REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

FEASIBILITY STUDY ON

KARIAN MULTIPURPOSE DAM

CONSTRUCTION PROJECT

VOLUME— I: MAIN REPORT

JULY 1985

JICA

JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

FEASIBILITY STUDY ON

KARIAN MULTIPURPOSE DAM

CONSTRUCTION PROJECT

VOLUME— I: MAIN REPORT

JULY 1985

JICA

JAPAN INTERNATIONAL COOPERATION AGENCY

FEASIBILITY STUDY ON

KARIAN MULTIPURPOSE DAM

CONSTRUCTION PROJECT

LIST OF VOLUMES

PREFACE

It is with great pleasure that I present this report entitled "Feasibility Study on The Karian Multipurpose Dam Construction Project" to the Government of Indonesia.

This report embodies the result of a survey which was carried out (in the North Banten area, West Java Province) from June 1984 to March 1985 by a Japanese survey team commissioned by the Japan International Cooperation Agency following the request of the Government of the Republic of Indonesia to the Government of Japan.

The survey team, headed by Mr. Takao Ichimiya of the Nippon Koei Co., Ltd., had a series of close discussions on the Project with the officials concerned of the Government of the Republic of Indonesia and conducted a wide scope of field survey and data analyses.

After the survey team return to Japan, further studies were made and the present report has been formulated.

I hope that this report will be useful as a basic reference for development of the Project.

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

July 1985

Keisuke Arita
President
Japan International
Cooperation Agency

July 1985

Mr. Keisuke Arita
President
Japan International
Cooperation Agency
Tokyo

Dear Sir,

LETTER OF TRANSMITTAL

We have the pleasure of submitting to you a Final Report of the Feasibility Study (Feasibility Report) on Karian Multipurpose Dam Construction Project (the Project) for consideration by the Government of Indonesia in implementing the water resources development in the nation's socio-economic development objective.

This report consists of two volumes. Volume 1 is the main report containing the feasibility study on the Project which is composed not only of the captioned dam but also many other items such as other dam, trans-basin tunnels, irrigation facilities, river improvement works and so forth. These items will function synthetically for achieving the concept of the Project that the low income standard of the North Banten Area is to be levelled to that of the West Java Province, as well as to level the income depression areas which exist within the North Banten Area to the same level. The feasibility study indicates that the Project is worthy of early implementation to bring about the concept into being. Volume 2 is Appendix containing results of studies in eleven sectors to support the Main Report.

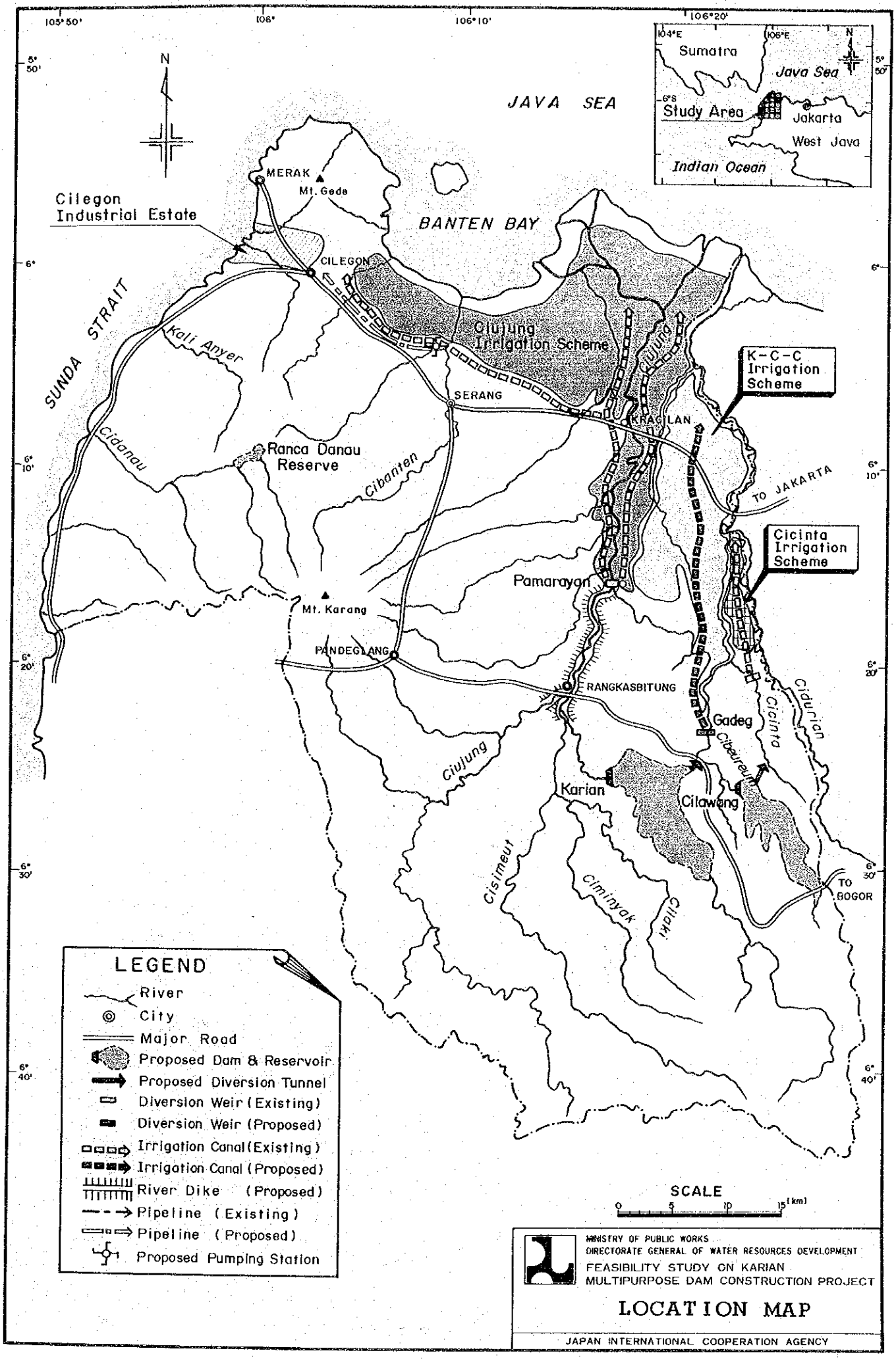
All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, Ministry of Agriculture and Fishery, Embassy to Indonesia and Japanese Colombo Plan Expert Team as well as the officials and individuals of Indonesia for their assistance extended to the Study Team.

The Study Team sincerely hopes that the study results would contribute to the socio-economic development and well-being in general and water resources development in particular in the North Banten Area.

Yours sincerely,

T. Ichimiya

Takao Ichimiya
Team Leader
Feasibility Study Team
on Karian Multipurpose
Dam Construction Project


JAVA SEA
BANTEN BAY
SUNDA STRAIT
Cilegon Industrial Estate
MERAK
Mt. Gede
CILEGON
Ciujung Irrigation Scheme
SERANG
KRAGILAN
K-C-C Irrigation Scheme
TO JAKARTA
Cicinta Irrigation Scheme
Ranca Danau Reserve
Kali Anyer
Cidanau
Cibanten
Mt. Karang
PANDEGLANG
Pamarayan
RANGKASBITUNG
Gadeg
Cibeureum
Cicinta
Cidurian
Ciujung
Karian
Cilawang
Cisimeut
Ciminyak
Citahi
TO BOGOR
LEGEND
River
City
Major Road
Proposed Dam & Reservoir
Proposed Diversion Tunnel
Diversion Weir (Existing)
Diversion Weir (Proposed)
Irrigation Canal (Existing)
Irrigation Canal (Proposed)
River Dike (Proposed)
Pipeline (Existing)
Pipeline (Proposed)
Proposed Pumping Station
SCALE
0 5 10 15 (km)
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON KARIAN
MULTIPURPOSE DAM CONSTRUCTION PROJECT
LOCATION MAP
JAPAN INTERNATIONAL COOPERATION AGENCY

SUMMARY

1. This is a Final Report of the Feasibility study (the Study) on the Karian Multipurpose Dam Construction Project (the Project). The Study is made based on the plan formulated in the foregoing Master Plan Study on North Banten Water Resources Development (the M/P Study) by JICA, as well as referring to the Feasibility Study on the Kopo-Cikande-Charenang (K-C-C) Irrigation Project by JICA. The Study was commenced in July 1984 and continued up to March 1985. This Report deals with the Study results obtained during this Study period.

2. In the M/P Study, the Project is formulated as a sole project in the North Banten area, and recommended to be worthy of early development. Concept of the Project is to level up before the year 2000 the income standard of the area to the level of the West Java Province, and also to level the income depressions which exist in the area. The present Study is made in line with this concept.

3. The Project area is located in the north-eastern part of the North Banten area. It is situated near Jakarta and on the main route which bridges Java to Sumatra. The Project area is low and flat in the northern part, moderately low but undulating in the middle part, and hilly predominated by tuffaceous sedimentary rocks in the southern part. The area is in the tropical monsoon zone. The Ciujung and the Cibeureum rivers, a tributary of the Cidurian river, flow in the south-north direction. Precipitation is rich ranging from 5,500 mm/yr in the south to 1,500 mm/yr in the north. River flow is rich in the rainy season, November through May, but rather poor in the dry season, June through October.

4. Main municipalities in the Project area are Rangkasbitung, Cilegon, and 17 I.K.K.s (capitals of sub-districts). There are two main existing irrigation schemes such as the Ciujung and Cicinta irrigation schemes, 24,200 ha and 1,435 ha in commanding areas. As these schemes depend on the natural flow of the Ciujung and Cibeureum rivers, commanding areas

are well irrigated in the rainy season but partly irrigated in the dry season. K-C-C area, 18,150 ha in gross area, has not been irrigated as yet except for a few pump irrigation spots, and rain fed paddy is cultivated in the rainy season.

5. The dominant land use in the Project area is paddy fields covering 66% of the total cultivated area. Present cropping intensities in the area are 174% in the Ciujung irrigation area, 107% in the Cicinta irrigation area and 113% in the K-C-C area. The present farming practices in the Project area, where about 124 kg/ha of urea and 73 kg/ha of triple superphosphare (T.S.P.) are applied, are at rather high level showing 3.7 ton/ha of yield for the irrigated paddy. The present main constraints to the agricultural developments are shortage of irrigation water in the dry season, fragmented land tenure system and under-developed road system.

6. The Ciujung river in the portion downstream from Rangkasbitung meanders. Bank erosion is often observed in the meandering parts and near confluences to tributaries. Floods occur usually in the west monsoon season often giving flood damages to Rangkasbitung and adjacent riparian areas. The largest flood of the Ciujung river ever experienced occurred in November 1981. Another notable flood occurred in January 1979.

7. Objectives of the Project to attain the aforementioned concept is (1) to provide storage reservoirs on the Ciberang river (the Karian reservoir), a tributary of the Ciujung river, and on the Cibeureum river (the Cilawang reservoir), (2) thereby to regulate seasonally the flow of two rivers, (3) to irrigate such areas as the existing Ciujung and Cicinta irrigation areas and new K-C-C area throughout the year, (4) to supply municipal and industrial water to Rangkasbitung, 17 I.K.K.s and the Cilegon area, and (5) to mitigate flood damages of Rangkasbitung by the river improvement works together with the flood control effect of the Karian reservoir.

8. Main structural items subject to the Study to achieve the objectives are as follows:

- Karian multipurpose dam on the Ciberang river,
- Cilawang dam on the Cibeureum river,
- Trans-basin tunnel from the Karian reservoir to the Cibeureum river,
- Trans-basin tunnel from the Cilawang reservoir to the Cicinta river,
- Irrigation facilities for the K-C-C area, and
- River improvement works on the Ciujung river on a portion centering about Rangkasbitung.

9. Delineation of irrigation area in the K-C-C area is made newly, and the commanding area amounts to 10,300 ha in net as compared with 8,000 ha given in the M/P Study. The increase is resulted from two factors. One is that the spots of paddy fields along the head reach portion of the main canal are included. The other is that scattering spots of cultivated lands are included which are used as upland fields at present but can be used as paddy fields when irrigation water is available.

10. New cropping pattern is proposed. Cropping intensity of new pattern is 250% as compared with 200% in the M/P Study. This increase is made for two main reasons. One is that there are some areas within the Ciujung irrigation area where 250% of cropping intensity has been in practice in the recent years. The other is that the present unit yield of this locality represented by southern part of the Ciujung irrigation area became rather high in the recent years so that more increase in income of the farmers is needed.

11. Demands for the municipal and industrial water supply are assessed. Values given in the M/P Study are retained except for slight increase for the Cilegon area. Demands assessed are 0.140 m^3/sec for

Rangkasbitung, 0.480 m^3/sec for 17 I.K.K.s and 1.145 m^3/sec for the Cilegon industrial area and Cilegon town.

12. In the foregoing M/P Study, the storage capacity of the Karian reservoir was measured on the new map in 1/5,000 scale with 5 m contour intervals, but that of the Cilawang reservoir was measured on the general topographic map in 1/50,000 scale with 25 m contour intervals. The air-photo map of the Cilawang reservoir area was later prepared by P3SA and, measurement of the Cilawang reservoir is newly made on the new air-photo map. As the result of measurement, two facts are found. One is that the new values of storage capacity are some 30% less than old values for the common elevations. The other fact is that the water level can be heightened above $1. 75 m by adding some saddle dams, whereas the upper limit was El. 75 m according to the measurement results on 1/50,000 scale map.

13. As the height of the Cilawang dam become variable, it becomes necessary to optimize the scale of the Cilawang reservoir and accordingly the scale of the Karian reservoir. Optimization is made taking such parameters as the high water level in the Karian reservoir, that in the Cilawang reservoir, diameter of trans-basin tunnel from the Karian reservoir to the Cibeureum river and the cropping intensity. Number of cases of various combinations are examined and optimum scales are obtained. Main results are as follows:

	Karian	Cilawang	Total
Effective storage capacity (10^6 m^3)			
Optimum case	219(+31)	62(+8)	281(+39)
(cf. M/P)	188 (0)	64 (0)	242 (0)

Cropping intensity in optimum case: 250%, cf. M/P: 200%
Discharge capacity of the Karian-Cibeureum trans-basin tunnel: 8 m^3/sec
Values in ( ): difference to values in the M/P Study

14. Dimensions of dams, reservoirs and tunnels are as follows:

Item		Optimum case
Karian dam		
Catchment area	(km^2)	288.0
Crest level	(El.m)	72.5
High water level	(El.m)	67.5
Low water level	(El.m)	46.0
Dam height from foundation	(m)	60.5
Effective storage capacity	(m^3)	219×10^6
Embankment volume	(m^3)	$1,490 \times 10^3$
Cilawang dam		
Catchment area	(km^2)	93.0
Crest level	(El.m)	81.0
High water level	(El.m)	76.5
Low water level	(El.m)	66.5
Dam height from foundation	(m)	36.0
Effective storage capacity	(m^3)	62.0×10^6
Embankment volume	(m^3)	532.0×10^3
Karian-Cibeureum trans-basin tunnel		
Design discharge	(m^3/sec)	8.0
Tunnel diameter	(m)	2.6
Tunnel length	(m)	1,540
Cilawang-Cicinta trans-basin tunnel		
Design discharge	(m^3/sec)	2.7
Tunnel diameter	(m)	2.0
Tunnel length	(m)	1,920

15. Karian dam is of rockfill type as planned in the M/P Study. Dam foundation is composed of alternate layers of tuffaceous sedimentary rocks which are not very hard. Spillway consisting of ungated and gated portions has a discharge capacity of 2,670 m^3/sec against the design flood inflow (PMF) of 3,400 m^3/sec.

