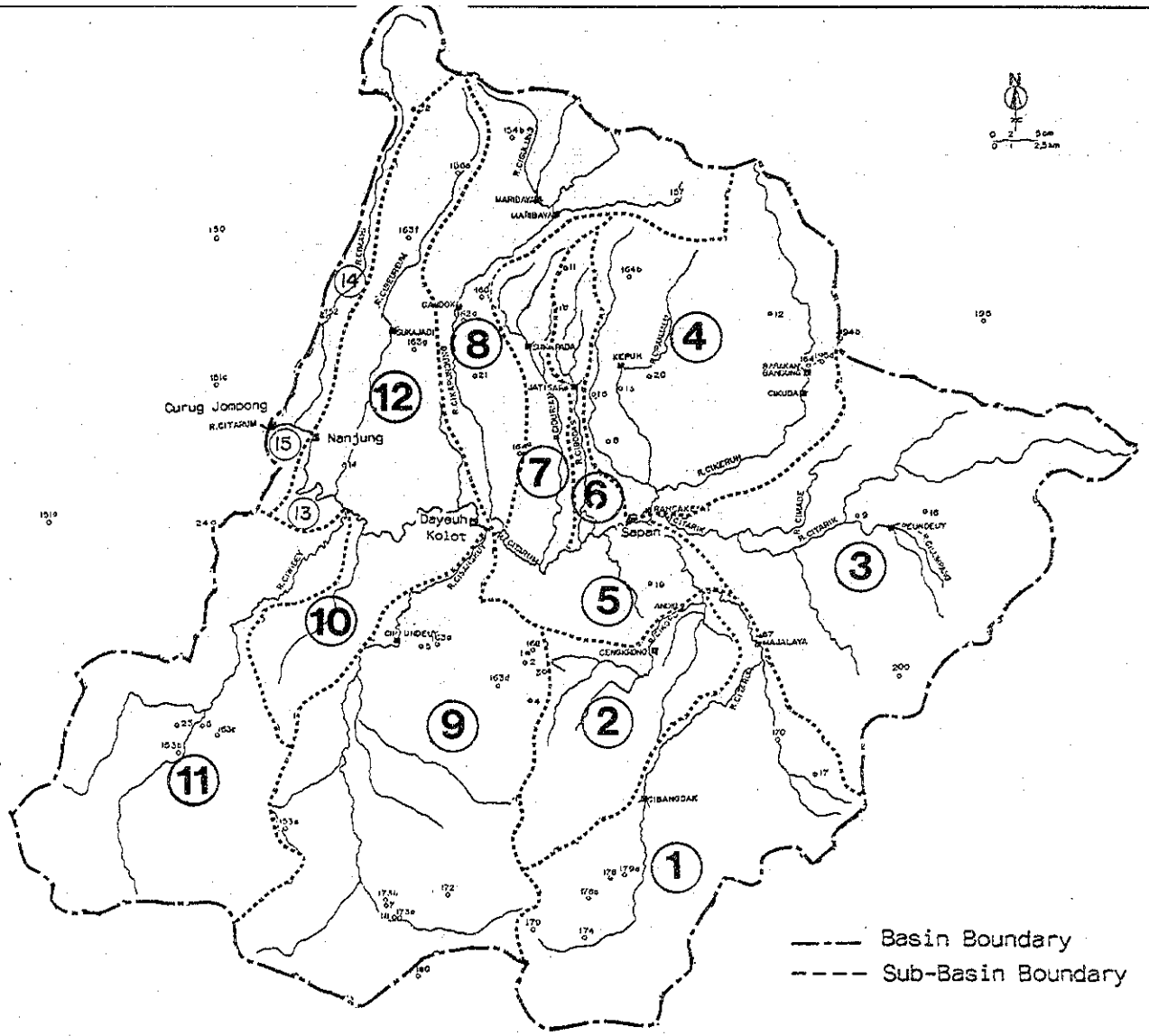

FIG. 3.1 DIVISION OF DRAINAGE BASIN

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

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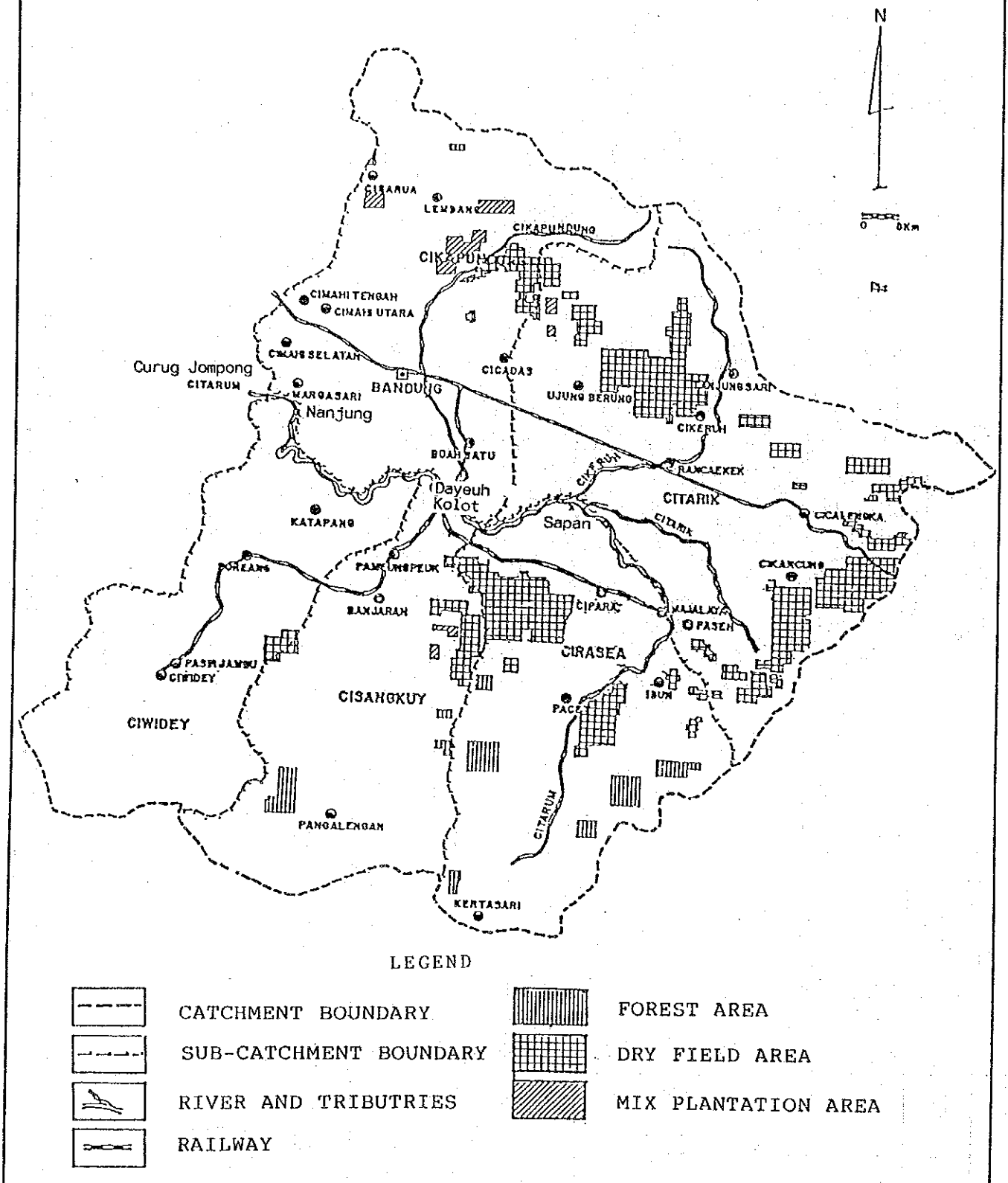

LEGEND

CATCHMENT BOUNDARY	FOREST AREA
SUB-CATCHMENT BOUNDARY	DRY FIELD AREA
RIVER AND TRIBUTRIES	MIX PLANTATION AREA
RAILWAY	

FIG. 3.2 AREAS OF SERIOUS LAND EROSION

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

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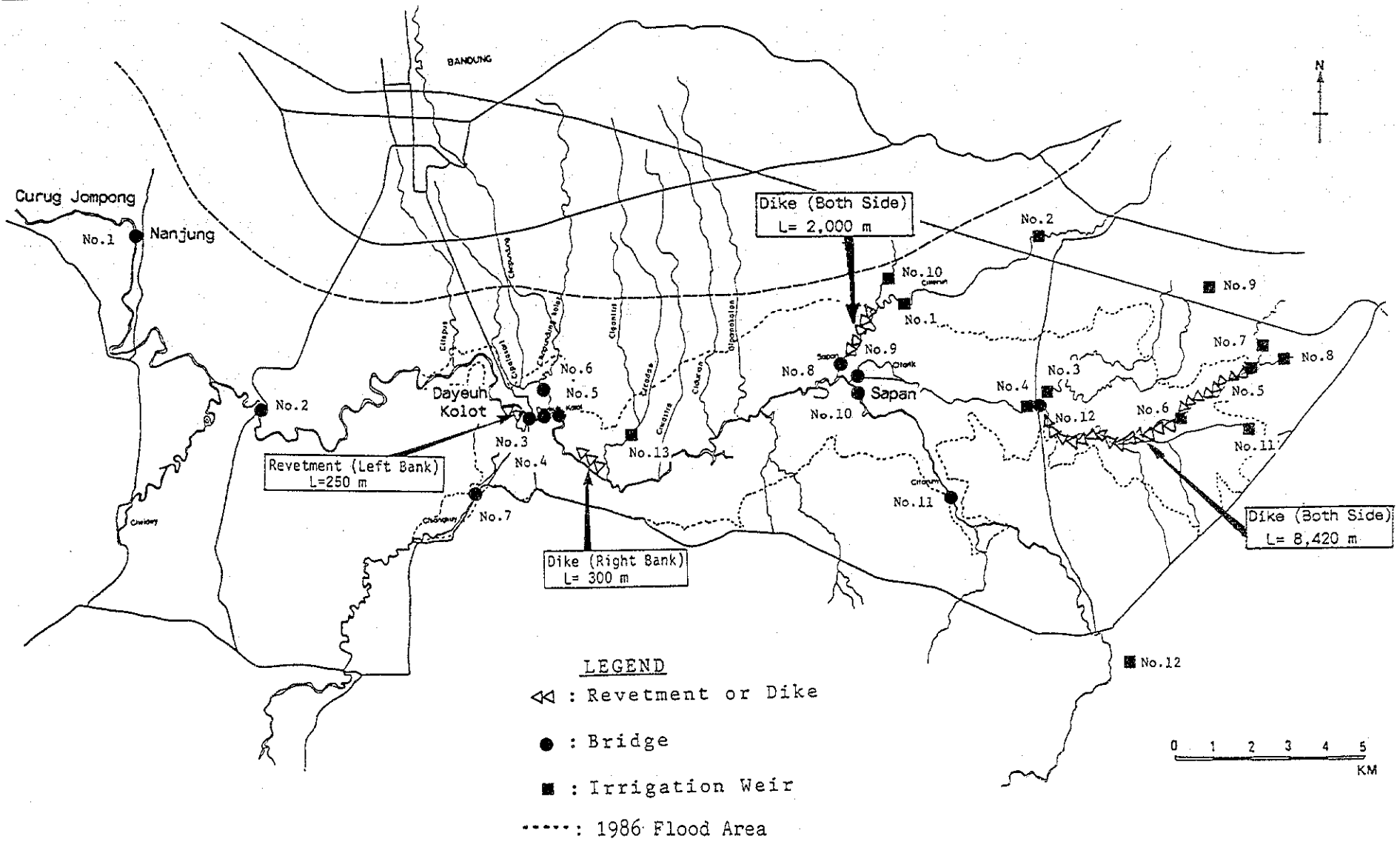

FIG. 3.3 EXISTING MAJOR RIVER FACILITIES

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

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CHAPTER 4

FLOOD AND FLOOD DAMAGE

Chapter 4. FLOOD AND FLOOD DAMAGE

4.1 Flood Condition

4.1.1 Historical Floods

Large floods in Bandung and its surrounding area have occurred in the years 1931, 1945, 1977, 1982, 1983, 1984 and 1986.

The available flood records among them are tabulated below.

Year	(1) Max. Flood Level at Dayeuh Kolot (m)	(2) Basin Average Rainfall Depth (mm) 5 days	Monthly	(3) Max. Discharge at Nanjung (m^3/s)
1931, Mar.	-	177 (14)	476	455
1982, Apr.	3.88	107 (1.4)	437	261
1983, Feb.	3.98	109 (1.4)	351	303
1984, Jan.	4.78	141 (3.0)	353	335
1986, Mar.	5.38	116 (1.5)	357	310

Source : (1), (3): IHE, (2): Study Team

Note : Figure in parenthesis is recurrent interval of basin rainfall depth (year).

The maximum flood water level at Dayeuh Kolot has risen from year to year. The March 1986 flood marked the highest flood water level at Dayeuh Kolot although the average basin rainfall depth and maximum flood discharge at Nanjung were not the largest. This fact shows that the discharge capacity of the downstream stretches of Dayeuh Kolot has decreased in the recent year due to sediment and garbage deposits, resulting in increase of back-water effect on the upstream reaches.

4.1.2 Frequent Flood

A frequent flood area which is affected two(2) or three(3) times a year was delineated based on the information obtained through interviewing the residents. The area is located in the low-lying areas along the

Citarum, Citarik and Cisangkuy Rivers with a total area of 2,000 ha, and is shown in Fig. 4.1.

4.1.3 March 1986 Flood

The Study Team carried out a survey on the flood conditions of the March 1986 flood through interviewing the residents in the flooded areas.

The total inundation area of the March 1986 flood was 7,249 ha with a water volume of about 66 million m^3. The inundation depth and area are summarized as follows:

Depth (m)	Area (ha)	Ratio (%)
Less than 0.5	1,894	26.1
0.5 - 1.0	2,484	34.3
1.0 - 1.5	1,854	25.6
More than 1.5	1,017	14.0
Total	7,249	100.0

The flood depth contour map and flood duration distribution map of the March 1986 flood are shown in Fig. 4.2 and Fig. 4.3 respectively.

4.1.4 Flood Water Stage Profile

The maximum water stage profile of the March 1986 flood was surveyed for the Citarum and Citarik Rivers. The results are shown in Fig. 4.4 and Fig. 4.5. The flood water was dammed up by about 2.0 m due to the narrow sections extending over a length of 6 - 7 km in the downstream reaches of Dayeuh Kolot.

The slope of the flood water stage was:

- 1/23000 (0.00004) in the stretches between Dayeuh Kolot and the site of 35 km distance of the Citarum River.

- 1/9400 (0.00011) in the stretches between the site of 35 km distance and Sapan of the Citarum River.

- 1/6100 (0.00016) in the Citarik River.

The above facts show that dredging or widening of the narrow sections in the downstream reaches of Dayeuh Kolot is essential for draw-down of the flood water level in the upstream reaches.

4.2 Flood Run-off Analysis

4.2.1 Effect of Rainfall on Flooding

(1) Rainfall Intensity

Rainfall intensity-duration curves with probabilities of 2-year and 50-year were made by the Study of Bandung Urban Development Project for four (4) gauging stations located in the Bandung Metropolitan Area.

Rainfall intensities for a duration of 60 minutes are:

2-year : 40 - 51 mm/hr
50-year : 67 - 80 mm/hr

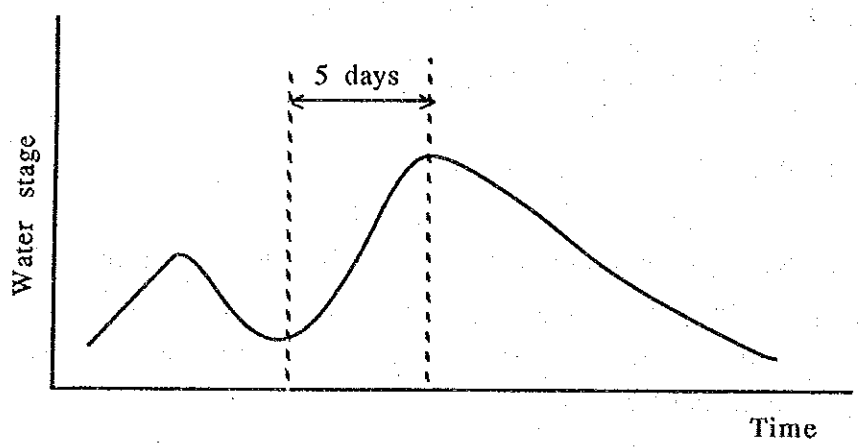
(2) Probable Basin Rainfall

Average basin rainfall depths of 1-day and 5, 10, 20-consecutive days were computed for various probabilities. The estimated probable basin rainfall depths of 1-day and 5, 10, 20-consecutive days for the drainage basins of Dayeuh Kolot and Nanjung are shown in Fig. 4.6.

(3) Rainfall Depth Governing Flood Peak

Flood peak at Dayeuh Kolot is governed by the rainfall depth accumulated during several days before the occurance of flood peak. This is due to the retarding effects of flood run-off in the basins.

According to the flood records in the recent years, the time of flood rising stage is approximately 5 days as shown below.



Based on this fact, average basin rainfall depth of 5-consecutive days is used as the probability variable for evaluation of recurrent floods.

(4) Basin Rainfall in the Past Floods

The basin rainfall depths of 5-consecutive days, governing the flood peaks in the past are shown in Table 4.1. Their estimated return periods are also presented in the same table.

The recurrence of the March 1986 Flood interval is estimated to be 1.5-year at Dayeuh Kolot and 1.8-year at Nanjung.

4.2.2 Existing Hydraulic Condition

(1) Water Stage and Discharge Relation

Water stage-discharge curves at Dayeuh Kolot and Nanjung gauging stations are shown in Fig. 4.7.

From the stage-discharge curve, the peak discharges of the March 1986 floods are estimated to be 310 m^3/s at Nanjung and 265 m^3/s at Dayeuh Kolot.

(2) The relationship of water stage, and flood area and flood storage volume

The Citarum River floods in the upstream reaches of Dayeuh Kolot gauging station.

The relation between the water stage at Dayeuh Kolot and flood area, and flood water storage volume in the upstream flood plain is shown in Fig. 4.8.

The March 1986 flood marked the peak water stage of EL. 659.8 m at Dayeuh Kolot with an inundation area of 7,249 ha and a flood water storage of approximately 66.0 million m^3 in the upper stretches.

4.2.3 Flood Run-off Simulation

(1) Simulation Model

The flood run-off simulation model applied for the Upper Citarum Basin consists of 28 sub-basins and one (1) flood plain. (See Fig. 4.9)

The Storage Function Method was used for run-off calculation.

(2) Simulation of March 1986 Flood

The calculated discharge hydrographs of the March 1986 flood at Dayeuh Kolot and Nanjung gauging stations are illustrated in comparison with the recorded ones in Fig. 4.10. The corresponding average basin daily rainfall distributions and water stage are also illustrated in the same figure.

(3) Estimated Probable Flood Discharge

The probable flood discharges of the Citarum River and its major tributaries: Citarum(Upstream), Citarik, Cikeruh and Cisangkuy Rivers, were estimated under the following river and basin conditions.

Land-use	:	Land-use in the year 2005
Inundation of the flood plain	:	Without inundation or with an allowable inundation area of 1,000 ha

The calculation results are summarized in Table 4.2.

4.3 Flood Damage

4.3.1 Flood Damage Potential

(1) Potential Flood Area

The 1986 flood area of 7,249 ha is assumed as the potential flood area since it was the largest in the recent years. The potential flood area includes 9 Kecamatans covering 50 Desas.

(2) Land-use in Potential Flood Area

The existing land-use in the potential flood area is as follows:

	Area (ha)	Ratio (%)
Paddy field	6,363	87.8
Upland	40	0.5
Plantation	298	4.1
Grass land	19	0.3
Fish pond	77	1.1
Built-up Area	452	6.2
Total	7,249	100.0

The regional distribution of the above land-use pattern is shown in Fig. 4.11.

The distribution of land-use by flood depth in the 1986 flood is shown in Table 4.3.

(3) Population in Potential Flood Area

Existing population in the potential flood area is estimated to be 112,252 with a population density of 15.5 persons/ha.

(4) Assets in Potential Flood Area

Assets existing in the potential flood area are described below.

1) Number of house

Permanent type : 14,133
Semi-permanent type : 3,759
Non-permanent type : 9,418
Total : 27,310

2) Number of industrial and commercial facilities

Large and small industries	:	45
Home industry	:	33
Marketing facilities	:	20
Retail store and refreshment shop	:	368
Total	:	466

3) Road length

Provincial road	:	6.9 km
Kabupaten road	:	75.6 km
Desa road	:	41.7 km
Total	:	124.2 km

4) Number of social infrastructure

Medical facilities	:	34
Educational facilities	:	120
Religious facilities	:	286
Administrative facilities	:	28
Total	:	468

(5) Flood Damage Potential

Existing flood damage potentials (values of assets and production) of agricultural production, residential building including household effects, industrial and commercial facilities, and social infrastructures are estimated in monetary term as shown in Table 4.4. The estimated value is approximately Rp. 160 billion.