16. Foundation of the Cilawang dam is composed of very similar rocks of the Karian dam site. As this fact is confirmed by the geological investigations of this time, this dam is proposed also as of a rockfill type as against the concrete gravity type proposed in the M/P Study. Spillway consisting of ungated and gated portions has a discharge capacity of 1,230 m^3/sec against the design flood inflow (PMF) of 1,700 m^3/sec.

17. Irrigation facilities for K-C-C area consists of head works, head reach, irrigation canals (main, secondary and tertiary), drainage canals (main, secondary, tertiary), inspection roads along irrigation canals, and necessary related structures. The head works are located 3 km upstream from the Gadeg site which was located in the M/P Study for minimizing costs and avoiding submergence of villages. The head works consists of a closure dam, 19 m high, a diversion channel on which gated weir is located, and an intake. Head reach is 2 km long and the main canal 30 km long.

18. Mitigation of flood damage is made by the joint effect of the flood control effect of the Karian dam and the river improvement of the Ciujung river upstream from the existing Pamarayan weir to Rangkasbitung. Basic high water discharge at Rangkasbitung is 1,300 m^3/sec with 1/10 return period. By providing a flood control capacity of 33 million m^3 in the Karian reservoir, the said 1,300 m^3/sec is regulated to 1,100 m^3/sec. River improvement works consist of shortcut and dredging of the riverbed. Combined effect of these two gives lowering of water level at Rangkasbitung by 0.9 m. In addition, groynes are needed to protect both river banks from being eroded.

19. Estimation of costs and benefits are made and the economic internal rate of return (EIRR) is calculated at 14.3%. This EIRR is derived from the benefit which is attained by the construction of the proposed items as well as of such other items as the rehabilitation of both of the existing Ciujung and Cicinta irrigation schemes, and construction of municipal and industrial water supply facilities, of which costs are unaccounted for in the present study.

20. The Project is formulated so as to be able to level up the income standard of the area to the level of the West Java Province, and also to level the income depressions which exist in the Project area. In line with this concept, each of the Project components have to be implemented without any missing items.

21. Thus, each of the Project component is technically possible, the whole Project is economically feasible and financially viable. Because the concept aims at levelling the income standard of the Project area as well as of the North Banten area, the Project is socio-economically desirable. It is, therefore, concluded that the Project is worthy of implementation.

22. It is recommended to take necessary steps for the implementation of the Project in administrative and technical aspects. The former will include the determination of the executing agency and procurement of foreign and domestic funds for construction. The latter will consist of the continuation and expansion of hydrologic observations as well as to of the addition of the geological investigations. These technical matters will be executed by DBPP aiming that ample data will become available before the start of the detailed design works (D/D).

FEASIBILITY STUDY

ON

KARIAN MULTIPURPOSE DAM CONSTRUCTION PROJECT

TABLE OF CONTENTS

Page

Page

Page

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

ABBREVIATIONS

(1) Local Terms

BAPPENAS	= Badan Perencanaan Pembangunan Nasional	: National Development Planning Agency
BIMAS	= Bimbingan Massal	: Mass Guidance for Self-sufficiency in Food
BKPM-D		: Investment Coordination Board of the Province of West Java
BPAM		: Provincial Water Management Unit
BPS	= Biro Pusat Statistik	: Central Bureau of Statistics
BULOG	= Badan Urusan Logistik	: National Food Logistics Agency
BUUD	= Badan Usaha Unit Desa	: Village Unit Executive Body
CIPTA KARYA		: Directorate General of Housing, Building, Planning and Urban Development
Danau		: Lake
DBPP		: Directorate of Planning and Programming
Desa		: Village
DGWRD		: Directorate General of Water Resources Development
DIPERTA	= Dinas Pertanian Pakyat	: Ministry of Agriculture
DOLOG	= Depot Logistik	: Provincial Food Depot of BULOG
DPMA	= Direktorat Penyelidikan Masalah Air	: Directorate of Hydraulic Engineering
DPU	= Departmen Pekerjaan Umum	: Ministry of Public Works
DPUP	= Dinas Pekerjaan Umum	: Provincial Department Office of Public Works
DSE		: Directorate of Sanitary Engineering
Gunung		: Mountain
IKK	= Ibu Kota Kecamatan	: Sub-district town
INMAS	= Intensifikasi Massal	: Mass Intensification
Kabupaten		: Regency
Kampung		: Settlement

K-C-C area		:	Kopo-Cikande-Carenang area
Kecamatan		:	Sub-district
Kotamadya		:	Municipality
KUD	= Koperasi Unit Desa	:	Village Unit Cooperative
Lama		:	Old
LEKNAS-LIPI		:	National Institute of Economic and Social Research
Palawija		:	Upland Crops
P3SA	= Proyek Perancang Pengembangan Sumber-Sumber Air	:	Water Resources Development Planning Project Division
PDAM		:	Regional Water Supply Enterprise
PELITA	= Pembangunan Lima Tahun	:	Five Year Development
PLN	= Perusahan Listrik Nagara	:	Public Cooperation of Electricity
PMA	= Penyelidikan Masalah Air	:	Hydraulic Engineering (Subdivision)
PMG	= Pusat Meteorogi Dan Geofisika	:	Meteorological and Geophysical Center
PPA		:	Nature Conservation and Wildlife Management
PPL	= Penyuluh Pertanian Lapangan	:	Agricultural Field Extension Worker
PPM	= Penyuluh Pertanian Madya	:	Agricultural Extension Officer
PPS	= Penyuluh Pertanian Spesialis	:	Agricultural Extension Specialist
PROSIDA	= Proyek Irigasi IDA	:	IDA Irrigation Project Division
P.T.	= Perusahaan Terbatas	:	Private Estate Enterprise
REPELITA	= Rencana Pembangunan Lima Tahun	:	Five Year Development Plan
Wilayah		:	Region

(2) International or Foreign Organization

ADB	:	Asian Development Bank
FAO	:	Food and Agriculture Organization of the United Nations
IBRD	:	International Bank for Reconstruction and Development

IDA	:	International Development Association
JICA	:	Japan International Cooperation Agency
UK	:	United Kingdom
UNESCO	:	United Nations Educational, Scientific, and Cultural Organization
US or USA	:	United States of America

(3) Others

B	:	Benefit
C	:	Cost
EIRR	:	Economic Internal Rate of Return
El.	:	Elevation above mean sea level
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
GRDP	:	Gross Regional Domestic Product
NPV	:	Net Present Value
O & M	:	Operation and Maintenance
PVC	:	Polyvinyl Chloride
TSP	:	Triple Super Phosphate

ABBREVIATIONS OF MEASUREMENT

Length

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

Area

cm^2 = square centimeter
m^2 = square meter
ha = hectare
km^2 = square kilometer

Volume

cm^3 = cubic centimeter
lit = liter
m^3 = cubic meter

Weight

mg = milligram
g = gram
kg = kilogram
ton = metric ton

Time

s = second
min = minute
h = hour
d = day
y = year

Electrical Measures

V = volt
A = ampere
W = watt
kW = kilowatt
MW = megawatt
GW = gigawatt

Other Measures

% = percent
PS = horsepower
° = degree
' = minute
" = second
°C = degree centigrade
10^3 = thousand
10^6 = million
10^9 = billion (milliard)
ppm = parts per million
pH = scale for acidity

Derived Measures

m^3/sec = cubic meter per second
micromhos/cm = scale for electrical conductivity
kWh = kilowatt hour
MWh = megawatt hour
GWh = gigawatt hour
kWh/y = kilowatt hour per year
kVA = kilovolt ampere

Money

Rp. = Rupiah
US$ = US dollar (US$1 = Rp. 1,050, as of November 1984)
¥ = Japanese Yen (¥100 = Rp. 440, as of November 1984)

I INTRODUCTION

1.1 General

Directorate General of Water Resources Development (DGWRD) of the Ministry of Public Works and the Japan International Cooperation Agency (JICA) agreed to carry out the Feasibility Study (the Study) on the Karian Multipurpose Dam Construction Project (the Project), and the Scope of Works (S/W) for the Study was signed by both sides on March 9, 1984.

The Team for the Study for the Project (the Team) and the Advisory Committee to provide advisory services for the Study (the Committee) were organized by JICA in July 1984. Executive agency of the Indonesian side on the Project is the Directorate of Planning and Programming (DBPP) of DGWRD. The Study was commenced in no time and continued till the completion of the final version of the feasibility report (the Final Report). In accordance with the description in the Scope of Works the inception report was prepared in August 1984, the interim report was prepared in December 1984, and the Draft Final Feasibility Report (the Draft Final Report) dealing was prepared in March 1985.

Discussion meeting between the Indonesian and Japanese sides on the Draft Final Report was held in Jakarta in the middle of March 1985. Later, comments on the Draft Final Report were delivered from DBPP to the Team in early June 1985.

This is a Feasibility Report (the Draft Final Report) on the Project dealing with all the results of surveys and studies to which the comments from DBPP are incorporated fully.

1.2 Historical Background

The DBPP of DGWRD has been in study activities, through its project division called the Proyek Perancang Pengembangan Sumber-Sumber Air (P3SA), on the water resources development of the North Banten area since 1977. Several measuring stations were installed to form a

meteorologic and hydrologic network in addition to those operated by other Governmental agencies.

From December 1978 through September 1979, the reconnaissance study on the water resources development in the North Banten area was performed by P3SA assisted by UK technical cooperation, and the report entitled "Banten Water Resources Development Reconnaissance Study" was prepared.

Later on from July 1982 through July 1983, the Master Plan Study on the Water Resources Development in the North Banten area (the M/P Study) was carried out by P3SA assisted by the Japanese technical cooperation through JICA. As the results of this study, the report entitled "Master Plan Study on North Banten Water Resources Development" was prepared in July 1983.

In parallel with the said study, two related activities were carried out separately by P3SA assisted also by the Japanese technical cooperation through JICA. One activity was the air-photo mapping of possible dam and reservoir areas such as Karian, Pasir-Kopo, Bojongmanik and Cibanten in 1/5,000 scale with 5 m contour intervals. Also longitudinal profile and cross-sectional surveys were made on principal portions of main rivers under the same activity. The Kopo-Cicande-Carenang area (the K-C-C area) was mapped separately by P3SA.

The other activity was the feasibility study of the K-C-C area on condition that the irrigation water is taken only from the Cibeureum river. The feasibility report was prepared in July 1983.

As the results of the M/P Study, one project was identified which was composed of many items such as dams, diversion tunnels, irrigation facilities, river improvement works and municipal and industrial water supplies, and it was recommended to take further steps soonest to meet the acute local needs. This Project is referred to as the Karian Multipurpose Dam Construction Project at present.

The Government of Indonesia, giving high priority to this Project, requested the technical cooperation to the Japanese Government. In response to the request, the Japanese Government took action as mentioned in the foregoing sub-chapter, and the Study was commenced in due time.

1.3 Objectives

1.3.1 Objectives

The present Study is to make a feasibility study of the Project which is formulated to achieve the main objectives itemized below:

- To store and regulate the outflow of the Ciujung river by providing reservoir by high dam (Karian dam) and Ciberang-Cibeureum trans-basin tunnel, and thereby also to control the flood discharge,
- To store and regulate the outflow of the Cibeureum river by providing reservoir by high dam (Cilawang dam) and Cibeureum-Cicinta trans-basin tunnel,
- To supply irrigation water in the dry season to the existing Ciujung irrigation scheme and the existing Cicinta irrigation scheme,
- To supply irrigation water throughout the year to the K-C-C area by providing new irrigation and drainage facilities,
- To mitigate flood damages of Rangkasbitung by river improvement works on the Ciujung river in addition to the flood control effect of the Karian dam, and
- To provide necessary amount of water for municipal and industrial water supplies for which demands will occur in future. Such demands consist of those for Rangkasbitung, those for 17 I.K.K. (capital towns of districts) and those for Cilegon industrial area and Cilegon town.

1.3.2 Project Component

To achieve the above-mentioned objectives, the Project components listed below are to studied.

- Karian dam and reservoir on the Ciberang river,
- Cilawang dam and reservoir on the Cibeureum river,
- Trans-basin tunnel from the Karian reservoir to the Cibeureum river,
- Trans-basin tunnel from the Cilawang reservoir to the Cicinta river,
- Irrigation and drainage facilities for K-C-C area including diversion works, headreach, irrigation canals and drains, and
- River improvement works on a stretch of the Ciujung river for about 26 km centering about Rangkasbitung down to the existing Pamarayan weir.

1.3.3 Activities of the Team

The Team consisting of 18 members in total started the Study works in the beginning of June 1984. The field works in Indonesia continued from the end of June 1984 till the end of December 1984. The homeworks were made from the beginning of January 1985 till the end of March 1985. Time schedule of the Team members and their counterparts personnel mobilized by P3SA is attached in Table 1-1.

II GENERAL BACKGROUND

2.1 Land and Population

Indonesia consists of 13,667 volcanic islands in a huge marine belt of about 5,000 km and 1,600 km respectively in longitude and latitude across the equator. Among these islands, Java is the fifth largest and pearl island of Indonesia, comprising the nation capital D.K.I. Jakarta, D.I. Yogyakarta, the relevant West Java and other two provinces. The land area of Java is about 132 thousand km^2 or 6.9% of the nation total of 1,919 thousand km^2.

According to the last national censuses in 1961, 1971 and 1980, the total population as well as its density increased accelerative ly up to 147.5 millions at the average annual growth rate of 2.23% throughout the period, particularly in the case of Java in excessive concentration as shown in Table 2-1. Besides major cities i.e. Jakarta, Surabaya, Bandung, etc., more than 80% of the population inhabits in rural area and a rapid increase of labour force makes themselves to be in unfavourable employment or poor living condition (Ref. Appendix-A, Chapter III).

Under such circumstances, the Government of Indonesia is aiming to slow down the population growth as low as 2% per annum with diffusion of the family plans and to maintain a sustainable growth of the Gross Domestic Products (GDP) and Gross Regional Domestic Products (GRDP) for improvement of the people's well-being.

2.2 National and Regional Economy

Throughout the decades, the Indonesian economy has marked a significant progress along with the First, Second and Third Five Years Development Plans (PELITA I, II and III). The GDP were grown from Rp. 12.6 trillion in 1975 to Rp. 21.1 trillion in 1983 at the 1975 constant price, corresponding to the growth of about 5.6 times at the current price. At the trend of economic growth, it is observed high

in infrastructures followed by manufacturing industry and low in mining, quarrying and agriculture as well as declining in their shares. Nevertheless, because of an inevitable gradient to the national economy by these primary industries, they are still ranked as the mainstay in the industrial structure (Ref. Appendix-A, Chapter I).