Note: It does not include such physical infrastructures as, irrigation facilities, electricity facilities, etc.

4.3.2 Damage of Frequent Flood

Number of people and assets affected by frequent floods, and their damage amounts are estimated as follows:

- Affected persons	40,387	
- Affected residential buildings	10,169	
- Affected industrial and commercial facilities	163	
- Affected paddy fields	1,794	ha
- Damage amount per one time	Rp.3.28	billion
- Expected damage amount per annum	Rp.8.20	billion

4.3.3 Damage of 1986 Flood

(1) Affected Residents

Total number of the affected residents is 112,252. Of the total, 34,460 or 34% is affected by more than 1.0 m inundation depth.

Number of the affected residents by inundation depth is shown in Table 4.5.

(2) Damaged Houses

Total number of the damaged houses is 27,310. Of the total, 8,254 or 30% is damaged by more than 1.0 m inundation above floor level.

Number of the damaged houses by inundation depth is shown in Table 4.6.

(3) Damaged Paddy

Total inundated paddy field is 6,363 ha. Of the total, 2,443 ha or 38% are inundated by more than 1.5 m depth. 5,236 ha or 82% is inundated for a period more than seven (7) days.

The affected area of paddy field by inundation depth and inundation duration is shown in Table 4.7.

4.3.4 Average Annual Flood Damage

The estimated flood damages are:

(1) Residential building damage : damage on building itself and household effects.

(2) Agricultural damage : damage on paddy and fishpond cultivations

(3) Industrial damage : damage on industrial and commercial facilities and productions.

(4) Infrastructure damage : damage on social and physical infrastructures such as medical educational, religious, transportation, water supply, electricity, communication and other facilities.

(5) Indirect damage : Costs for emergency activities.

The amount of flood damage estimated for various frequency floods under the existing socio-economic conditions without project are shown in Fig. 4.12.

The average annual flood damage under the existing socio-economic conditions without project is estimated to be Rp. 17,508 million. The corresponding damage cost expressed in term of economic price is Rp. 16,135 million, as dealt with in Chapter 10 on Economic Evaluation.

Table 4.1 5-DAY BASIN RAINFALL OF PAST FLOODS

LOCATION	DATE	5 DAYS DEPTH (mm)	RETURN PERIOD (year)
DAYEUH KOLOT	2/28 - 3/ 4, 1931	177	14
	4/11 - 4/15, 1982	107	1.4
	1/18 - 1/22, 1983	95	1.1
	1/11 - 1/15, 1984	141	3
	1/ 4 - 1/ 8, 1985	100	1.2
	3/ 7 - 3/11, 1986	116	1.5
NANJUNG	2/28 - 3/ 4, 1931	164	10
	4/11 - 4/15, 1982	99	1.2
	1/18 - 1/22, 1983	102	1.3
	1/11 - 1/15, 1984	134	3
	1/ 4 - 1/ 8, 1985	94	1.1
	3/ 7 - 3/11, 1986	119	1.8

Table 4.2 PROBABLE FLOOD DISCHARGE OF CITARUM RIVER

(Unit:m3/s)

River	Catchment Area (km2)	Without Inundation			With 1,000 ha Inundation		
		5-year	20-year	50-year	5-year	20-year	50-year
Cirarum River							
Sapan	754.7	256	316	351	256	316	351
Dayeuh Kolot	1,332.1	414	514	572	374	466	534
Nanjung	1,718.0	547	678	754	505	627	712
Citarum (Upstream)	290.1	101	130	153	101	130	153
Citarik River	281.4	74	98	114	74	98	114
Cikeruh River	183.2	72	98	115	72	98	115
Cisangkuy River	276.5	132	169	193	132	169	193

Table 4.3 LAND-USE OF 1986 FLOOD AREA BY FLOOD DEPTH

(UNIT: ha)

FLOOD DEPTH (m)	0 - 0.5	0.5 - 1.0	1.0 - 1.5	1.5 - 2.0	2.0 - 2.5	2.5 - 3.0	3.0 - 3.5	TOTAL
PADDY FIELD	1,757.2	2,162.3	1,675.9	609.8	112.0	7.8	37.8	6,362.8
UPLAND FIELD	0.0	6.3	11.9	18.1	1.2	1.0	1.7	40.2
PLANTATION	2.1	65.4	50.5	108.2	25.9	14.1	31.6	297.8
GRASS LAND	0.2	9.1	9.3	0.0	0.0	0.0	0.0	18.6
FISH POND	11.9	64.7	0.0	0.0	0.0	0.0	0.0	76.6
BUILT-UP AREA	122.3	176.5	106.1	37.4	6.4	1.3	2.8	452.8
TOTAL	1,893.7	2,484.3	1,853.7	773.5	145.5	24.2	73.9	7,248.8

Table 4.4 FLOOD DAMAGE POTENTIAL

(Unit: billion Rp., 1987 price)

(1) Agricultual production	
Paddy	5.46
Fish pond	0.07
Total	5.53
(2) Residential buildings	
Permanent type	45.18
Semi-permanent type	3.92
Non-permanent type	7.65
Total	56.75
(3) Industrial and Commercial facilities	
Large-scale industry	90.18
Small-scale industry	3.66
Home industry	0.12
Marketing facilities	0.28
Retail store and refreshment shop	0.36
Total	94.60
(4) Road	
Provincial Road	0.22
Kabupatan Road	0.88
Desa Road	0.25
Total	1.35
(5) Social infrastructure	
Medical facilities	0.51
Educational facilities	1.80
Religious facilities	1.57
Public facilities	0.32
Total	4.20
Grand Total	162.43

Note: It does not include physical infrastructures such as irrigation facilities, electricity facilities, etc..

Table 4.5 AFFECTED RESIDENTS OF 1986 FLOOD BY DEPTH

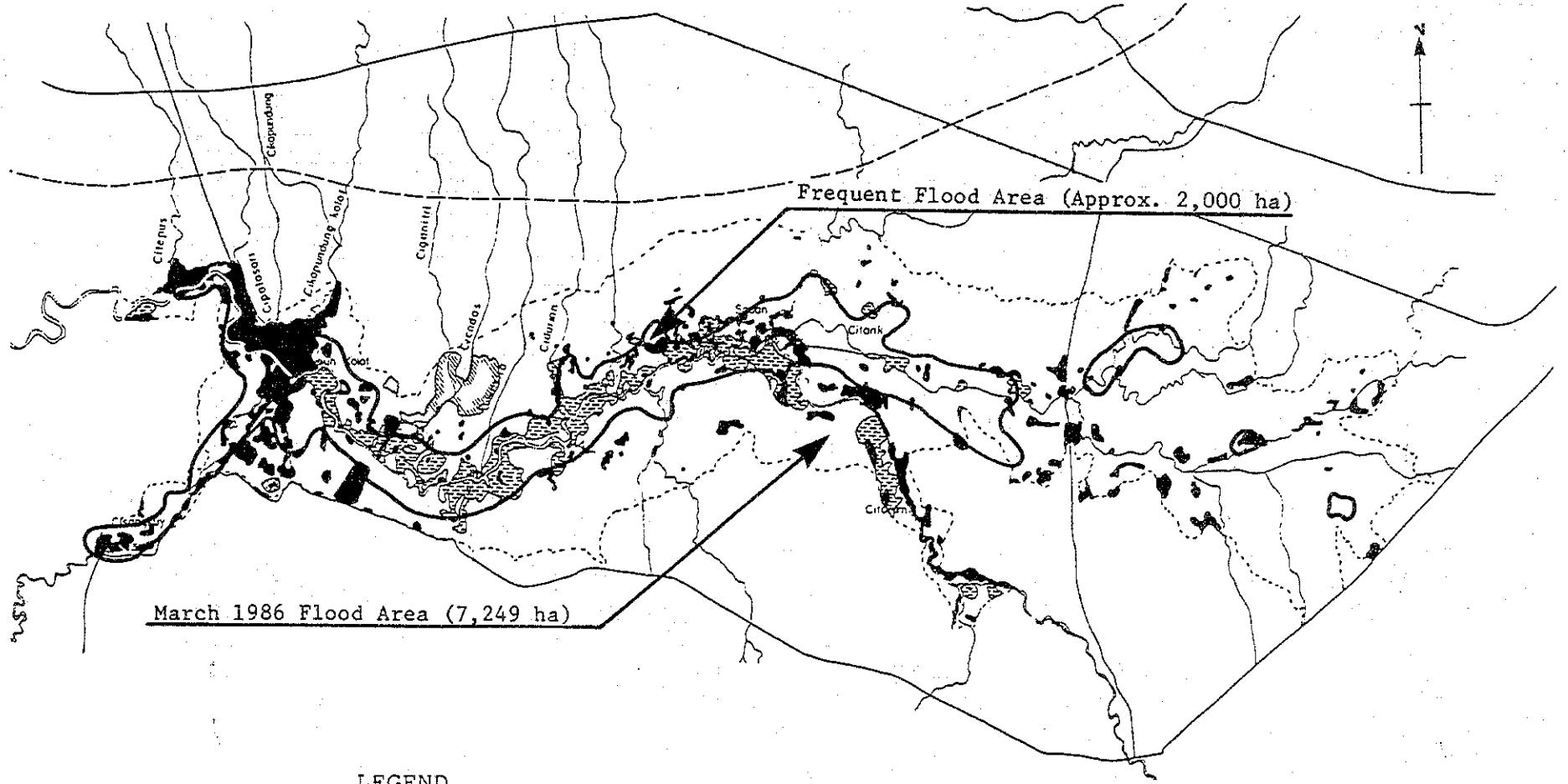
Inundation Depth (m)	0.0 - 0.5	0.5 - 1.0	1.0 - 1.5	1.5 - 2.0	2.0 - 2.5	2.5 - 3.0	More than 3.0	Total
Resident	30,162	43,630	24,846	9,912	2,788	340	574	112,252
(%)	26.9	38.9	22.1	8.8	2.5	0.3	0.5	100.0

Table 4.6 DAMAGED HOUSES OF 1986 FLOOD BY DEPTH

Inundation Depth Above Floor (m)	Below Floor	0.0 - 0.5	0.5 - 1.0	1.0 - 2.0	2.0 - 3.0	More than 3.0	Total
Houses	1,283	7,406	10,367	7,502	654	98	27,310
(%)	4.7	27.1	38.0	27.5	2.4	0.3	100.0