In consequence with the worldwide stagnation especially in oil market, the foreign trade and account of the Indonesia, as an oil export country, were downdrifted in early 1980s and resulted in an exchange devaluation of Rupiah to cut 38.5% downward in March 1983. Thus in the current Indonesia economy, yet involved are higher population growth and hidden underemployment; earning and economic differentials in region, urban/rural, industrial sectors and workers; uneven distribution of industrial structure; and foreign exchange deficit.

For viable long-term economic growth, the Fourth Five Years Development Plan (REPELITA IV) for 1984/85 - 1988/89 has been released by the Government of Indonesia to implement effective April 1984 along with the aims as below.

Objective:

(1) To level up the living, intellectual and welfare standards of the people; and

(2) To place a strong and firm foundation for a prospective feature of the nation development. The feature, thereupon, means taking off to the fruitful national economy during the forthcoming REPELITA V and achievement of prosperity and justice of the country based on GBHN "Pancasila" (Five principals on basic line of the nation) by the end of REPELITA VI.

Strategy:

(1) Fair and harmonic improvement among the respective development fields and sectors;

(2) Potential development centering around autarky of foods and intensification of machine manufacturing industry;

(3) Improvement of physical and mental welfare, parity allotment of development fruites and expansion of working opportunity; and

(4) Fulfillment of the unsolved problems in the course of REPELITA III.

Guideline:

(1) Equity of developments with sharing of their fruits: relevant to diffusion of provisions, materials and houses necessary for living of all citizen; educational and hygienic opportunity; allotment of earning; working opportunity; business opportunity; participation of young age and female groups to development program; extension of development programs into each district of the country; and appreciation of justice;

(2) Substainable economic growth; and

(3) Sound and dynamic stability of the nation.

As per the summary in Table 2-2, it set forth the target of annual average growth rates as real economic growth of 5%, inflation of 8% and nominal economic growth of 13.4%, provided with the population growth of 2.0% per annum at the end of the period. To achieve such targets, a stupendous scale of treasury accounts with the public for sum of Rp. 145.2 trillion or 26% of total GNP for the overall period is scheduled to disburse to the potential objectives. Thus, the industrial structure will be congruously moderated through the period; the share of manufacturing sector in total GDP will increase from 15.8% to 19.4% at the growth rate of 9.5% per annum, while that of agriculture will decline from 29.2% to 26.4% at rather lower annual growth rate of 3.0%.

REPELITA IV, in addition, specifies to much of character and concrete measure in every concern of industrial sector, infrastructure and region (Ref. Appendix-A, Chapter I). It is quite conceivable that the conceptual approaches to this project since its master plan study would appeal to REPELITA IV particularly in the following context:

(1) Rural development;

Improvement of income level and local depression of the inhabitants can be expected by means of participation to development opportunities and fruits.

(2) Industrial structure;

As for agricultural along with self-sufficiency of foods, the development potential has an aptitude for water reservoir and irrigation. Centering around agriculture, diversification of industrial sectors can be extended to home-industry, trade, construction, transportation and so forth.

(3) Employment; and

With establishment of the above sectors, working opportunity as well as job training can be introduced respectively at the site.

(4) Comprehensive development of water resources.

Flood control, municipal & industrial water supply and/or hydropower generation can be commonly applicable as a part of the total plan.

2.3 Agriculture

Agriculture in Indonesia still plays an important role providing foods and employment opportunity for the people, though its economic importance lessens gradually. The share of agriculture in the gross domestic products at current prices in recent years dropped to around 25% as shown below.

Agriculture Production in GDP (1978-82)

	1978	1979	1980	1981	1982
Agricultural GDP (billion R.)	6,706	8,996	11,290	13,643	15,668
Total GDP (billion Sp.)	22,746	32,025	45,446	54,027	59,633
Percent of Agriculture (%)	29	28	25	25	26

Source: Economic Indicator, July 1984

The economic active population in agriculture in 1980 was 28,834,041 which corresponds to 56% of the total economic active population. The earning of foreign currency by agriculture in recent year is very small, i.e. 6 to 7% of the total earnings as shown below.

Exports of the Agricultural Products

	Exports of Agricultural Products	Percents in Total Export
1981	1,639 (US$ x 10^6)	6.5%
1982	1,297 "	5.8%
1983	1,451 "	6.9%

Source: Economic Indicator, July 1984

The Government is paying effort to attain self-sufficiency of rice, but still facing some difficulties for the attainment owing to a rapid population increase together with the increase in per capita consumption. The production of major food crops in recent years are presented in the following table. Annual increase in paddy production between 1981 and 1983 was 5.9% per annum.

Production of Major Food Crops

(Unit: 1000 tons)

	1980	1981	1982	1983
Paddy	29,653	32,774	33,584	35,273
Maize	3,991	4,509	3,235	5,095
Cassava	13,726	13,301	12,988	11,651
Sweet Potato	2,079	2,094	1,676	2,044
Groundnuts	470	475	437	476
Soy beans	653	704	521	568

Source: Economic Indicator, July 1984

The rice import dropped to 310,000 ton in 1982 from about 1,550,000 ton in previous years, though, in 1983 it increased to 1,200,000 tons.

The Government has put the highest priority in increase in rice production. The expansion and improvement of irrigated paddy fields are one of the Government strategy for the attainment of self-sufficiency in food-stuff.

III THE STUDY AREA

3.1 Location

The study area is located in the northwest corner of the West Java province, and defined broadly as the area bordered by the Java Sea in the north, by the southern boundary of the Upper Ciujung Watershed in the south, by the Cidurian river in the east and by the Ciujung Left Primary Canal in the west. The study area is further specifically defined as the area encompassing all the component structures newly proposed and all the existing facilities to be benefited by the Project Works as detailed below.

- Karian dam site and reservoir area,
- Cilawang dam site and reservoir area,
- Sites for two trans-basin tunnels including inlet and outlet areas,
- K-C-C area including the diversion works site,
- Rangkasbitung town and stretch of the Ciujung river centering about Rangksbitung mainly down to the existing Pamarayan Weir and subsidiary down to the estuary,
- Existing Ciujung irrigation scheme area,
- Existing Cicinta irrigation scheme area,
- Cilegon area including the town area and neighbouring areas where future demands will occur, and
- Serang and Pandeglang towns where the concerned offices are located.

3.2 Natural Condition

3.2.1 Topographic Maps and Aerophotographs

The topographical maps and aerophotographs available for Karian multipurpose dam construction project are summarized below.

(1) Topographical maps

Scale	Index No.	Contour interval (m)	Sheets	Remarks
1 : 50,000	34-36-D	25	1	National map (HIND 1090S)
	34-37-B,C,D	25	3	"
	34-38,A,B,C	25	3	"
	34-39-B	25	1	"
	35-36-A & C	25	1	"
	35-37-A	25	1	"
	35-36-D & 35-37-B	25	1	"
	35-37-C,D	25	2	"
	35-38-A,B,C,D	25	4	"
	39-39-A,B	25	2	"
1 : 5,000	1 to 21	5	21	Aerophoto maps
1 : 5,000	1 to 5	5	5	Aerophoto maps (newly produced)
1 : 5,000	1 to 13	5	13	Aerophoto maps (Ciujung river area)
1 : 500	1 to 12	1	12	Newly prepared by plane-table survey (Karian dam site)
1 : 500	1 to 6	1	6	- do - (Cilawang dam site)
1 : 500	1 to 3	1	3	- do - (Gadeg weir site)
1 : 500	1 & 2	1	2	(Cicinta trans-basin tunnel site)
1 : 500	1 & 2	1	2	- do - (Ciuyah trans-basin tunnel site)

(2) Aerophotographs

Scale	Index No.	Sheets	Remarks
1 : 20,000	R-XId 1-10	10	Used to check land use in K-C-C irrigation area
	R-XII 5-14	10	
	R-XIIa 1-19	19	
	R-XIII 5-30	26	
	R-XIV 1-20	20	
1 : 20,000	Banten R-XI 1-15	15	Used to estimate flood damaged area along Ciujung river
	Banten R-X 1-16	16	
	Banten R-XII-A 1-19	19	

The map newly produced from aerophotographs and by ground control survey in this stage cover Cilawang reservoir area and Cicinta irrigation area in 1 : 5,000 scale. The maps of 1 : 500 scale have been prepared for the main structure sites of the project such as, Karian dam site, Cilawang dam site, Gadeg weir site, Ciuyah trans-basin tunnel site and Cicinta trans-basin tunnel site.

3.2.2 Geology

The proposed dam sites, trans-basin tunnels and diversion intakes are located in and adjacent to the Ciberang River Basin and Cibeureum River Basin, and tuffaceous sedimentary rocks hilly area was formed by volcanism with the tectonic subsidence in Tertiary period. The volcanic mountains are formed by andesite, basalt and volcanic breccia which are erupted and/or intruded along the faulting structure zone in Quaternay to Tertiary. The general geological condition in the project area is shown in Fig. 3-1.

The tuffaceous sedimentary rocks are composed of mainly Pliocene fine to coarse grained tuffaceous sandstone, pumice tuff, lapili tuff, basal conglomerates, welded tuff, and tuffaceous claystone facies (the Genteng Formation). They are now exposed primarily along the edge of

the river bank and dip in low angles. These tuffaceous rocks are generally classified as soft rock especially weakness in pumiceous facies. The stratigraphy of project area is shown on Table 3-1.

The core samples from drilling hole are sometimes only in the fragments of rocks, especially in the layer of pumiceous lapilli tuff with open cracks joint. Numerous field permeability tests at both dam sites show high permeability coefficient in excess of $K = 3 \times 10^{-4}$ cm/sec.

Along the riverside, Quaternary deposit is distributed on the river terrace, which is underlain by stiff silty clay of Pleistocene with some gravel of volcanic rocks and fragments of lapilli tuff.

The soft rock lies below 2 to 5 meters from the surface in the abutments of on the both dam sites, and has moderately to rather low bearing strength for a high fill dam. According to the rock test of boring core, the degree of induration of these rocks are generally low. The average compressive strength of the both dam sites is in order of $\sigma c = 10$ kg/cm^2 to 30 kg/cm^2. The result of the standard penetration test carried out from topsoil to soft rock show N-value of 50 at the bottom of residual soil.

The southern mountains consists of basalt, volcanic breccia (G. Alung) and andesite (G. Guradog and G. Sendi) of Miocene. These volcanic mountains are expected for quarry site of construction materials.

Most of lineaments and fault lines with NW-SE trend and NE-SW trend are marked on aerial photographs. Well defined NE-SW trending faults have been confirmed along the Ciberang River at the Karian dam site.

The engineering geology condition of the project site understood through the boring survey and seismic exploration are explained as follows.

(1) Water tightness

Field permeability tests were carried out in the boreholes along the dam axis and other sites. The borehole KB17 and KB18, located left bank abutment; show high permeability value of $K = 3.0 \times 10^{-4}$ cm/sec at 15 - 40 m in depth. The borehole KB19 and KB20, located riverside of Karian dam site, show rather high permeability value of $K = 3.0 \times 10^{-4}$ cm/sec to $K = 1.0 \times 10^{-3}$ cm/sec at 10 - 30 m in depth. From these results recommended depths of curtain grout for adequate water tightness under the dam crest are from 10 m to 40 m under the ground surface. The borehole CB-4 of Cilawang dam site shows high value of $K = 3.0 \times 10^{-4}$ cm/sec to $K = 1 \times 10^{-3}$ cm/sec at 14 - 20 m in depth. The average permeability coefficient of Cilawang dam site is in the order of $K = 3 \times 10^{-5}$ cm/sec to $K = 3 \times 10^{-4}$ cm/sec. The permeability coefficient in the pumiceous tuff and coarse grained sandstone is rather high.

(2) Rock quality designation

Generally, rock quality designation (RQD) of drilling cores is shown poor (25 - 50%), in the other case, RQD is often very poor (0 - 25%). In several cases, the RQD exceeds 75%. Especially, boring cores obtained at Cicinta trans-basin tunnel site and shallow part of quarry site show a rather poor condition.

(3) Rock classification

Rock classification of drilling cores except quarry site was divided into three classes such as CM (the rock is slightly soft), CL (the rock is soft) and D (the rock is very soft).

Core samples of Karian dam site consists of CL and CM, and its ratio is about 2 to 1. Core samples of Cilawang dam site also consist of CL and CM, however, its ratio is about 1 to 2.

Core samples at quarry site contain B (the rock is hard) and CH (the rock is fairly hard) which is equivalent to basalt or tuff breccia.

(4) Rock bearing strength

Rock test of core samples were carried out at dam sites, Cilawang-Cicinta trans-basin tunnel and quarry site,

Generally, rock bearing strength of drilling core at the both dam sites and tunnel site shows low compressive strength $\sigma c = 10$ to 30 kg/cm^2, in some cases, compressive strength is very low $\sigma c = 4$ to 9 kg/cm^2.

The core sample of basalt at G. Alung shows very high value of the compressive strength ($\sigma c = 892 - 1,864$ kg/cm^2). The core sample of tuff breccia at G. Alung shows moderate value of $\sigma c = 116 - 162$ kg/cm^2.

(5) Velocity of elastic wave propagation

Seismic exploration was carried out at dam sites, trans-basin tunnel sites, quarry site and borrow site. Based on these results, the ground is calssified into four zones. Velocity of seismic wave ranges from 0.3 to 2.5 km/sec at Karian dam site, and ranges from 0.3 kg/sec to 3/0 kg/sec at Cilawang dam site.

On the other hand, seismic test at quarry site shows fairly high wave velocity ranging from 0.3 to 5.0 kg/sec, at a tunnel sites and borrow area from 0.3 km/sec to 2.4 km/sec,

Detailes of survey and the results can be referred to APPENDIX-C.

3.2.3 Soil and Land Capability

(1) Geomorphological condition

A soil survey is carried out over the total area of 21,870 ha in and around the K-C-C area. From a geomorphological viewpoint, the land in the K-C-C area is broadly divided into following four land forms:

(a) Alluvial plain generally has a flat terrain with some exceptions of natural leyees and shallow depression. This land form lie on the elevations from 0 to 6 m above mean sea level. The soils in the area consist of fine textured sediments deeply deposited by the Ciujung, Cidurian, Cibeureum and Cimendaya rivers and their tributaries in the recent formation stage. Almost all of the area have been developed as the paddy fields. The northern part of the area had suffered from heavy floods before construction of dikes along the lower reaches of the Ciujung and Cidurian rivers.

(b) River terrace mainly extends over the northern part of the surveyed area having a level to gently undulating releaf. This landform has a layer of acid tuff and lava flow. The soils in this area comprises coarse sand fraction of quartz-like materials, The land on the lower terrace is mainly developed for paddy fields, while the land on the middle and high terraces has been developed for mixed upland farming.

(c) Depressions scatter over the deeply dissected flat hilly area. The soils in this area consist of fine textured sediments and contain relatively high organic matters. The lands are mainly covered with palm, bush and aquatic plants.

(d) Undulating or rolling hills mainly develop over the southern part of the K-C-C area bounded by the Jakarta-Merak road. The soils in this erea consist of acid tuff and/or lava flow containing-significant amount of quartz-like materials. The lands are covered with shrub for the most parts and partly developed for upland crops cultivation.

(2) Soil classification

A soil classification is made in accordance with FAO/UNESCO soil classification system. According to the soil survey, the soils extending in the K-C-C area are classified into four soil units, which are further subdivided into 13 sub-units as follows (Ref. Appendix-D):

	Soil Unit/Sub-unit	Area (ha)	Proportional Extent (%)
(a)	Eutric Fluvisols (Grayish Brown Alluvial Soils in Indonesian System)	320	1.5
	- Sub-unit 1 : Flat, Deep, Eutric Fluvisols	(320)	(1.5)
(b)	Eutric Gleysols (Gray Hydromorphic Soils in Indonesian System)	8,760	40.1
	- Sub-unit 2 : Flat, Deep, Eutric Gleysols	(7,690)	(35,2)
	- Sub-unit 3 : Gently Sloping, Deep, Eutric Gleysols	(670)	(3.1)
	- Sub-unit 4 : Depressed, Deep, Eutric Gleysols	(400)	(1.8)
(c)	Orthic Acrisols (Yellowish Brown Podzolic Soils in Indonesian System)	6,420	29.3
	- Sub-unit 5 : Flat, Deep, Orthic Acrisols	(3,900)	(17.8)
	- Sub-unit 6 : Gently Sloping, Deep, Orthic Acrisols	(1,300)	(5.9)
	- Sub-unit 7 : Sloping, Deep, Orthic Acrisols	(110)	(0.5)
	- Sub-unit 8 : Flat, Moderately Deep, Orthic Acrisols	(220)	(1.0)
	- Sub-unit 9 : Gently Sloping, Shallow, Orthic Acrisols	(850)	(3.9)
	- Sub-unit 10 : Sloping, Shallow, Orthic Acrisols	(40)	(0.2)
(d)	Dystric Nitrosols (Reddish Latosols in Indonesian System)	6,370	29.1
	- Sub-unit 11 : Flat, Deep, Dystric Nitosols	(1,310)	(6.0)
	- Sub-unit 12 : Gently Sloping, Deep Dystric Nitosols	(2,800)	(12.8)
	- Sub-unit 13 : Sloping, Deep, Dystric Nitosols	(2,260)	(10.3)
	Total	21,870	(100.0)

(3) Land capability

The Japanese land classification standard for rice crop is applied for the assessment of land capability of the K-C-C area. In the standard, land is classified into four capability classes as follows:

Class I : Land has almost no limitation for crop production and/or no risk of soil degradation. It is naturally fertile and has a high potential for crop production without any improvement of soils.

Class II : Land has some limitations for crop production and/or some risks of soil degradation, and requires some improvement of soils for normal crop production.

Class III : Land has many limitations for crop production and/or is likely subject to risks of soil degradation, and fairly intensive improvement of soils is required for normal crop production.

Class IV : Land has much more limitations than those in Class III, but can be used for cultivation of some specific crops under very careful management.

Based on the above standard, the lands in the K-C-C scheme area are classified as follows:

Capability Class	Area (ha)	Proportional Extent (%)
I	8,360	38.3
II	12,220	55.8
III	1,250	5.7
IV	40	0.2
Total	21,870	100.0

3.2.4 Climate

A typical monsoon climate prevails in the study area with well marked wet and dry season corresponding with the monsoons. The west monsoon dominates the area with abundant rainfall from December through March, and the east monsoon appears with less rainfall from June through September. April to May and October to November belong to the transitions.

The precipitation in the study area is rich with the areal average of about 2,500 mm per annum. The annual rainfall varies according to the location and the topography, ranging from about 1,500 mm in the northern coastal plain to about 5,000 mm in the southern mountainous region near Gunung Endut and Gunung Halimun. The seasonal variation of the rainfall is also notable with marked wet and dry periods. The northern coastal plain receives less than 30% of the annual rainfall during the dry period from May through October, or the months of east monsoon (June - September) and its neighbours. The mid-range area around Pamarayan and Rangkasbitung receives about 40% of the annual rainfall during the same period as above.

The monthly mean air temperature will be principally a function of elevation. However, at Serang in the northern coastal plain, the monthly mean air temperature varies little throughout the year ranging between 26°C and 27°C.

The relative humidity is generally high ranging from 80% to 85% almost throughout the year with some declines to about 75% around September and its neighbouring months.

The monthly mean wind velocity at Serang ranges between 3.8 and 4.7 knots or 2.0 m/sec and 2.4 m/sec.

The monthly mean sunshine duration at Serang ranges between five and six hours daily in the dry season, whereas between three and four hours daily in the wet season.

3.2.5 Hydrology

(1) Meteorologic and hydrologic stations

It is reported that the rainfall observation was started in late 1970's at Serang and over 60 stations were installed by 1920 in the North Banten region. Presently, about 100 rain gauge stations are operated in and around the North Banten region under the management of P3SA and the Meteorology and Geophysics Center (PMG). Out of them, 10 stations are equipped with automatic rain recorders. Taking the availability of observed data into account, 85 stations will be selected for the study. Their locations are shown in Fig. 3-2.

Most of the data on these 85 stations are useful for arranging the daily and the monthly rainfall data. Their data-keeping condition will be summarized in Table 3-2.

Two groups of rain gauge grid networks spacing at 2 km have been installed in 1978 by P3SA, one near Ciruas in the northern coastal plain, and the other near Leuwidamar in the upper Ciujung catchment. The object of these rain gauge grid networks is to investigate the rainfall patterns in the coastal and the hill areas and their effects on floods. The accumulated data to date in the grid networks are yet insufficient for processing into the daily and the monthly rainfall data for the present study, however, the hourly rainfall data by some automatic rain recorders in the networks will be useful for the flood runoff analysis.

In the North Banten region, PMG installed a meteorologic station at Serang in 1949, which has been the principal station in the region. Besides, P3SA installed four meteorologic stations in 1978 at Padarincang, Cadasari, Cikadu and Cileles. Their locations are shown in Fig. 3-2, and the observation periods are listed in Table 3-3.

Table 3-4 shows the water level gauging stations on the Ciujung and the Cidurian river systems. Two stations on the main stem of the Ciujung river, at Rangkasbitung and Kragilan, are under operation by

the Directorate of Hydraulic Engineering (DPMA) since 1970 and 1969, respectively. The available gauging data at Pamarayan weir, since 1975, are kept by the Serang Regional Office, Provincial Public works Department (DPUP). P3SA has been operating three stations on the tributaries of the Ciujung river since around 1978-1980, at Sajira on the Ciberang river, at Cileles on the Upper Ciujung river and at Leuwidamar on the Cisimeut river.

New automatic gauging station on the Ciberang and the Cibeureum rivers, at Sabagi and Gadeg, were installed by DPMA in June 1984. Sabagi station is located downstream from the Karian dam site near Sabagi Village, and Gadeg station is located downstream from the Cilawang dam site near Gadeg staff gauge.

The water level recorders installed at Rangkasbitung, Sajira and Leuwidamar gauging stations were damaged by the flood in November 1981. The gauging has been performed by staff gauge observation three times a day since then. The water level recorder was installed again at Rangkasbitung by DPMA in January 1982.

For the DPMA gauging stations at Rangkasbitung and Kragilan on the Ciujung river, the discharge rating curves have already been prepared by DPMA and the daily discharge tables are also ready to use. The Rangkasbitung gauging station will be the key station in the Ciujung catchment, which gives the well arranged discharge data for a fairly long observation period since 1972 to date.

On the P3SA gauging stations, a series of discharge measurement have been carried out since the year of installation to date and the measurement data are available for drawing up the discharge rating curves. The discharge rating curves and their formulae were prepared by the Feasibility Study Team for the estimation of discharges at each gauging station. At Sajira gauging station on the Ciberang river, the observed data show some inconsistency affected by simple intake facilities located immediately downstream of the gauging station. Therefore the data will not be available for the study.

Presently, the Cibeureum river has one water level gauging station at Gadeg, however, four water level gauging stations are operated on the main stem of the Cidurian river as listed in Table 3-4. Two gauging stations at Parigi and Kopomaja are under operation managed by DPMA since 1969 to 1975 at Parigi and to date at Kopomaja. P3SA has been operating two gauging stations at Rancasumur and Tanjung since 1978 to date. The Kopomaja gauging station will be the key station because of its fairly long observation period.

(2) Precipitation

The annual rainfall in the study area varies, according to the location and the topography, ranging from around 1,500 mm in the northern coastal plain to about 5,000 mm in the southern mountainous region near Gunung Endut and Gunung Halimun. The mid-range area in-between, around Pamarayan and Rangkasbitung, receives 2,000 to 2,500 mm. Gunung Karang affects the local pattern with richer rainfall of 2,500 to 3,500 mm on its southern foothills near Pandeglang. The upper Ciujung catchment south-west of Rangkasbitung lies in a rain shadow between two mountain areas and receives less rainfall than the Ciberang and the Cisimeut catchments.

An isohyetal map of the annual rainfall is presented in Fig. 3-3 which was prepared by the M/P Study Team taking account of the average annual rainfall data from 1942 through 1980 at selected stations in and around the study area.

The seasonal variation of the rainfall in the study area is also notable corresponding with the monsoons. The northern coastal plain receives only about 15% of the annual rainfall during the period from June through September or the months of east monsoon, whereas about 60% of the annual rainfall during the period from December through March or the months of west monsoon, the rest of 25% during the months of transitions. The mid-range area around Pamarayan and Rangkasbitung receives about 20% of the annual rainfall during the period from June through September, whereas about 45% of the annual rainfall during the period from December through March, and the rest of 35% during the months of transitions.

The typical patterns of monthly rainfall in the study area are illustrated in Fig. 3-4 which are prepared based on the observed data at nine typical gauging stations in the northern coastal plain, the mid-range area and the mountainous region.

(3) Surface water

(a) Watershed

The Project area occupies a total area of about 2,320 km^2 including the objective irrigation area in the northern coastal plain. The main rivers running through the Project area are the Ciujung, the Cibanten and the Cibeureum rivers. The last is a tributary of the Cidurian river system.

The Ciujung river has a total catchment area of 1,850 km^2 on its estuary. The river splits into three main tributaries in the upstream basin at or near Rangkasbitung where the catchment area comes to 1,383 km^2, comprising 594 km^2 of the Upper Ciujung, 331 km^2 of the Ciberang and 458 km^2 of the Cisimeut river basins.

In the Ciujung river basin upstream from Rangkasbitung, the present land use will be briefly classified as follows:

- the natural forest covers 124 km^2, or only 9.0% of the catchment area, mainly in the Ciberang and the Cisimeut basins,
- the plantation and the shrub forest cover 417 km^2, or 30.1% of the catchment area mainly in the Cisimeut and the upper Ciujung basins,
- the upland crop field covers 703 km^2, or 50.8% of the catchment area, and
- the wet paddy field covers 139 km^2, or 10.1% of the catchment area.

The Cibeureum river has a catchment area of 255 km^2 at the confluence of the Cidurian river. The present land use in the basin will be briefly classified as follows:

- the natural forest covers 11 km^2, or only 4.3% of the catchment area,
- the plantation and the shrub forest cover 61 km^2, or 23.9% of the catchment area,
- the upland crop field covers 135 km^2, or 52.9% of the catchment area,
- the wet paddy field covers 43 km^2, or 16.9% of the catchment area, and
- the grass land covers 5 km^2, or 2.0% of catchment area.

(b) Discharge at gauging stations

The monthly mean discharge and the annual runoff at each water level gauging station on the Ciujung river and the Cidurian river are summarized in Table 3-5. The annual runoff of the Ciujung river is accordingly estimated at about 3.08×10^9 m^3 at Kragilan (CA = 1,812 km^2), about 3.55×10^9 m^3 at the Pamarayan weir (CA = 1,451 km^2) and about 3.05×10^9 m^3 at Rangkasbitung (CA = 1,383 km^2) on average during each observation period. The Cibeureum river has Gadeg gauging station at present. Making reference to the main stem of the Cidurian river, the annual runoff at Kopomaja (CA = 304 km^2) is estimated at about 0.72×10^9 m^3.

The flow regime of the Ciujung river has a similar monthly pattern to that of the rainfall, which is characterized generally by the rich flow during the period from December through May and the less flow during the period from June through November. July and August belong to the months of drought flow. The Cidurian river has an approximately similar monthly flow pattern, however, usually the rich flow appears from January through May.

(c) Discharge at dam site and weir site

The estimation of 10-day mean daily discharge at each proposed dam site and weir site will be done as follows and the results are given in Table 3-6.

- Karian dam site

Because of the low accuracy of observed data at Sajira gauging station and no available data from newly installed Sabagi gauging station on the Ciberang river, and relatively short observation periods at P3SA's gauging stations on other tributaries, the 10-day mean daily discharge at Karian dam site will be estimated on the basis of daily discharge data at DPMA's Rangkasbitung gauging station, which gives well arranged data for a fairly long period from 1972 through 1983.

However, considering the non-uniformity of rainfall distribution within the river basin upstream from Rangkasbitung, being richer in the Ciberang catchment, the estimation of discharge at Karian dam site will be made taking account of the runoff-depth ratio calculated from the annual rainfall and catchment losses in the basin together with its catchment area ratio between Karian dam site and Rangkasbitung.

- Pamarayan weir site

The 10-day mean daily discharge at Pamarayan weir site will be similarly derived from the daily discharge data at Rangkasbitung gauging station. Also the runoff-depth ratio calculated from the annual rainfall and catchment loss together with its catchment-area ratio will be taken into account.

- Cilawang dam site and Buyut weir site

P3SA's staff gauge at Gadeg on the Cibeureum river has provided with only fragmentary data on daily discharge

since its start of observation in 1982. DPMA's newly installed automatic water level recorder at Gadeg gives no available data by the time of the study yet.

DPMA's Kopomaja gauging station, with staff gauge, has the longest observation period among the gauging stations on the main stem of the Cidurian river. It provides with year round daily discharge data from 1970 through 1979, however, recently giving only fragmentary data since 1980.

Considering the above-mentioned unsatisfactory condition of gauging stations on the Cibeureum and the Cidurian rivers, the 10-day mean daily discharge at Cilawang dam site and Buyut weir site will be estimated on the basis of the well arranged daily discharge data at Rangkasbitung gauging station from 1972 through 1983. Also the runoff-depth ratio calculated from the annual rainfall and catchment loss together with its catchment-area ratio will be taken into account.

(d) Spillway inflow design flood

PMP-type rainfall will be used for the design storm rainfall to estimate the spillway inflow design flood at each proposed dam site. Hershfield's PMP approach will be employed for the analysis with storm rainfall data at principal rain gauge stations in and arund the Ciberang and the Cibeureum river basins.

Six gauging stations are selected for analysis, where annual series of maximum daily rainfall data are available for fairly long observation periods of around 25 to 30 years. The point PMP referring to these stations, in terms of daily rainfall, are calculated by Hershfield's approach in the range between 490 and 720 mm.