Table 4.7 DAMAGED PADDY OF 1986 FLOOD BY DEPTH AND DURATION

Inundation Depth (m)	Duration (days)				Total
	1 - 2	3 - 4	5 - 6	More than 7	
0.5	740.7	89.4	18.5	908.7	1,757.3
0.5 - 1.5	154.6	74.4	6.7	1,926.5	2,162.2
1.5	10.7	31.9	0.0	2,400.7	2,443.3
Area (ha)	906.0	195.7	25.2	5,235.9	6,362.8
(%)	14.2	3.1	0.4	82.3	100.0



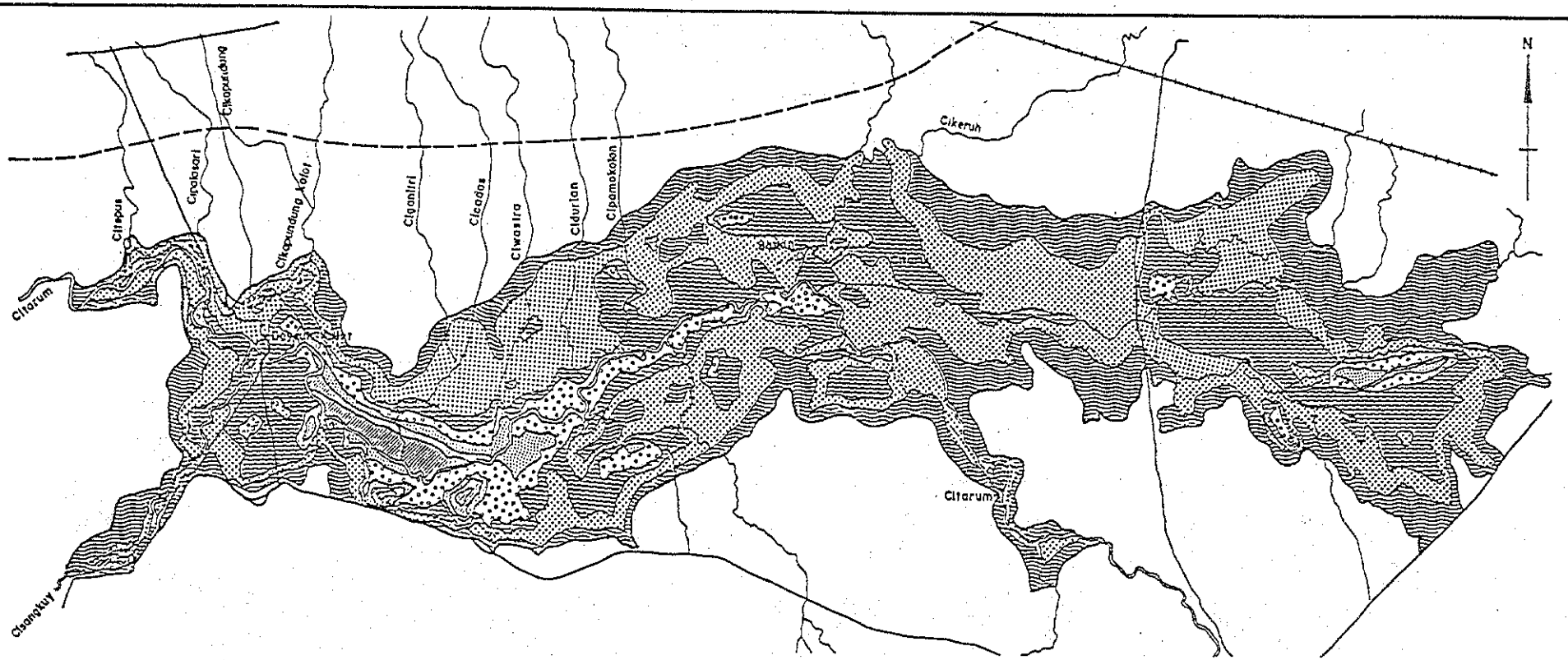
LEGEND

- : Built-up Area
- : Fishpond
- : Paddy Field
- : Plantation
- : Upland Field
- : Grass Land
- : March 1986 Flood Area
- : Frequent Flood Area

FIG. 4.1 FREQUENT FLOOD AREA

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA

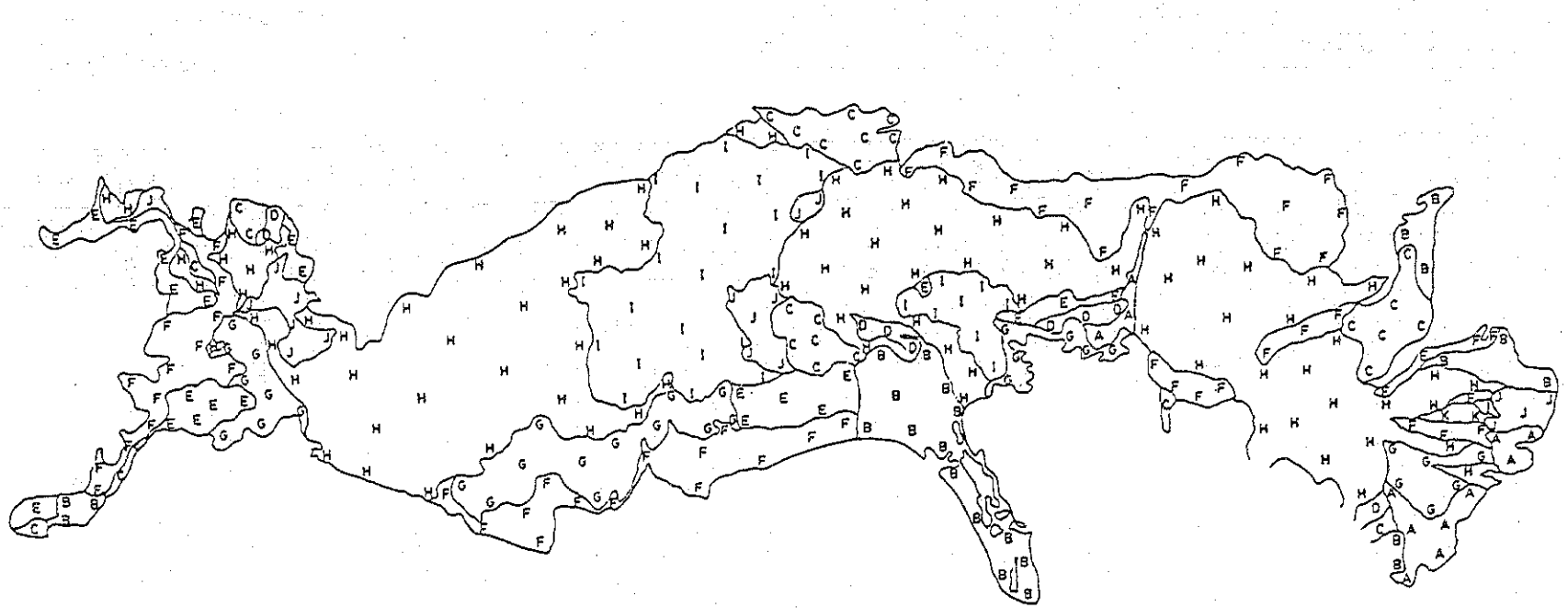


Flood Depth	Area (Unit ; ha)
3,7 - 2,5 m	98,1
2,5 - 2,0 m	145,6
2,0 - 1,5 m	773,5
1,5 - 1,0 m	1853,7
1,0 - 0,5 m	2484,4
0,5 - 0,0 m	1893,7

NOTE : FLOOD DEPTHS ARE VALUES ON PADDY FIELD

FIG. 4.2 FLOOD DEPTH CONTOUR MAP OF 1986 FLOOD

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN



LEGEND

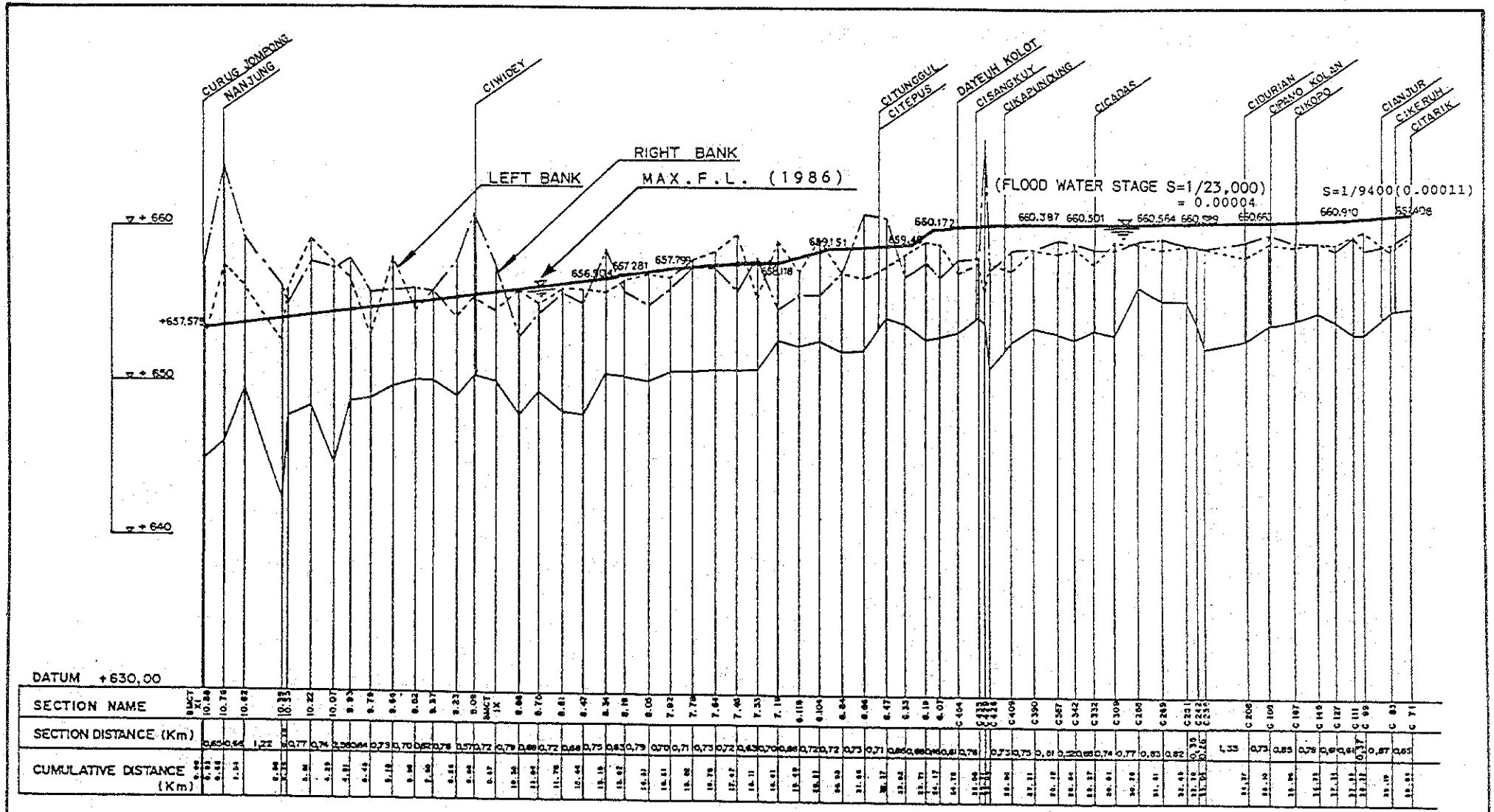
Sign	Flood Duration
A:	t< 1day
B:	t= 1day
C:	1day ≤t< 3days
D:	3days ≤t< 7days
E:	7days ≤t< 14days
F:	14days ≤t< 21days
G:	21days ≤t< 30days
H:	30days ≤t< 45days
I:	45days ≤t< 60days
J:	60days ≤t< 90days
K:	90days ≤t