The highest recorded storm rainfall among these six stations are reported to have occurred in different months or years. The estimated PMP above may be expected not to occur in the same date. Accordingly, considering the effective area assumed for each gauging station, the weighted average point PMP for the objective catchments are estimated at 610 mm with application of Thiessen polygon. The estimated PMP of 610 mm will be used as the point PMP for both the Ciberang and the Cibeureum basins.

The estimated point PMP of 610 mm is higher than the experienced highest daily rainfall of 340 mm in the upper Ciujung basin at Sampang Peundeuy by 80% and those of 475 mm in the Banten region (BMG) at Mandalawangi and Cigeulis by 28%.

The catchment PMP for Karian and Cilawang dam sites will be estimated by applying the area-reduction factor of 0.82 and 0.92 to the above PMP-value of 610 mm respectively, which are derived from the storm rainfall depth-area curve on the July 1939 storm over the Malang area, East Java. Thus the catchment PMP, in terms of daily rainfall, are estimated at 500 mm for the Karian catchment and 570 mm for the Cilawang catchment.

Based upon the observed hourly rainfall data at P3SA's automatic rain recorders during the 1981 November storm, the hourly distribution of the design storm rainfall is assumed to have a rainfall duration of eight hours with a peak rainfall in the middle as shown in Fig. 3-5.

The PMFs for Karian and Cilawang dam sites will be estimated on the basis of above-mentioned design storm rainfalls employing the storage function method. The estimated PMFs will be used as the spillway inflow design floods.

Thus the peak spillway inflow design floods for the Karian and the Cilawang dams are estimated at 3,400 m^3/sec and 1,700 m^3/sec respectively, which correspond to around the Creager 90 floods. Corresponding specific discharge are estimated at 11.8 $m^3/sec/km^2$ and 18.3 $m^3/sec/km^2$ respectively.

(e) River maintenance flow

The river maintenance flow will be defined as the required river discharge at the time of drought flow, which is retained in view of maintaining the normal function of river such as the river transportation, fisheries, prevention of salinity intrusion and estuary blockage, protection of river control facilities, maintenance of water quality and groundwater table, preservation of animals and plants, and scenic view.

In any water resources development plan, the river maintenance flow will have to be taken into account together with relevant irrigation and other water utilization right.

It is difficult to define the commonly applicable amount of river maintenance flow clearly, however, in most cases it would be desirable to guarantee the flow corresponding to the 10-year average of 355-day discharge or to the specific discharge of around 1 m^3/sec per 100 km^2.

The river maintenance flow at each dam and intake site in this study will be estimated as follows:

- Pamarayan weir

The river maintenance flow at the Pamarayan weir will be estimated considering the aforementioned normal function of the river and the discharge data in the low-water stage.

The 355-day discharges at Kragilan gauging station, during eight years of observation in 1970 and from 1972 through 1978, lie in the range between 2.40 m^3/sec and 31.40 m^3/sec

(Ref. Appendix-B). It will be considered to be the sum of the actual discharge from the Pamarayan weir and the local inflow downstream thereof. In other words, above figures will include some amount of river maintenance flow presently discharged from the weir, if any.

Accordingly, taking the average of observed 355-day discharge into account, the river maintenance flow at the Pamarayan weir will be estimated at 9.70 m^3/sec. The specific discharge will be 0.67 m^3/sec per 100 km^2.

- Other dam and intake sites

The river maintenance flow at Karian, Cilawang dam sites and Buyut, Cicinta intake sites will be estimated in the same way, however, discharge data at Rangkasbitung gauging station will be used for the estimation.

The 355-day discharges at Rangkasbitung gauging station, during twelve years of observation from 1972 through 1983, lie in the range between 3.80 m^3/sec and 43.30 m^3/sec (Ref. Appendix-B). The lowest 5-year data lie in the range between 3.80 m^3/sec and 14.50 m^3/sec, and the next 5-year data between 17.20 m^3/sec and 32.80 m^3/sec.

Taking account of the average of 355-day discharges for the lower ten years, the river maintenance flow will be estimated at 3.50 m^3/sec at Karian dam, 1.10 m^3/sec at Cilawang dam, 1.40 m^3/sec at Buyut intake and 0.40 m^3/sec at Cicinta intake. The specific discharge will be 1.20 m^3/sec per 100 km^2.

(f) Sedimentation

- Sediment rating curve

A series of measurement of suspended sediment load were previously conducted by P3SA on the Ciberang river at Sajira gauging station. The results of measurement are shown in

Fig. 3-6 with a sediment rating curve which is derived from the measurement data as follows:

$$Q_S = 12.296\, Q_W^{1.387}$$

where,

Q_S : Suspended sediment load in ton/day

Q_W : River discharge in m^3/sec

- Sediment transport

The annual mean discharge at Sajira gauging station is estimated at 26.26 m^3/sec based on the discharge data at Rangkasbitung gauging station. The corresponding suspended sediment discharge is estimated at 1,144 ton/day on the sediment rating curve in Fig. 3-6. Thus the specific annual suspended sediment transport at Sajira (C.A. 244 km^2) will be estimated at 1,711 ton/km^2.

The bed load is reported commonly to lie in the 5 to 25% range of the suspended load. Accordingly the bed load is assumed to be 10% of the suspended load, i.e. 171 ton/km^2 annually. Thus the total specific sediment transport into the reservoir will be estimated at 1,882 ton/km^2 annually.

- Sediment trapped in reservoir

From the storage capacity and the annual inflow at each proposed dam, the capacity-inflow ratio will be calculated at around 0.25 for both dams. Applying this ratio to Brune's reservoir trap efficiency curve, the trapped specific suspended load for each dam will be estimated at 1,625 ton/km^2 annually.

Thus the total specific sediment load trapped annually in the reservoir will be estimated at around 1,800 ton/km^2, which will be given as the sum of the trapped suspended load of 1,625 ton/km^2 and the bed load of 171 ton/km^2.

- Storage volume occupied by sediment

Generally the specific weight of settled sediment will vary with the age of deposit, with an average of about 1.0 ton/m^3 for fresh sediment and about 1.30 ton/m^3 for old sediment. Assuming the specific weight of settled sediment at 1.10 ton/m^3, the specific volume occupies by settled sediment will be estimated at around 1,700 m^3/km^2 annually.

Thus the storage volume occupies by 100-year sediment transport in the proposed reservoirs will be estimated at about 49×10^6 m^3 for Karian dam and 16×10^6 m^3 for Cilawang dam.

3.3 Socio-economy

3.3.1 Administration

The study area for this socio-economic study is defined as a jurisdication of whole or a part of Kabupatens (Kab.) of Serang, Lebak and Pandeglang, taking account of the catchment of the relevant rivers and the prospective beneficiaries of this water resources.

The administrative district of the study area covers 39 Kecamatans or 523 Desas including overall 26 Kecamatans in Kab. Serang, 10 out of 15 Kecamatans in Kab. Lebak and 3 out of 16 Kecamatans in Kab. Pandeglang, as well as the capital town of each Kabupaten: Serang, Rangkasbitung and Pandeglang. The boundary of this study area is shown on Fig. 3-7 Administrative Division. It holds a land area of 3,623 km^2, equivalent to about 8% of that in West Java Province (Ref. Appendix-A, Chapter II).

3.3.2 Population

According to the last population censuses in 1961, 1971 and 1980, the population in the study area was rapidly increased by 2.75% per annum between 1971 and 1980, and reached to about 1.65 million or 6% of that in West Java. Besides urbanization in Serang, Rangkasbitung,

Pandeglang, Cilegon and Merak as the administrative, commercial and/or industrial centers, more than 90% of the total population resides in rural area. Such growth, however, is deemed so excessive and requested to slow down to 2% per annum by the end of REPELITA IV for sake of sustainable growth of the national economy (Ref. Appendix-A, Chapter III).

Assuming from the working trend in Banten region, the current labour force in the study area seemed some 510,000 (male 350,000 and female 160,000), in which 500,000 is in employment including 330,000 in agriculture sector. As indicated in REPELITA IV, the regional economy is facing many labour problems i.e. unskilled and unfavourable quality of manpower and underemployment. Because of the existing majority of under 20 years of age in population, further expansion of labour-incentive industrial sector and educational approach to the labour force are urgently required.

3.3.3 Infrastructure

(1) Transportation and communication

Transportation in the study area depends mainly on roads, comprising 73 km of national roads, 125 km of provincial roads and some 600 km of regional and canal inspection roads.

As an artery to connect Java and Sumatra, a two-lane national road runs between Jakarta and Merak across the norther part of the area passing through the major towns of Serang and Cilegon. In addition, the construction of a new highway as a part of "Asian Highway" is now progressing in parallel with this route to improve the current traffic congestion.

A network of provincial and other smaller roads are also available. The former of about 125 km long with well-maintained asphalt pavement is stretched between Cilegon and Anyer; from Serang to Bogor through Pandeglang and Rangkasbitung; and some more extents from Pandeglang and Rangkasbitung to the Southern Banten. The latter, however, is generally

poor in its condition and not well functioning for the total road network in the area.

A single-lane railway runs from Jakarta to Merak via Rangkasbitung, Serang and Cilegon with some branches to Labuan through Pandeglang and to Anyer. Besides the roads, this railway is also an essential means for routine cargo and inhabitants' daily traffic.

Among a number of large and small seaports, Merak is the most active ferry liner terminal as the gate to Sumatra. Cigading and other neighbouring ports are well facilitated for handling of fuel, raw materials and products of PT. Krakatau Steel and others in Cilegon. Banten is a small port along with shallow Banten bay and yet useful for domestic lumber transport and fishery.

The communication system in the study area is still primitive and the telephone sets fiffuse merely in some urban areas for office and commercial uses (Ref. Appendix-A, Section 4.1).

(2) *Electric power supply*

In the study area, there is no hydropower station but a modern giant thermal power station with final output of 2,800 MW under staged construction in Suralaya. The Public Corporation of Electricity (PLN) has been distributing the power to some limits of major towns and these vicinities through a Bogor-Rangkasbitung-Pandeglang-Serang 70 kV power transmission line. In addition, small diesel power plants are available for some rural isolated electrification.

Other than the above public utilities, a variety of large and small private facilities have been prevailing, from 400 MW power station of PT. Krakatau Steel to portable individual power supply (Ref. Appendix-A, Section 4.2).

(3) Water supply

The towns of Serang, Pandeglang and Rangkasbitung have their own piped water supply systems out of dug well, spring and river. As well, town of Cilegon and PLN Suralaya complex have the same diverted from PT. Krakatau Steel who owns an independent total facility including Cidanau dam, pipeline, raw water reservoir, Krenceng treatment plant and distributions.

Besides, there is no particular water supply system in rural area, except hand-operated pumping performances for each communal faucet. Thus and so, the current situation is still open to a considerable improvement both qualitywise and quantitywise (Ref. Appendix-A, Section 4.3).

(4) Tourism

For the epoch of tourism, the historical ruins and temples are sited near to Banten port and a variety of sand beach resort facilities are located in Anyer and Merak (Ref. Appendix-A, Section 4.4).

3.3.4 Industries

In the northwestern coastal zone, there are typical modern manufacturing industries such as PT. Krakatau Steel Works in Cilegon, PT. Satya Raya Indah Woodbased Industries in Anyer, Pertamina Petrochemocal and PT. Statomer PVC Resin in Merak. The Cilegon Industrial Estate has enough space with public utilities and is ready for the prospective expansion. Many other small scale manufacturing industries including brick, tile, sawmill, food processing, bamboo and wood handicraft are scattered in various locations of the study area.

In parallel with the progress of heavy manufacturing industries and infrastructures, the sectors of construction and transportation have been widely expanding in recent years. Except agriculture as the prime industrial sector in the study area, trade and service sectors such as wholesale, retail, restaurant and others are still sharing rather bigger portion under closed relation with the inhabitants and community.

In the field of industrial sectors, this project will directly fill a role for development of agriculture and industrial water supply, and more likely contribute to expand these labour-incentive food processing, home-industries, trade and services (Ref. Appendix-A, Section 4,5).

3.3.5 Economic Indices

Since no direct information to exactly cover the study area is found available, the most equivalent and reliable trends and indicies are interpolated on the basis of Banten region. Whereas, Banten region covers the whole of the relevant 3 Kabupatens and shares 1.5 times in population and 2.1 times in territory of the study area (Ref. Appendix-A, Sections 5.1 and 5.2). Banten region expresses GRDP of Rp. 489 billion in 1982 at current price, which corresponds to 4,3 times in nominal growth and average real growth rate of 10.6% per annum for the past 7 years between 1975 and 1982. Comparing with those in the Province of West Java and Indonesia for the same period, they are faster in nominal growth respectively as 4.4 times and 4.7 times, but rather lower in average real growth rate as 8.5% and 7.0%. It appears, in the national economy, likely that Banten region had been started from far behind of the provincial and national levels, and the trend in price increase is more advancing in such province and whole country than in Banten region.

In view of industrial origin, a remarkable progress in Banten region both in growth rate and share has been achieved by most of the industrial sectors and infrastructures with a mere exception of agriculture in declining pace. Such tendency coincides with those in the province and country. Nevertheless, because of these irregularly high shares by agriculture as 35.8% in GRDP for 1982, about 66% among the labour force in employment and 70% among the households in this case of Banten region or the study area, it cannot expect much of sweeping improvement of all sectors and utmost exertion would be required for attribution of high productivity to agricultural sector.

As similar to the above, the debate continues about promotion of the regional potential and industrial structure from reviewing the per capita regional income. That is, during the period of 1975 to 1982, the real growth rate of per capita income in Banten region was 8.1% per annum and so higher than 5.9% in West Java and 4.3% in whole Indonesia. Despite such encouraging signs, the figures of Banten region for 1982 indicate, in comparison with (a) the Province of West Java and (b) the whole Indonesia, still low with handicap as 84% of (a) and 81% of (b) at 1975 constant price and 83% of (a) and 56% of (b) at current price respectively.

3.4 Rivers

3.4.1 General

The principal rivers in the Project area are the Ciujung, the Cibeureum and the Cibanten rivers as shown in Fig. 3-8. The Ciujung river occupies the major portion of the Project area, followed by the Cibeureum and the Cibanten rivers. Brief explanation will be given in the following.

3.4.2 Ciujung River

(1) General outline

The Ciujung river is the largest river in the Project area with a catchment area of 1,850 km^2 and an average annual runoff of 3.35 billion m^3 on its estuary. In the upstream basin, it splits into three main tributaries at Rangkasbitung where the catchment area comes to 1,383 km^2 comprising 594 km^2 for the Upper Ciujung, 331 km^2 for the Ciberang and 458 km^2 for the Cisimeut river basins.

Since 1918, its river water has been used for the Ciujung irrigation scheme which commands 24,400 ha of paddy field extending on both banks of the lower Ciujung river.

Flood outflows from split three main tributaries in the upstream basin have afflicted the area in and around Rangkasbitung with frequent damage, whereas the area along the lower Ciujung river has experienced almost routine flood due to gentle gradient and meager flow capacity of the river.

The lower reaches of the Ciujung river have already been provided with dykes, of which some sections were recently improved by PROSIDA. However, the rest of the Ciujung river has no special provision for flood mitigation except a few groynes on some places.

(2) Present condition

The configuration of the Ciujung river and its major tributaries are shown in Fig. 3-9 and Table 3-7. The present condition of the Ciujung river will be briefly described as follows:

- The river section from the estuary to Kragilan has already been provided with dykes on both river banks. Recently the additional river improvement works were completed by PROSIDA with the design flood discharge of 1,100 m^3/sec.

- In the river section from Kragilan to the Pamarayan weir, the embankments of left and right primary canals for the Ciujung irrigation scheme form the boundaries of flooded area stretching along the river. Small tributaries joining to the main stream, especially the Cikambuy river with a catchment of 48 km^2, have troubles of interior inundation. A remarkable river bend exists about 3 km upstream from the Kragilan bridge, which has resulted in some collapse of river bank.

- In the river section from the Pamarayan weir to Rangkasbitung, sedimentation is remarkable on the riverbed upstream from the Pamarayan weir, which may aggravate the flood water stage. Many meanders exist in the upper reaches of this section, which have resulted in collapses of river bank. The configuration of the confluence with the Ciberang river is intricate, leading to collapses along downstream river bank.

- The city of Rangkasbitung, which is located by the confluence of the Ciberang and the Upper Ciujung rivers, has frequently been afflicted by joined flood outflow from the upstream tributaries. Some short cuts have already been provided on large river bends of the Ciberang and the Ciujung rivers around Rangkasbitung to protect the city.

- Some groynes and bank protections are provided on the Ciberang and the Upper Ciujung rivers near Rangkasbitung to stabilize the river channel or to protect the road and village yard.

- The Pamarayan weir was completed in 1918 to divert the river water into the Ciujung irrigation scheme. The weir has a total crest length of 160 m with 10 gates of 12 m in span and 6 m in height. During the flood in November 1981, the gate hoists were operated by manpower, however, they were motorized with diesel engin e driven generator in 1982. Severe bank erosion and scouring in the river section directly downstream from the weir were recently improved by PROSIDA.

- Sand in the riverbed of the Ciujung river has been gathered for construction materials which has shown an increasing prospect recently. The volume of gathered sand has amounted to about 120,000 m^3 annually in the river section around Kragilan and Rangkasbitung.

3.4.3 Cibeureum River

The Cibeureum river is a tributary of the Cidurian river. It has a catchment area of 255 km^2 at the confluence with the Cidurian river.

In the Cibeureum basin, the upland crop field occupies and area of 135 km^2 corresponding to 53% of the basin area, the wet paddy field has an area of 43 km^2 or 17% of the basin area, the forest has an area of 11 km^2 or 4% of the basin area, and the rest of 66 km^2 or 26% of the basin area belongs to plantation, shrub and grass land.

The Cilawang dam site and Buyut weir site are located in the central part of the river basin, occupying the catchment areas of 93 km^2 and 117 km^2 respectively.

3.4.4 Cibanten River

The Cibanten river is located in the north-western part of the Project area with a medium scale catchment of 183 km^2. It rises in the foothills of Gunung Karang and flows down by west of Serang northwards to Banten Bay with an annual runoff of about 153 million m^3.

Its river water has been used for the Cibanten irrigation scheme since 1931, which commands an area of 2,200 ha in the wet season, however, declining to about 420 ha in the dry season due to shortage of river flow.

The Cibanten river flows down through a small valley upstream from Serang. Whereas, in downstream reaches, the low-lying farmland extending on both banks of the river has frequently suffered from flooding. Recently the lower reaches were improved with dyking for about 6 km. The design flood discharge is reported to be based on 25-year return period.

The possibility of providing a reservoir on the Cibanten river was investigated in the Master Plan study, however, the result was in the negative because of a small storage capacity of the expected reservoir and poor runoff of the river.

3.5 Land Use and Agriculture

3.5.1 Introduction

The agricultural condition is discussed in the following paragraphs majorly in terms of 14 Kecamatans listed below. The total area of Kecamatans concerned is 911 km^2.

Kecamatans Related to the Project

Kaseman	Kragilan	Carenang	Bojonegara
Kramatwatu	Cikande	Pamarayan	Kopo
Ciruas	Pontang	Cikeusal	
Walantaka	Tirtayasa	Cilegon	

3.5.2 Present Condition of Agriculture

(1) Demographic resources

The total population of Kecamatans concerned is about 592,760 in 1983. The population growth rate between 1980 and 1983 is estimated at 1.5% per annum. The population density is about 650 persons/km^2. The average family size is estimated at 5.0 persons/family. About 85% of the total households are agricultural households, of which about 75% of the farms are owner cultivators, 3% are tenant farmers, and 22% are landless farmers.

(2) Present land use

The present land use survey was made on areas of about 55,600 ha based on the land use map prepared by the Directorate of Agrarian in 1978. Area of each land category is shown in the next table.

Land use category	Area (ha)	Proportional Extent (%)
Residential areas	2,330	4
Paddy fields	36,700	66
Garden	7,140	13
Upland fields	1,940	4
Forest land	390	1
Plantation land	120	-
Grass land	580	1
Fishponds	6,370	11
Total	55,570	100

The survey area is economically utilized to the maximum extent. No idle land is observed in large scale. The major land use is paddy fields (66%) followed by garden (13%) and fishponds (11%). Upland fields and grass land are very limited.

(3) Present Cropping Pattern

The major crop of the study area is lowland rice followed by palawija crops such as maize, chilly, groundnuts, sweet potato and peas. Fruit trees like banana, mango, rambutan, coconuts, etc. are planted around houses.

Almost all the lowlands are planted with paddy in the wet season. Double or year-round cropping of paddy are prevalent where irrigation water is available. In Ciujung irrigation scheme, about 59% (14,280 ha) of the land is estimated to be used for second paddy and 2% (480 ha) for the year-round rice cultivation. However, as many as about 30% (7,260 ha) are left fallow after 1st paddy due to lack of irrigation water. About 2,180 ha (9%) are planted with palawija crops and vegetable after wet season paddy. In Cicinta irrigation scheme, about 93% (1,330 ha) of the land are left fallow in dry season because of irrigation water shortage.

In rainfed paddy fields, major parts of the land are left fallow after wet season paddy. But very limited parts of the fields are devoted to the second paddy making good use of seasonal rainfall distribution. In K-C-C area, 87% of the rainfed paddy fields are not used in dry season, while 7% are planted with 2nd paddy and 6% are with palawija and vegetables making use of the residual moisture in the ground.

On the uplands, many types of cropping pattern combining different upland crops are distinguished. In most cases, 1 - 3 cropping per year are practiced. Cropping intensity is calculated at 168%. The details of the cropping sequences in the lowland paddy field are presented in the following table.

Present Cropping Sequences in Lowland Paddy Field

(Unit: %)

Cropping Sequences	K-C-C Area		Cicinta Area	Ciujung Area
	Irrigated Area	Rainfed Area	Irrigated Area	Irrigated Area
A. Paddy-Paddy-Paddy	-	-	-	2
B. Paddy-Paddy-Vegetables	-	-	-	2
C. Paddy-Paddy-Fallow	100	7	7	57
D. Paddy-Palawija-Fallow	-	2	-	1
E. Paddy-Vegetables-Fallow	-	4	-	8
F. Paddy-Fallow	-	87	93	30
Cropping Intensity	200	113	107	173

Source: Agricultural Office of Kabupaten Serang, 1982
Sample Survey

The first paddy starts at the onset of wet season usually in October to December, and harvested in April to June depending upon a variety used. The second crop starts following the harvest of the 1st crop and ends in September.

(4) Farming practices

There are 3 kinds of paddy cultivations in the study area, namely, wet season paddy, rainfed paddy and dry season paddy cultivations.

The wet season paddy cultivation is adopted transplanting seedling in the low lands when enough water is available in the fields. If the water is not enough and the transplanting time is limited, the rainfed rice cultivation is applied transplanting seedlings in water-unsaturated fields. Dry season paddy cultivation is carried out in most cases with irrigation.

The prevalence of high-yielding varieties is very high, i.e. 90% in area. The major variety is Cisadane variety occupying 37.6% of the lands planted in Kabupaten Serang followed by PB(IR) 36 (17.3%).

Fertilizer is applied usually 3 times; one day before transplanting, 3 to 4 weeks after transplanting and 7 to 8 weeks after transplanting. In 1983/84 crop season 124 kg of urea and 73 kg of T.S.P. per ha are applied on an average in Kabupaten Serang.

Insect pest control is conducted spraying Diazinon against stem borers and bugs when in most cases symptom of damage are observed. Zinc phosphate is widely used as rodenticide.

Maize is usually planted in upland after rainfed paddy or groundnuts. Urea is applied basically at the rate of 100 to 150 kg/ha, sometimes with compost or green manure. Pest controls are conducted when damaged. Major varieties are Metro and Harapan.

Groundnuts are grown in lowlands as well as uplands. In uplands groundnuts are planted after rainfed rice or maize in most cases. Sometimes groundnuts are intercropped with maize. Fertilizers are applied at a rate of 25 kg urea/ha on an average as a basal dressing.

Soy beans and mung beans are the new crops to the farmer and are economically minor in the study area.

(5) Crop production

The most important crop in the area is paddy (53,700 ha in 1983) followed by groundnuts (10,900 ha), chilly (3,600 ha), cassava (2,800 ha), maize (1,600 ha), and sweet potato (1,600 ha) in recent years. The harvested area of paddy did not exceed 57,400 ha in recent years which seemed to show that lands suitable for rice growing have already been fully developed for the rice growing and no substantial increase in the area could not be expected unless additional large irrigation facilities will be built in less suitable areas such as undulating hilling lands. The present paddy yield with irrigation is 3.7 ton/ha and that without irrigation is 2.7 ton/ha. Rice yields in demonstration farms were obtained from the results in Kecamatan Cikande. From the total planted area of about 830 ha, the average yields were 6.6 ton/ha for the wet season growing and also 6.6 ton/ha for the dry season growing.

Serang is the most important groundnut producing area in West Java. The intensive groundnut growing is found in Kecamatan Bojonegara where well drained sandy soils are developed. The unit yield of groundnuts was 0.73 ton/ha in 1983.

Chilly is the second important palawija crop and source of cash for farmers in the area. The major producing area is the Kecamatan Cikande having 2,025 ha of harvested area in 1983. Cikande has large area of well drained sandy soils, which is suitable for this crop. The unit yield of the crop was 1.8 ton/ha in 1983.

Onion is a minor crop in Kabupaten Serang. In 1984, 1,616 tons of red onion was harvested from 350 ha. The unit yield was 4.6 ton/ha.

(6) Livestock production

Chickens, goats, sheep, carabaos and ducks are the major livestock in the study area.

Carabaos are kept for draught work (land preparation), for security in times of financial needs and for milk sources. Goats and sheep are grown for cash source by selling them to the local meat markets. Chickens and ducks are major source of proteins (eggs and meat) and are sold to the market when cash is needed. Numbers of livestock in the related Kecamatans in 1983 were 36,700 ton carabao, 79,500 ton goats and sheep and 36,800 ton chicken.

The average number of livestock per agricultural household is 0.35 heads for carabao, 0.77 heads for goat/sheep and 3.56 heads for chicken. The carabao population density is 1.13 heads/ha of paddy field. According to results of socio-economy survey conducted by local governments in 1984, the average livestock production per agricultural household per year is 0.16 heads for carabao, 0.37 heads for goat, 0.12 heads for sheep, 1.9 heads for duck and 3.9 heads for chicken.

3.5.3 Present Condition of Agro-economy

(1) Land holding and farm household

An average farm size in the study area is very small. According to the 1983 agricultural census, the average farm size is 0.61 ha/ household comprising 0.17 ha of irrigated paddy field, 0.22 ha of rain-fed paddy field and 0.22 ha of upland fields. The distribution of farm household by farm size is shown in the next table,

Farm Size (ha)	Percent Distribution (%)
0 - 0.04	8.3
0.05 - 0.09	4.5
0.10 - 0.24	16.4
0.25 - 0.49	28.5
0.50 - 0.74	17.1
0.75 - 0.99	7.5
1.00 - 1.99	12.8
2.00 - 2.29	3.0
more than 3.00	1.9
	100.0

The total number of farm household in the study area was 106,173 showing 85% of the total households in 1983. The average family size is estimated at 5.0 persons, in which 2 to 2.5 persons can work for agricultural practices.

Tenant farms occupy very small portion (about 3%) of the farm households. However, the existence of many landless labourers, about 22% of the total agricultural households, shows the wide prevalence of latent land tenancy system.

Favoured by the nearness to the largest city and plantation areas, Jakarta and Lampung, where much employment opportunity exists, many farmers go out of the area to find the additional sources of income during off-farm season such as between transplanting and harvesting seasons of paddy.

(2) Market and price of farm products and inputs

Paddy is a main farm products and is self-sufficient in the study area. There are 3 channels of rice marketing for producers (farmers) i.e. KUD, broker and millers. The paddy collected by KUD is sold to DOLOG after milling, while paddy collected by broker or millers is transported to rice deficient areas such as Jakarta. The handling share of surplus paddy by KUD is estimated at 10% (about 40,000 tons in paddy rice).

In Kabupaten Serang, there are some agricultural products which are not self-sufficient in the area. According to a interview to officials of Serang public market, red onion, chili and chicken meat are most deficient as shown below.

Name of farm products	Self-sufficiency (%)	Outside source
Red onion	15	Brebes
Chili	25	Lampung
Chicken meat	20	Jakarta, Bekasi

Production of paddy rice in the study area was approximately 200,000 tons in 1983, in which about 100,000 tons was estimated to be locally consumed and the remaining 100,000 tons to be exported to outside markets, Serang city, Jakarta, etc.

Red onion production in Kab. Serang was only 1,600 tons (1983), filling only 15% of the whole consumption (11,000 tons). The remaining 9,400 tons are brought from Brebes in Central Java, situated 400 km away from Serang city.

The prices of main farm products at the Serang public market are shown below.

Wholesale Prices of Main Crops

		1980	1981	1982	1983	1984
Paddy	(Rp/kg)	120	120	120	120	150
Groundnuts	(Rp/kg)	700	700	750	800	900
Red onion	(Rp/kg)	600	600	600	600	750

Consumer prices are mostly in the range of 1.3 to 2.0 times compared with producer prices as shown below.

Difference in Producer/Consumer Price (1984)

	A Farm price (producer price)	B Retail price (consumer price)	B/A
Paddy (Rp/kg)	100	180	1.8
Groundnuts (Rp/kg)	600	1,200	2.0
Red onion (Rp/kg)	700	900	1.3

Paddy seeds of improved varieties are distributed by KUD, however, only 10% of the farmers purchase the paddy seeds through KUD. Most farmers use seeds from other farmers or self-supplied ones. As for groundnuts, farmers use exchanged seeds from other farmers or self-supplied ones, just like the case of paddy. Seeds of vegetables are dealt with by local private dealers.