FIG. 4.3 FLOOD DURATION MAP OF 1986 FLOOD

Source;STUDY TEAM

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA

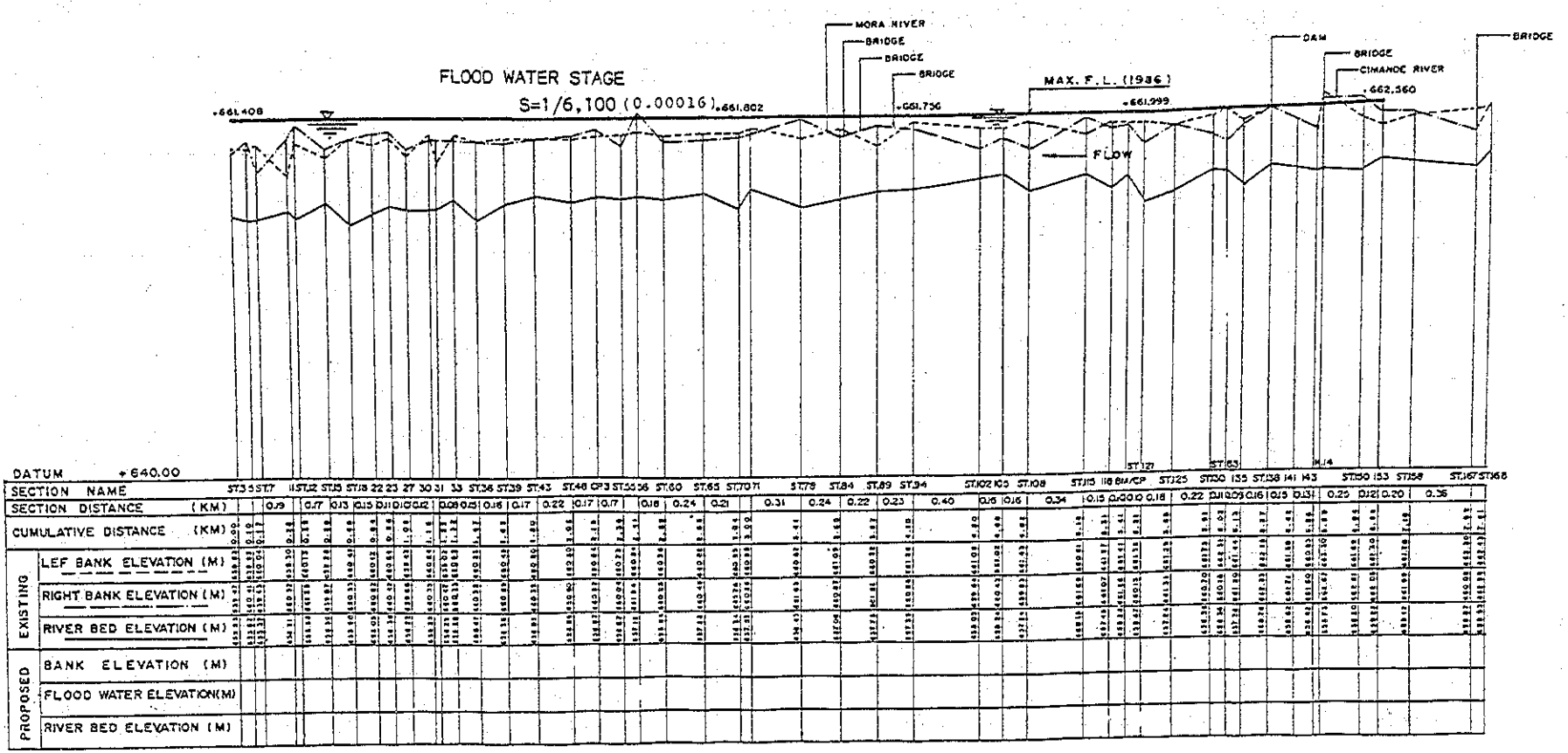


LEGEND

- LEFT BANK
- RIGHT BANK
- RIVER BED

FIG. 4.4 MAXIMUM FLOOD WATER STAGE PROFILE OF CITARUM RIVER IN 1986 FLOOD

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN



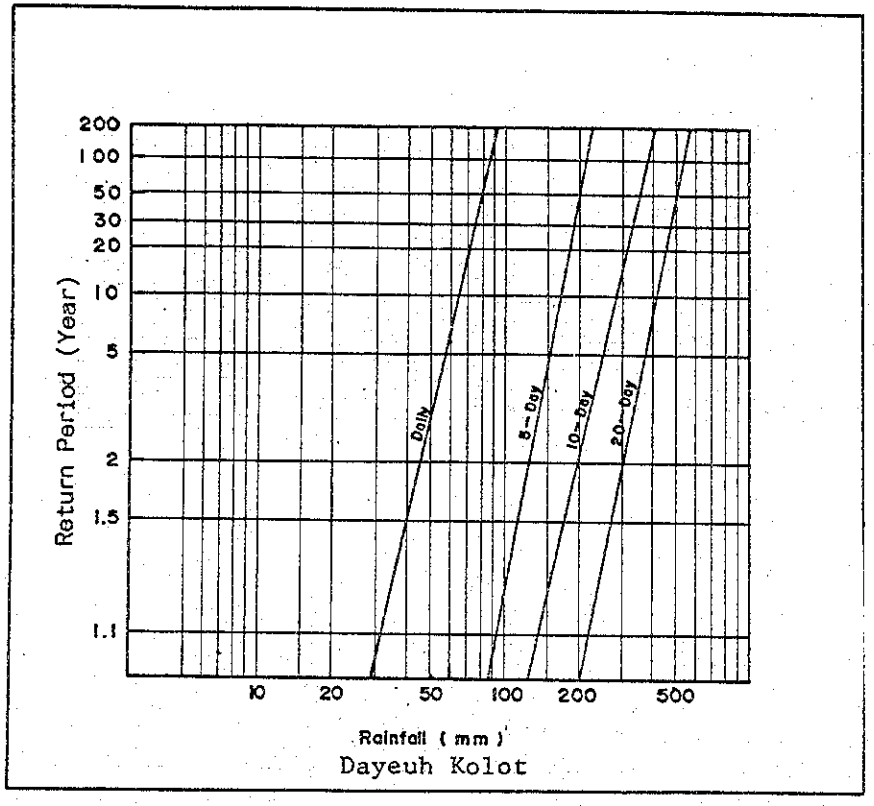
LEGEND

- - - - - - - - : LEFT BANK
—·—·—·— : RIGHT BANK
———— : RIVER BED

FIG. 4.5 MAXIMUM FLOOD WATER STAGE PROFILE OF CITARIK RIVER IN 1986 FLOOD

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA



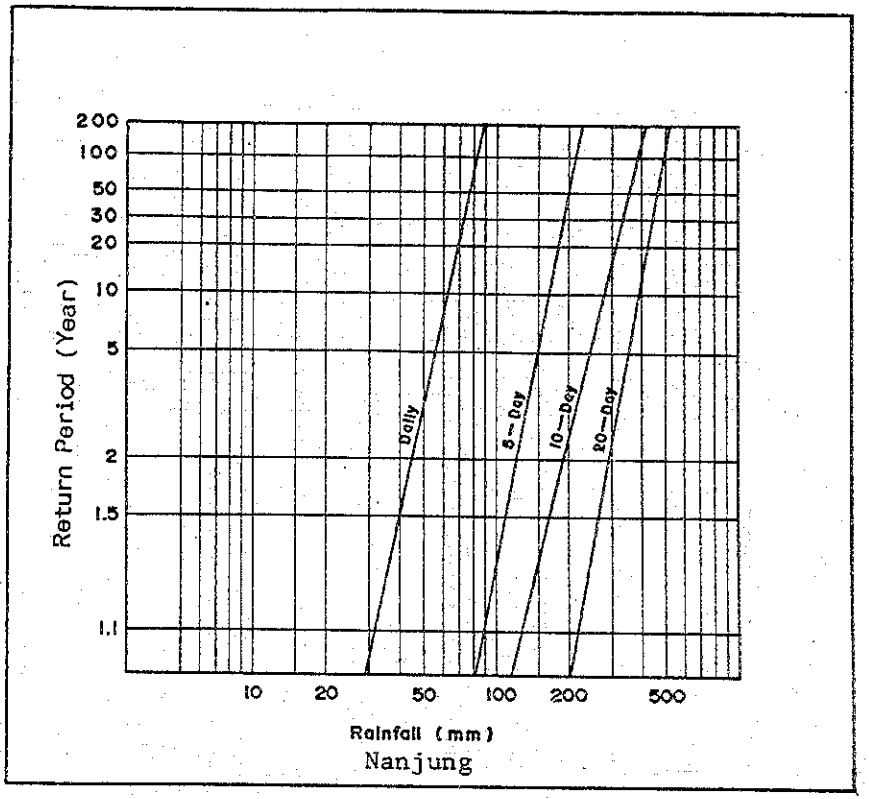
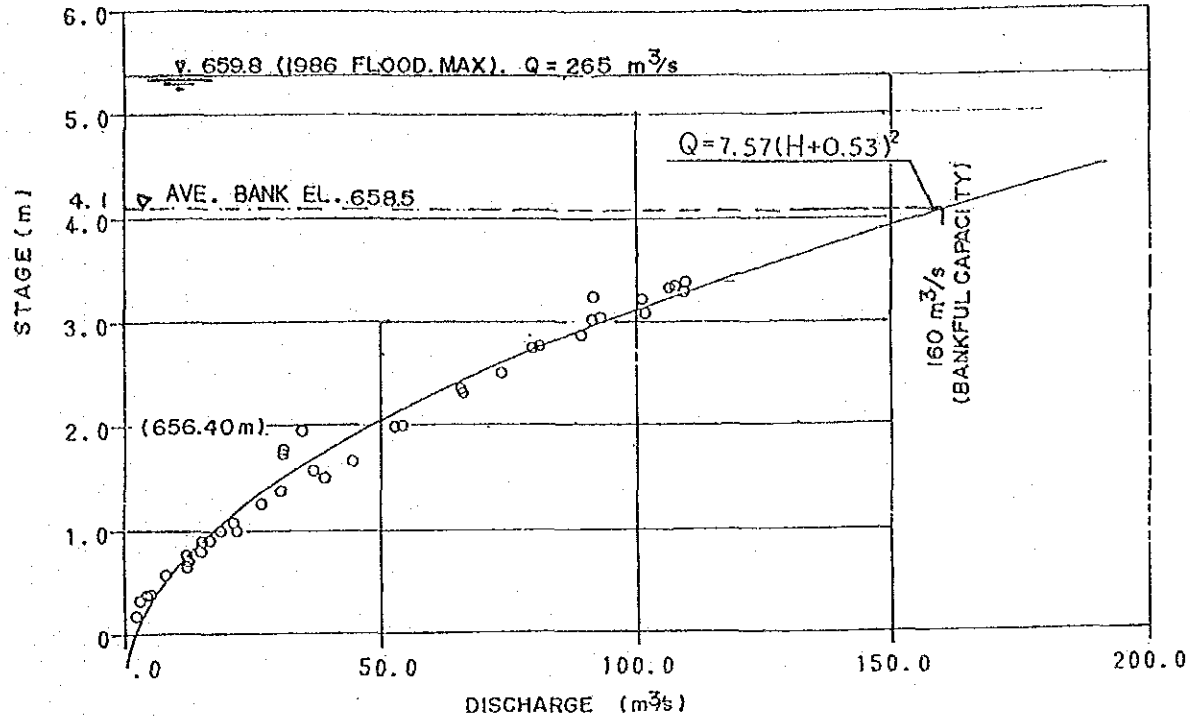