Distribution of fertilizers are carried out mainly by PT. PUSRI, and agro-chemicals and some farm machinery are distributed by PT. PERTANI. These companies are the semi-government corporations. After PT. PUSRI or PT. PERTANI, these farm inputs are distributed to farmers through KUD, Kios and local private dealers. The retail prices of agro-chemicals supplied by official route are decided by the Government.

The prices of major farm inputs through government channel are shown below.

Official Prices of Agricultural Requisites

(November 1984 KUD)

	Unit	Rp./unit	Remarks
Paddy Seed	kg	300	Cisadane IR Varieties
Fertilizers	kg	100	All the same price UREA, TSP, KCL
Agro-chemicals			
Diazinon	ℓ	1,500	Insecticide
Sevin	kg	1,500	
Zinc Phosphate	kg	6,000	Rodenticide
Klerat	kg	750	

Agricultural labour charge is from Rp. 1,000 to 1,500/day excluding meals equivalent to about Rp. 750/day. The total cost is from Rp. 1,750 to Rp. 2,250/day.

(3) Agricultural support services

Kab. Serang has ten agricultural service stations (BPP), 2 specialists (PPS), 22 middle class experts (PPM), and 107 service workers (PPL).

There are 7 district extension offices (BBP) in the study area.

Agricultural policies and new farming technologies are delivered to common farmers by PPLs through advanced farmer's groups. An advanced farmer's group consists usually of a key farmer, 20 progressive farmers and 60 - 80 common farmers. An advanced farmer's group is visited bi-weekly by a PPL.

This farmers group, "Kolonpok Tani", composed of 80 - 100 farmers, is registered in an extension office by the name of a key farmer.

Main activities of extension services are concerned with technical intensification programs for paddy cropping, Bimas and Inmas programs. The areal coverage of the paddy intensification programs in the study area had been below 60% until 1981, however, it extraordinarily increased to 86% in 1982 and to 88% in 1983.

The agricultural extension for the study area is much restricted by limited manpower (1,200 ha/PPL), bad road condition and insufficient transportation means for a PPL such as a motorcycle. About 15% of PPLs have purchased motorcycles at their own expenses.

Agricultural credit is loaned through the Indonesian People's Bank (BRI) to farmers. There are 2 branch offices and 20 sub-district branch offices (BRI Unit Desa) in the study area.

Three kinds of credit are available; namely, short-term, medium-term and long-term. The BIMAS credit is a short-term credit with an interest of 1%/month and 7 month loan period. The BIMAS loan released and repaid in Kabupaten Serang from 1976 to 1982 is shown below.

BIMAS Loan Released and Repaid in Kab. Serang

(1976 - 1983)

(Unit: Rp. x 1,000,000)

Year	Loan Released	Loan Repaid	Percent of Repayment
1976	376	223	59%
1977	786	434	55
1978	681	313	46
1979	549	241	44
1980	664	268	40
1981	828	188	23
1982	1,926	108	6
1983	657	46	7

The average amount of the loan given to a farmer was Rp. 28,990/ha in 1982 and Rp. 9,880/ha in 1983. These amounts are not enough to fill the standard package of farm inputs for paddy growing, Rp. 42,000/ha for high-yielding varieties and Rp. 29,500/ha for local varieties.

Inmas credit for individual farmer by KUD is limited to Rp. 20,000/ha.

Credits given to individual farmer in Bimas/Inmas programs are stopped in 1984 in Kabupaten Serang due to very low repayment rate. The credits are given to farmer's groups.

There were 50 KUD Cooperatives and 83 non-KUD Kios Cooperatives having 7,261 and 15,953 members', respectively in Kab. Serang in 1982. These correspond to 5% and 10% of the total farm households in Kab. Serang. The activity of KUD is not so high.

The shares of KUD in major activity are estimated 10% for sales of seeds, 30% for sales of fertilizer and insecticide, 10% for collection of harvested paddy and 10% for Inmas credit.

(4) Farm economy

Present crop budgets of paddy, groundnuts, red onion, chili, string bean and cucumber are studied to identify profitability of them. Crop production costs are analyzed breaking them into several items, i.e. farm inputs, (seeds, fertilizers, agro-chemicals), labour, interests on credits, tax, water charge, etc. The most important criteria for the profitability of cropping to farmers is a net household income which is the practical income including family labour charge. The net household income by each cultivation crop is estimated at:

Rp. 246,080/ha for irrigated paddy
Rp. 158,910/ha for rainfed paddy
Rp. 360,900/ha for irrigated groundnuts
Rp. 294,900/ha for rainfed groundnuts
Rp. 1,814,160/ha for red onion
Rp. 672,880/ha for chili
Rp. 139,250/ha for string bean
Rp. 836,020/ha for cucumber

The details are shown in the following table.

Net Household Income by Crop Cultivation

	Paddy/2	Ground-nuts/2	Red onion	Chili	String bean	Cucumber
A. Production cost	397,520	299,900	1,401,840	189,120	230,750	159,980
A = A + b (Rp./ha)	384,690	299,900				
a. Family labour cost/1	273,600	156,800	416,000	112,000	120,000	96,000
	273,600	156,800				
b. Cash inputs	123,920	143,100	985,840	77,120	110,750	63,980
	111,090	143,100				
B. Yield (kg/ha)	3,700	840	4,000	1,500	2,500	9,000
	2,700	730				
C. Farm gate price (Rp./kg)	100	600	700	500	100	100
	100	600				
D. Gross production value	370,000	504,000	2,800,000	750,000	250,000	900,000
D = B x C (Rp./ha)	270,000	438,000				
E. Net income	-27,520	204,100	1,398,160	560,880	19,250	740,020
E = D - A (Rp./ha)	-114,690	138,100				
F. Net household income	246,080	360,900	1,814,160	672,880	139,250	836,020
F = D - b or E + a (Rp./ha)	158,910	294,900				

Remarks: /1 : Estimated at 80% of total labour cost.
Unit price is Rp. 2,000/man-day

/2 : Above : Irrigated paddy field
Below : Rainfed paddy field or upland

Present farm household income and expenditure of a typical farm in the study area is worked out based on the average holding size, cropping pattern, crop budgets, non-agricultured income and living costs. The total disposable household income is estimated at Rp. 376,320 consisting of Rp. 226,320 from cropping and Rp. 150,000 from non-agricultured section. Living costs are estimated at around Rp. 370,000.

Calculation of Disposable Income

1. Holding Size	
Irrigated paddy field	0.17 ha
Rainfed paddy field	0.22 ha
Upland field	0.22 ha
Total	0.61 ha
2. Cropping Ratio	
Irrigated paddy	162% of irrigated paddy field
Rainfed paddy	107% of rainfed paddy field
Upland crops in irrigated field	11% of irrigated paddy field
Upland crops in rainfed paddy field	6% of rainfed paddy field
Upland crops in uplands	168% of uplands
3. Planted Area	
Irrigated paddy	0.28 ha
Rainfed paddy	0.24 ha
Upland crops irrigated	0.02 ha
Upland crops rainfed	0.38 ha
4. Net Household Income by Cropping	Rp. 226,320
5. Non-agricultured Disposable Income	
150 man-days/year x Rp. 1,000/man-dya	Rp. 150,000
6. Total Disposable Income	Rp. 376,320

Remark: Upland crops are represented by groundnuts.

3.6 Existing Irrigation and Drainage Conditions

3.6.1 General

In and around the Project area, there exist 93,000 ha of paddy fields of which 62,000 ha are irrigated and 30,320 ha are rainfed. The major portions of the irrigated paddy fields, 24,200 ha (39%), are occupied by the Ciujung irrigation scheme which is located in the Kabupaten Serang. The other notable irrigation schemes are the Cibanten scheme of 2,200 ha, Ciwaka scheme of 1,560 ha, Cicinta scheme of 1,430 ha and Cisangu scheme of 1,441 ha (Fig. 3-10). Out of these irrigation schemes, the Ciujung and Cicinta schemes will receive irrigation water for the Karian and Cilawang reservoirs under this Project.

There are two types of irrigation schemes; DPU and non-DPU irrigation schemes. The former has permanent irrigation facilities which are operated and maintained under the direction of the Provincial Public Works Department (DPU). The latter has temporary irrigation facilities handled by local Government (PU Desa). These schemes are ranked as technical, semi-technical or simple depending on the quality of irrigation facilities. At present, there are 13 technical, 35 semi-technical and 23 simple irrigation schemes in and around the Project area.

Major water source for irrigation is the Ciujung river. About 43,100 ha of paddy fields, or 70% of the whole irrigated paddy fields, depend their irrigation water on the Ciujung river. Other water sources are the Cibeureum, Ciwaka, Cibanten and Cidanau rivers. The command areas of these rivers amount to about 7,900 ha. Due to limited discharge in these river particularly in the dry season, however, the irrigation area for dry season paddy is limited to about 25,300 ha, or about 40% of the whole irrigation area of 62,700 ha.

The DPU responsible for the operation and maintenance of technical, semi-technical and simple irrigation schemes. In all the schemes, the operation and maintenance staff are limited and insufficient money are

expended on maintenance of the schemes; Rp. 5,500 (US$5.2) per hectare, which includes wages of all the operation and maintenance staff, materials, equipment, labour and transport.

3.6.2 Ciujung Scheme Area

The Ciujung irrigation scheme area of 24,200 ha is located in the northern low-lying coastal area in the Kabupaten Serang. This scheme was completed in 1918. The irrigation water of this scheme area is led from the Ciujung river through the Pamarayan diversion weir. The irrigation area is largely divided into two; left and right bank areas, by the Ciujung river. The left bank area of 18,600 ha is irrigated by a 44.8-km long Left Primary Canal with a discharge capacity of 24.6 m^3/sec at its head and a 16.2 km long Central Primary Canal with a discharge capacity of 13.6 m^3/sec at its head, which branches off from the Left Primary Canal at the 14.3 km point to irrigate 5,900 ha extending in the central part of the scheme area. The right bank area of 5,600 ha is irrigated by a 31.1 km long Right Primary Canal having a discharge capacity of 9.6 m^3/sec at its head.

Since the start of operation, the scheme had not received sufficient maintenance and accordingly the irrigation facilities had been badly damaged. The rehabilitation was started in 1971 and completed in 1975 under the PROSIDA program spending Rp. 2.68 billion. The major works included in the rehabilitation program were renewal of all gates of the Pamarayan Weir, rehabilitation of the upstream and downstream aprons and rehabilitation of the primary and secondary canals including their related structures.

Construction of tertiary and quaternary canals was started by PROSIDA in 1977 and has been completed by 1984 for the total area except for the flooded area of 1,200 ha. Meanwhile, the drainage improvement program was started in 1980 and scheduled to be completed in 1986. The program includes widening of drainage canal embankments, dredging of existing drains, improvement of roads along drains and rehabilitation and new construction of drainage structures including installation of flap gates at the heads of drains.

The field inspection and study based on the available data and information have revealed that almost all the reaches of both Right and Left Primary Canals; have less discharge capacities than required, and actually the downstream areas of 600 ha for the Right Primary Canal and 1,600 ha for the Left Primary Canal have never received irrigation water in the dry season. The study has also revealed that in the recent 5 years, the irrigated area in the dry season has been limited to 14,800 ha varying from 13,000 ha to 17,000 ha as a whole due to water shortage in the Ciujung river in the dry season.

The canal system has suffered some deterioration such as damages of gates, bank erosion, siltation in canals and damages of bridges due to insufficient maintenance. The canal system is closed for one month from October 16 to November 15 every year for maintenance work.

Water users' group has been established in every quaternary canal area of 20 - 25 ha on an average. One water users' group consists of 40 - 50 farmers on an average. In general, the water users' group acts as not only the operation and maintenance body for the quaternary canal but also a communication body for new agricultural technicals and procurement body for fertilizer and agricultural chemicals.

3.6.3 Cicinta Scheme Area

The Cicinta irrigation scheme, 1,430 ha in net, is located between the Cidurian river and the Cibeureum river (Fig. 3-10). The water source for irrigation is the Cicinta river which a catchment area of 30 km^2. A diversion weir and a 13.5 km long main canal were completed in 1916. About 25.0 km of tertiary canals had been constructed by 1977. Due to shortage of river discharge particularly in the dry season, only 100 ha of paddy fields are irrigated in the dry season. Supplementary water is supplied by pump to 65 ha at Carenang Udik.

The canal system has suffered severe deterioration. Most of the structures have damaged gates, lifting devices, aprons and bank protection. Many gates can no longer be lifted. Canals have been silted up

and their embankments have been broken down or serverely eroded. In some areas, tertiary canals no longer exist as farmers have leveled the canals to increase their cropped areas. Illegal pipe turnouts have been installed by farmers. Under such existing conditions, effective irrigation is no longer possible.

There is no drainage problem in this scheme area except for the some 100 ha of lower reach area because of its favorable topography sloping down toward both Cidurian and Cibeureum rivers and no existence of depressed land.

3.6.4 K-C-C Scheme Area

The scheme area of 18,150 ha in gross (10,300 ha in net) is located between the Ciujung right bank irrigation area, which forms the western boundary, and the Cidurian and Cibeureum rivers, which form the northern and eastern boundaries. The southern boundary is generally acknowledged to be the Rangkasbitung - Kopo road (Fig. 3-10). The area is characterized by the undulated topography which has also been a limiting factor for the irrigation development in the area.

For irrigation purpose, three pump stations have been constructed along the Cidurian river at Nambo, Koper and Sanggom Jaya villages under the donation of the Presidential Office in 1984. Each pump station is installed with a 30-Hp engine driven pump with a capacity of 425 m^3/hr and covers 50 ha of paddy fields in the dry season and 100 ha in the rainy season. Other than three pump stations, there is no notable irrigation facility in the scheme area except in the northern low-lying area where the farmers irrigate their farm lands by leading water from swamps scattered in the area.

Generally the northern half of the K-C-C area suffers from mal-drainage due to its depressed and low-lying topography. Particularly in the depressed lands, rain water stagnates throughout the year in deeply depressed lands of about 300 ha and for 7 - 8 months in shallowly depressed lands of 480 ha. On the shallowly depressed lands, about 300 ha can be improved through provision of drains at the reasonable cost.

3.7 Municipal and Industrial Water Supply

The municipal water supply system has not been developed well so far in the project area except the four major towns, of which Serang, Pandeglang and Rangkasbitung are supplied by pipes from water sources of dug wells and springs, and Cilegon is supplied by pipes from the Krenceng water treatment plant of PT. Krakatau Steel Works. In rural areas, shallow wells equipped with hand pumps are used for cooking and drinking purposes, while the water of rivers and irrigation canals is used for washing and laundry purposes. The Directorate General of Housing, Building, Planning and Urban Development (CIPTA KARYA) is promoting the IKK water supply program in which most urbanized settlements are to be served by water supply systems. Following this program, the systems for Ciruas, Pontang, Carenang and Baros are under construction and the construction of the systems of Cadasari and Sajira will be started soon.