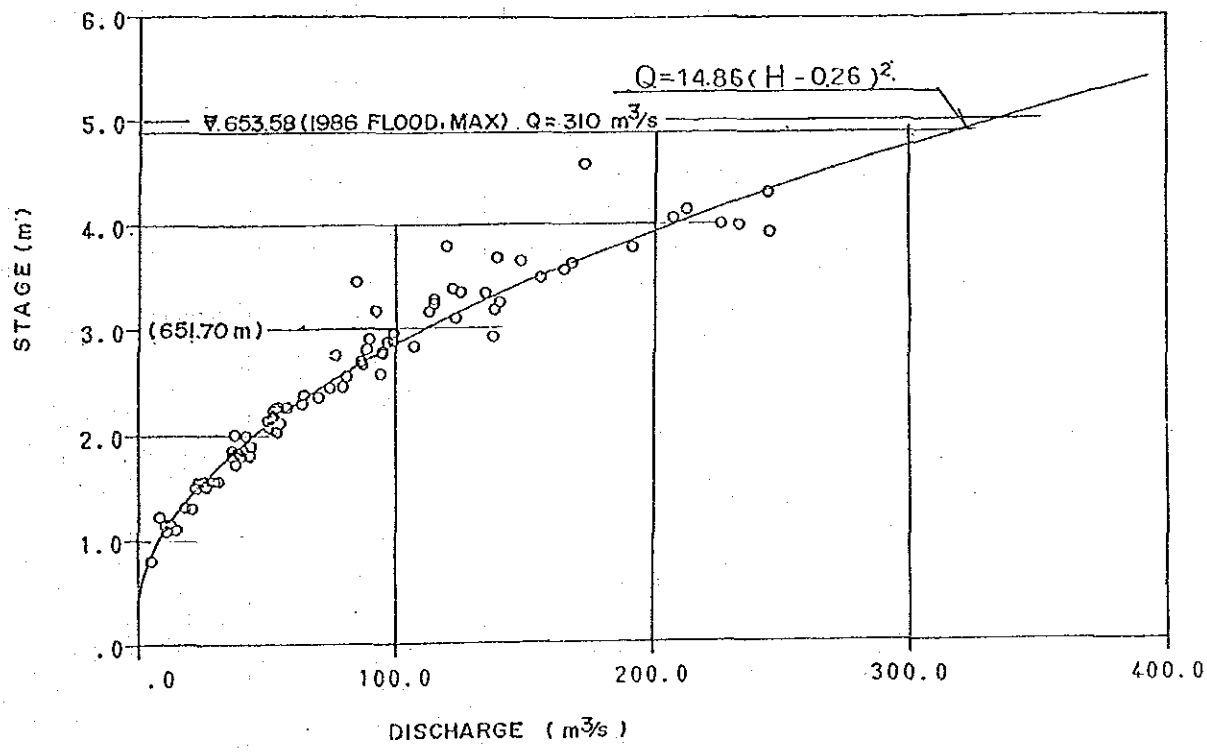
FIG. 4.6 PROBABLE BASIN RAINFALL DEPTH AT DAYEUH KOLOT AND NANJUNG

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

DAYEUHKOLOT



NANJUNG

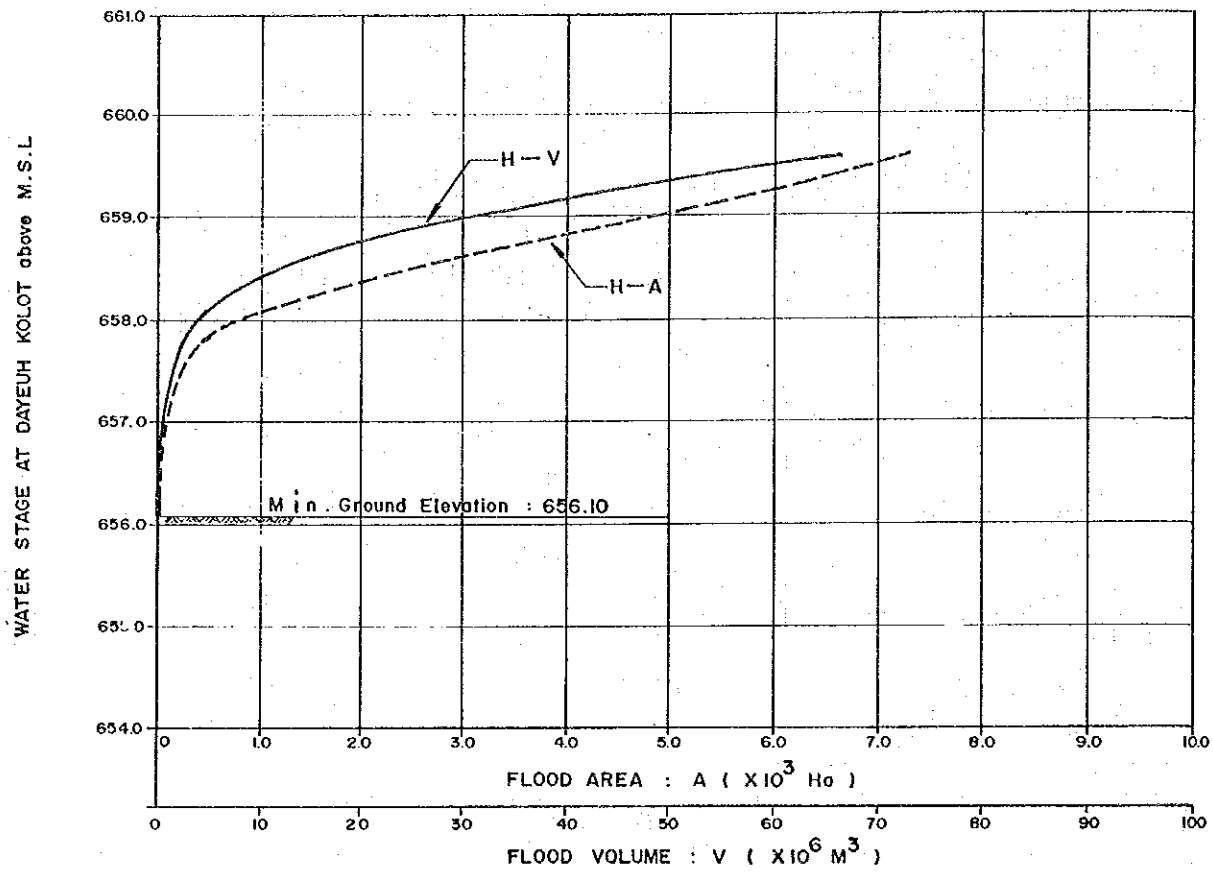


SOURCE : IHE DATA, STUDY TEAM

FIG. 4.7	WATER STAGE - DISCHARGE CURVES AT DAYEUH KOLOT AND NANJUNG GAUGING STATIONS

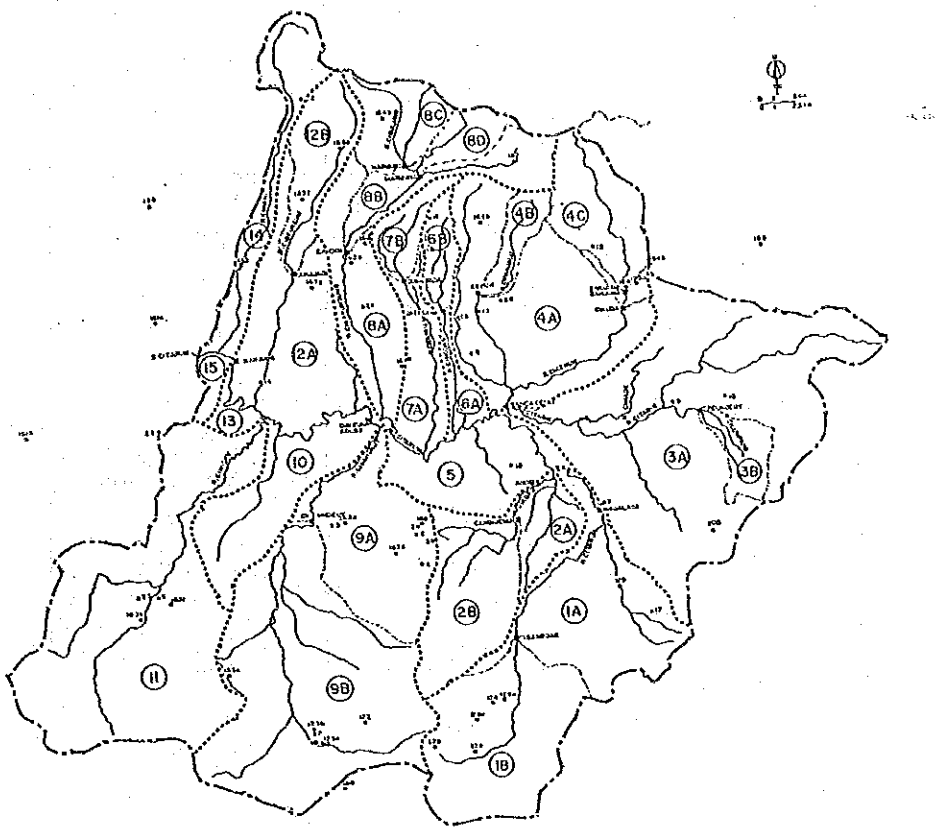
STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA



WATER STAGE (m)	FLOOD AREA (x 10^3 ha)	FLOOD VOLUME (x 10^6 ha)
656.1	0	0
657.1	0.098	0.49
657.6	0.244	1.34
658.1	1.017	4.50
658.6	2.871	14.22
659.1	5.355	34.78
659.8	7.249	66.29

FIG. 4.8 FLOOD WATER STAGE AT DAYEUH KOLOT - FLOOD AREA AND FLOOD WATER STORAGE VOLUME CURVE



Name of Drainage basin	Area (km2)
1. Citarum	197.0
2. Cirasea	93.1
3. Citarik	281.4
4. Cikeruh	206.6
5. Kopo	53.7
6. Cibodas	29.7
7. Cidurian	51.8
8. Cikapundung	144.3
9. Cisangkuy	276.5
Dayeuh Kolot	1332.1
10. Cijalupang	60.1
11. Ciwidey	200.6
12. Cibeureum	117.2
13. The basin of the rest	8.0
Nanjung	1718.0
14. Cimahi	48.0
15. The basin of the rest	6.0
Curug Jompong	1771.0

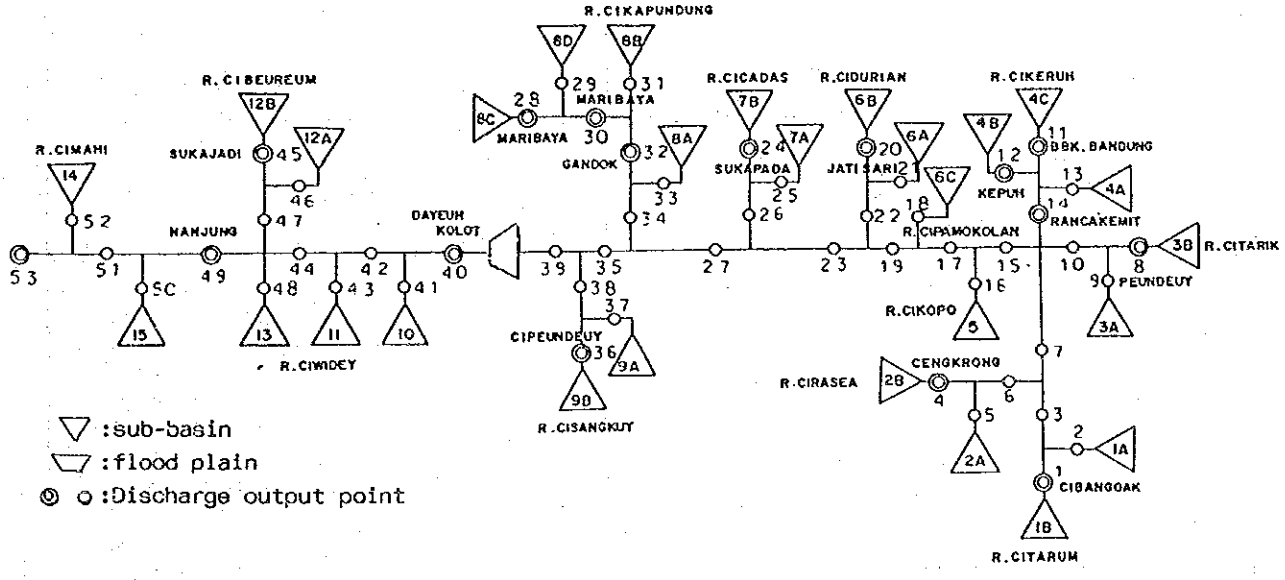
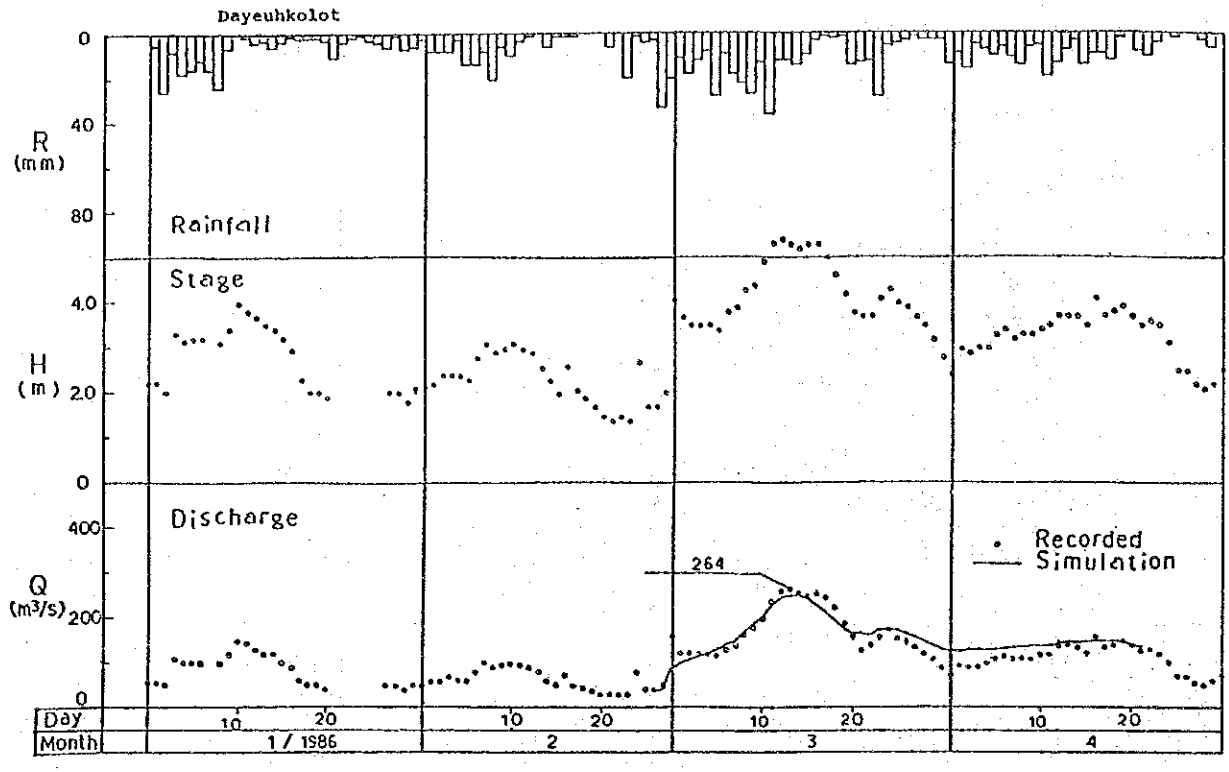


FIG. 4.9 FLOOD RUN-OFF SIMULATION MODEL

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA



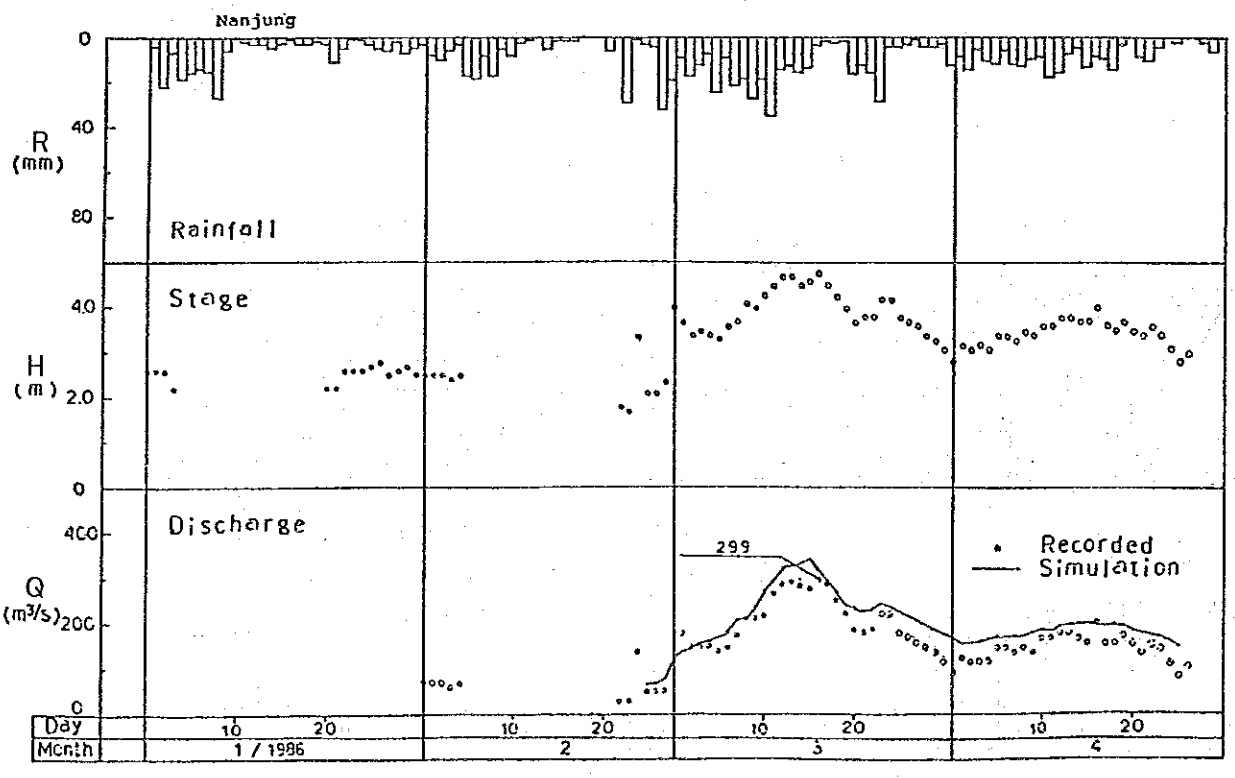
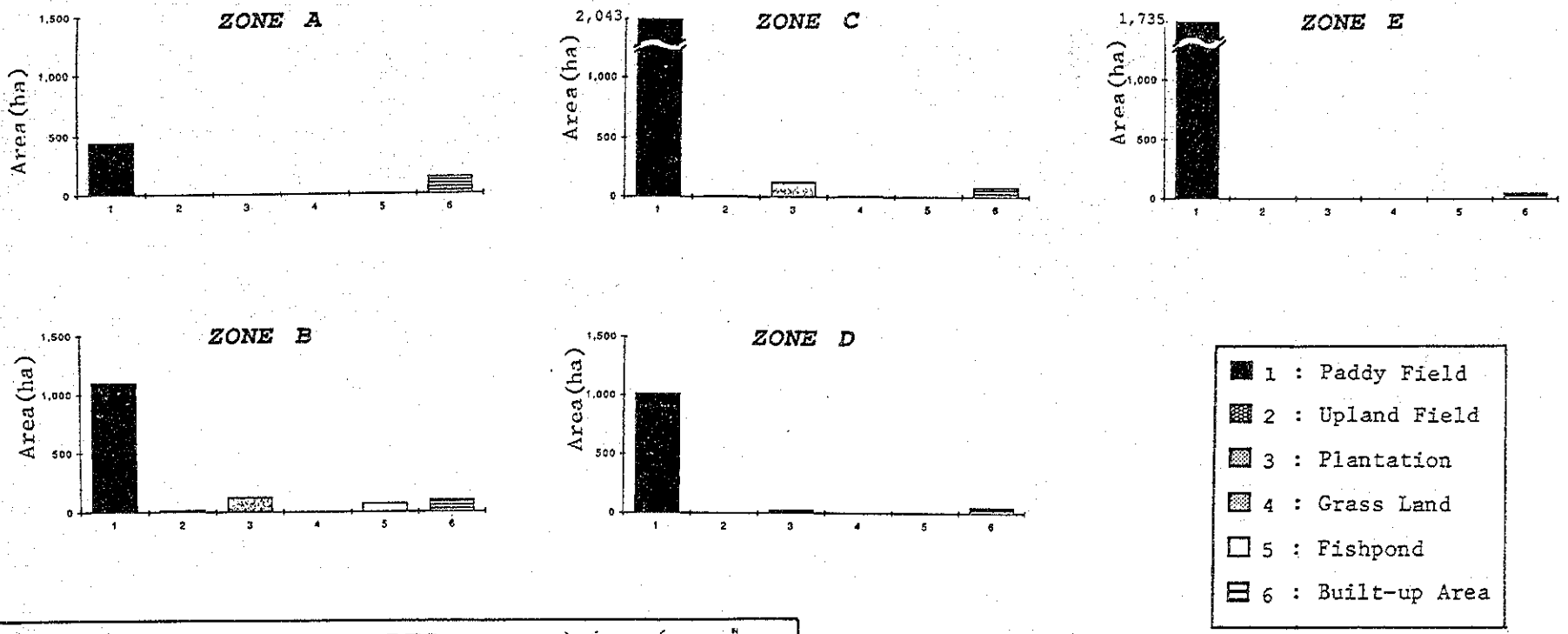
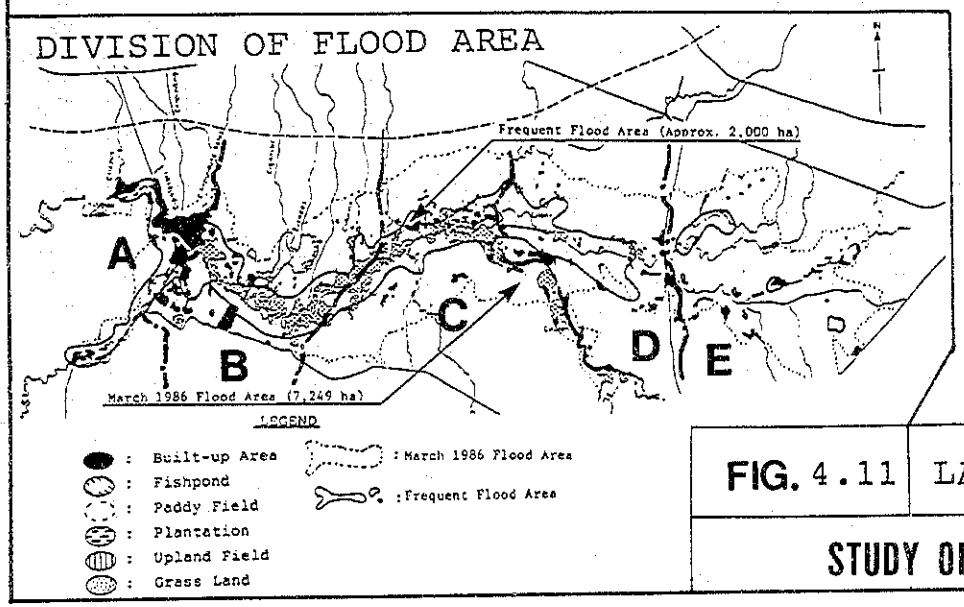


FIG. 4.10 RUN-OFF SIMULATION OF MARCH 1986 FLOOD

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA





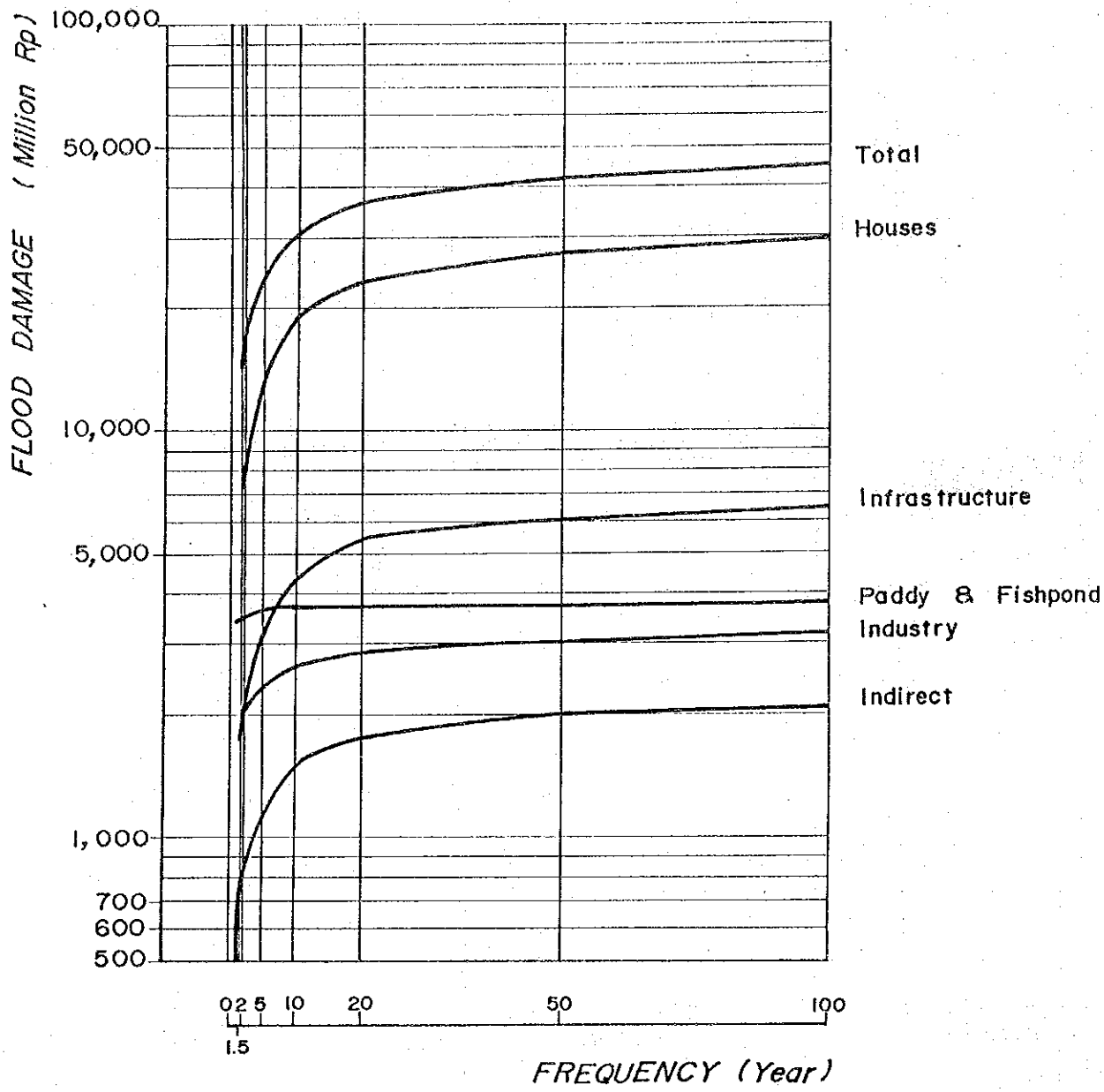
Land-use in Flood Zone (ha)

Item	Area (ha)						Percentage Distribution (%)
	Zone A	Zone B	Zone C	Zone D	Zone E	Total	
Paddy Field	451	1,112	2,043	1,022	1,735	6,363	87.8
Upland Field	2	22	16	0	0	40	0.5
Plantation	1	134	130	33	0	298	4.1
Grass Land	0	3	16	0	0	19	0.3
Fishpond	2	75	0	0	0	77	1.1
Built-up Area	150	108	90	53	51	452	6.2
Total	606	1,454	2,295	1,108	1,786	7,249	100.0

FIG. 4.11 LAND-USE IN FLOOD AREA BY ZONE IN 1986 FLOOD

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA



ESTIMATED FLOOD DAMAGE AND AVERAGE ANNUAL DAMAGE POTENTIAL BY ASSET AT 1987 FINANCIAL PRICES

(Unit : Million Rupiahs)

Asset Item	Recurrent Interval						
	1986 Flood	2-Years	5-Years	10-Years	20-Years	50-Years	100-Years
Houses	6,998.0	8,709.3	13,910.4	19,468.8	23,428.1	27,194.5	29,429.7
Industry	1,777.2	2,020.9	2,432.9	2,675.8	2,850.1	3,053.0	3,182.1
Paddy & Fishpond	3,403.5	3,521.7	3,698.7	3,748.3	3,764.9	3,784.4	3,792.3
Infrastructure	1,755.0	2,146.0	3,268.7	4,428.9	5,255.6	6,049.5	6,522.4
Indirect Damage	696.7	819.9	1,165.5	1,516.1	1,764.9	2,004.1	2,146.3
Total	14,630.4	17,217.8	24,476.2	31,837.9	37,063.7	42,085.5	45,075.8

FIG. 4.12 FLOOD DAMAGE AMOUNTS FOR VARIOUS FREQUENCY FLOODS