The Government has been paying much attention to the industrial development in Cilegon. The main industrial factories presently operated in the project area are PT. Krakatau Steel Works, PT. Satya Raya Indah Wood-Based Industries, PT. Statomer PVC Resin Factory and Port and Ferry Installations. Other than these, there are small-scale factories of brick and tiles, bamboo products, coconut products, etc. Since there is no public water supply system for these factories, they have their own supply systems. The water supply source for PT. Krakatau Steel Works is river water led from the Cidanau river. The river water is lifted up by pumps and conveyed through a 1,400 mm dia. pipeline with a total length of 27 km to the Krenceng treatment plant near PT. Krakatau Steel Works. Adjacent to the said treatment, a raw water reservoir with an effective storage capacity of 2.5 million m^3 was constructed at Krenceng for emergency use.

3.8 Inland Fishery and Watershed Management

3.8.1 Introduction

A study on the inland fishery and watershed management is carried out to assess the impact of a water resource development project to inland fishery, and to predict the future trends of soil erosion in watersheds. The study is made on inland fishery in downstreams of the Ciujung river and the Ciujung canal, and on watersheds of the Karian and Cilawang dams. Based upon the finding of problems if any countermeasures are proposed to solve problems.

3.8.2 Inland Fishery

(1) Present Condition of Inland Fishery

There are two kinds of inland fishery in the study area, brackish fishery and freshwater fishery. The brackish fishery is done in coastal fishponds. The freshwater fishery develops in freshwater ponds, rice fields, rivers and swamps. The major inland fishery in the study area is brackish pond fishery (5,801 ha) occupying 89% of the total water surface for inland fishery. The total production from brackish pond fishery in 1983 was about 15,600 tons, which was equivalent to Rp. 2,225,000. The main fish species harvested from brackish ponds is shrimp (35%) followed by milk fish species harvested from brackish ponds in shrimp (35%) followed by milk fish (27%), Tilapia (15%), and Mullet (10%) in terms of weight. The major producing areas are Kecamatans Tirtayasa and Pontang.

The area of freshwater pond is 25 ha, from which about 5 tons of fish is harvested. The major species is golden fish occupying about 60% of the total production from freshwater ponds.

The rice field fishery is carried out in a very limited area of 12 ha. The production was about 1.3 tons in 1983. The main species is golden fish. Fishing in swamps and river is extensive showing 667 ha and 240 km, but the productivity is very small, i.e. 0.11 ton/ha and 0.15 ton/km respectively. The details of the present inland fishery are shown below.

Extent of Inland Fishery in 1983

Kecamatan	Brackish Pond	Freshwater Pond	Rice Field	Swamp	River
A. Extent (ha)					
Pontang	2,046	13	-	5	106 (km)
Tirtayasa	2,427	1	-	7	66
Kramatwatu	359	2	-	6	15
Pamarayan	-	8	12	75	53
Carenang	-	1	-	564	-
Kasemen	887	-	-	10	-
Bojonegara	82	-	-	-	-
Total	5,801	25	12	667	240
B. Unit Yield (ton/ha)	2.69	0.21	0.11	0.05	0.15 (ton/km)
C. Price (1,000 Rp./ton)	827	1,447	1,686	873	1,239
D. Total Value (1,000 Rp.)	2,225	304	185	44	186

Source: Fishery office of Kabupaten Serang, 1983

(2) Impact of Water Resource Development Project to Inland Fishery

The construction of a dam or a weir, or the development of irrigated rice cultivation change the aquatic environment to fish. Probable adverse impacts are listed below.

a) hampering of migration of fish, particularly of anadromous species

b) destruction of sprawling grounds by flood control structures

c) Disturbance of sprawling and breeding habits by fluctuation in water surface by dam operation

d) salt water intrusion to fishponds by excessive water taking in upstreams at dams or weirs

e) prevention of water flow causing oxygen shortage in the water

f) pollution of water by insecticides, herbicide, fungicide and fertilizers sprayed in rice fields

Assessment of the impacts by the Project is done in Chapter VIII.

3.8.3 Watershed Management

(1) General

The watershed management has objectives such as conservation and improvement of soils, sediment reduction, runoff retardation and preservation of groundwater resources. Consequence of watershed management of a dam can be considered from two points. One is the efficiency in utilization of the dam storage capacity which is hampered by sediments deposited in the dam reservoir. Another is the efficiency in utilization of rainfall caught in a watershed of the dam. By good watershed management, the runoff is retarded and prolonged resulting in high utilization of precipitation.

(2) Present Condition of Watersheds

Directorate of agrarian reform surveyed a soil erosion situation and land use of the watershed of the Ciujung and the Cibeureum rivers in 1978. According to the result of the survey, the dominant land use of the watershed of the Karian and Cilawang dams is forest, i.e. 55.3% and 61.5% respectively. Cultivated lands are very few, 9.5%, 9.1%. Vegetative cover of the watersheds are in good conditions. The details of the present land use are given below.

Present Land Use in Watersheds of Karian and Cilawang Dams

(Unit: ha)

	Residential Area	Paddy Fields	Garden	Upland Fields	Forest Land	Plantation	Grass Land	Total
Karian	316	2,100	9,634	519	15,941	266	25	28,801
(%)	(1.1)	(7.3)	(33.5)	(1.8)	(55.3)	(0.9)	(0.1)	(100.0)
Cilawang	35	331	2,226	511	5,720	341	141	9,305
(%)	(0.3)	(3.6)	(23.9)	(5.5)	(61.5)	(3.7)	(1.5)	(100.0)

Areas subject to soil erosion are estimated at 659 ha in the Karian dam watershed and 449 ha in the Cilawang dam watershed. Those areas consist of upland crop areas, and plantations near prospective Cilawang dam site. There is no serious soil erosion problem in the areas.

IV THE PROJECT

4.1 Basic Concept

The Project has been formulated in the foregoing "Master Plan Study on North Banten Water Resources Development" as a sole project in the North Banten area worthy of early development.

Despite favourable location of the area being close to the capital of the nation as well being on a trunk route to bridge Java and Sumatra, the income level of the inhabitants in the North Banten area is lower than that of the West Jawa Province, and there exist number of income depression areas even within the North Banten area. Mainstay of the area is agriculture which depends mainly on paddy. Said poverty is attributable largely to a fact that the irrigation water is insufficient. Hence, it is necessary to increase the irrigation water to raise up and to level the income standard of the area.

On the other hand, available surface water in the dry season has been exhausted by existing irrigation systems or farm lands, whereas the rainy season flow of the rivers are discharged without being used, even causing sometimes flood damages to the riparian areas. In fact, the upper parts of the catchment basin of the main rivers in the area receives ample precipitation.

It is, therefore, needed to provide storage reservoirs so that ample rainy season flow is stored for use of irrigation in the dry season. Also, occasional flood outflow can be dissipated by such reservoirs.

The Project is composed of many integral parts and synthetic effects of all of these integral parts will lead the Project to meet the concept. Therefore any integral parts cannot be missed out. As the Project is thus planned, each of the integral parts will have to be implemented.

4.2 Project Planning

4.2.1 Needs for Water Resources Development

Subject rivers as water source are Ciujung and Cibeureum rivers. The former is the largest river in the North Banten area having more than two thirds of the outflow from the whole North Banten area. The latter is a tributary of the Cidurian river whose main stream flows in parallel with the Ciujung river.

Subject irrigation areas are the Ciujung irrigation area, the Cicinta area and the K-C-C area. The Ciujung irrigation area is located on the lower reaches of the Ciujung river and extends to the west. This area has been irrigated by the existing Ciujung irrigation system having 24,200 ha of commanding area. As the Ciujung river has rather high dry season flow, nearly three quarters of the commanding area is irrigated throughout the year, whereas the rest one quarter is left unirrigated in the dry season. Present cropping intensity is 174%.

The existing Cicinta irrigation area (1,430 ha) is located between the Cibeureum river and its main stream Cidurian river. Water is taken from the Cicinta river, a tributary of the Cibeureum river. As the catchment area of the Cicinta river is small, flow of this river is not rich especially in the dry season. Hence, this area is almost not irrigated in the dry season. Present cropping intensity is 107%. Existing irrigation facilities are rather deteriorated.

The K-C-C area is located between the main streams of the Ciujung and Cidurian rivers so that the watershed of these two rivers passes through this area. Ground surface of this area is high in the middle, low in the both flinges, and undulating in the longitudinal direction. Because of such topography as well as of the location to be distant from possible water source, the K-C-C area has not been irrigated as yet. Present cropping intensity is 113%. For this reason, this area is generally poor forming a spacious income depression area in the North Banten area.

Rangkasbitung, the capital of the Lebak district, is situated by the middle reach of the Ciujung river just downstream from the point where three tributaries join and form the main stream. This town has being suffered from occasional floods. Such floods often cause flood damage and decrease the town area by erosion in a long run. It is required to mitigate these floods and damage thereof.

Rangkasbitung, on the other hand, is in short of source for municipal water supply that hinders smooth development of city expansion plan. Also there are number of I.K.K. (Capital town of sub-district) of which water sources for municipal water supply are scanty. Cilegon is a center city of the Cilegon area where the Krakatau Steel Works, the nation's sole steel mill, the Cilegon Industrial Estate and many other heavy industrial factories are at work. There exists a complete water system owned by the Krakatau Steel Works consisting of intake on the Cidanau river, pipeline, reservoir and purification plant. Water demand in the Cilegon area will be met for some future years by the existing system, but it is forecasted that shortage of water will occur around the year 2000.

The water demands for municipal and industrial water supply composed of Rangkasbitung, 17 I.K.K.s and the Cilegon area, will appear in the future. As it is almost impossible to find their water source nearby each location, it is needed to provide necessary amount of water in the reservoir of the Project.

Said needs are categorized into two groups. One is those whose demands or needs are existing. They are the water demands for irrigation for the existing Ciujung scheme, that for the existing Cicinta scheme and that for the K-C-C area on which irrigation is to be realized newly. Also the mitigation of flood damages of Rangkasbitung and vicinity is included in this group. The second group encompasses those whose demands will occur in the future. Municipal and industrial water supplies are included in this group. It is intended that the Project is so planned as to meet the demands and needs of both groups.

4.2.2 Water Soruce

Sites for dams and storage reservoirs are found on the Ciberang river, one of three tributaries of the Ciujung river, and on the Cibeureum river. The former is the Karian site and the latter is the Cilawang site. In view of the mutual locations of water demand areas and water sources as well as of the available amount of river flow, these two water sources are to be used to the optimum extent for the irrigation of Ciujung and Cicinta irrigation areas and the K-C-C area (water demands are existing), and the municipal and industrial water supply (water demands appear in future). As the Karian site is located upstream from Rangkasbitung, the Karian dam is to function also as flood regulation.

4.2.3 Original Plan

In formulating the original plan of the Project in the preceding M/P study, the following maps were used;

- For Karian reservoir: new air-photo map in 1/5,000 scale with 2 m contour intervals prepared in 1982, and
- For Cilawang reservoir: existing general topographic map in 1/50,000 scale with 25 m contour intervals.

The original plan is as follows;

- Karian dam and reservoir is located on the Ciberang river having an effective storage capacity of 188 million m^3 and a flood regulation capacity of 30 million m^3. Stored water is to be allotted for whole of the Ciujung irrigation scheme (24,200 ha in the rainy season and 20,000 ha in the dry season), for part of the K-C-C area (8,000 ha), and for municipal and industrial water supply. Water for the K-C-C area is discharged through a trans-basin tunnel from the Karian reservoir to the Cibeureum river.

- Cilawang dam and reservoir is located on the Cibereum river having an effective storage capacity of 54 million m^3. Stored water is to be used for the K-C-C area and for the Cicinta irrigation area (1,430 ha) in addition to the flow released from the Karian reservoir.

Both dams are planned to have maximum height judging the topography show on the said available maps.

As the Cilawang reservoir was planned based on less precise map than that for the Karian dam, it was recommended in the M/P Report to prepare an air-photo map of the Cilawang reservoir area also in scale of 1/5,000. Later on, such map was prepared by P3SA delivered to the present study team in July 1984.

Proposed cropping intensity is 200% for all of three irrigation areas. It is also planned that no additional works are made on two existing irrigation schemes.

4.2.4 Present Plan

In the early stage of the present study, storage capacity is measured based on the newly prepared air-photo map of the Cilawang reservoir area. As the results of the measurement new facts are found. They are;

(1) For the same water level, capacity is less by some 30% than that measured on the old map.

(2) It is possible to add the dam height above the extent which was measured on the old map, by means of providing saddle dams.

Hence, it becomes necessary to determine the optimum capacity of the Cilawang reservoir, and accordingly that of the Karian reservoir. Optimization study is made taking such parameters as the capacity of the Cilawang reservoir, that of the Karian reservoir, and discharge through the trans-basin tunnel from the Karian reservoir to the Cibeureum river.

In parallel with the optimization, the agricultural and irrigation studies achieve new results. The commanding area of the K-C-C scheme becomes 10,300 ha (viz. 8,000 ha in M/P). This increment is attributable to two reasons such as, (1) the plots are included which are located near the approach canal and (2) the plots in the K-C-C area are included which are used presently as upland fields but can be used as paddy field if irrigation water is available.

Cropping intensity is taken at 250% for whole three irrigation areas because of the main reason that the existing paddy yield per crop is pretty high. Accordingly it becomes necessary to increase the flow capacity of the existing west primary canal of the Ciujung irrigation scheme as well as to improve the existing facilities in the existing Cicinta irrigation scheme.

Many cases of water balance in different combinations of the parameters are made. And the final result in view of obtaining the minimal cost is selected out. Effective storage capacities of the selected case are as follows:

(Unit: 10^6 m^3)

Effective capacity	Karian	Cilawang	Total
present study	219	62	281
cp. M/S	188	54	242
cf. Difference	+31	+8	+39

Effective capacities of the reservoirs have increments as compared with those in the M/P Study. These increments are mainly due to increase in the cropping intensity and in the commanding area. Details of studies are set forth in the relevant sections to follow.

4.3 Resources and Requirements

4.3.1 Water Resources

Selection of water sources to meet the water demand has been made in depth in the foregoing Master Plan Study. The surface water and spring water has already been almost exhausted for the irrigation and domestic uses. Hence, the rainy season flow of rivers is to be stored in reservoirs and used in the dry season. In view of location and amount of available water, the Ciberang and Cibeureum rivers are used. The Karian dam and reservoir are located on the Ciberang river.

The Ciberang river is one of the three tributaries of the Ciujung river which join and form the main stream of the Ciujung river just upstream from Rangkasbitung. Catchment area of the Ciujung river is 1,850 km^2 at the estuary and 1,383 km^2 at Rangkasbitung where the annual outflow is 3,046 million m^3. The Ciberang river has a catchment area of 331 km^2 at the confluence to the Ciujung river, and 288 km^2 at the Karian dam site. Annual outflow of the Ciberang river is 909 million m^3 at the dam site, or the yearly mean discharge is 28.8 m^3/sec. The upper basin of the Ciberang river receives heavy precipitation. Mean annual precipitation is 4,282 mm. This value is the largest out of all the rivers in the North Banten area, hence the aforementioned outflow is the richest of all the possible dam sites in the North Banten area.

The Cibeureum river is a tributary of the Cidurian river which has a total catchment area of about 800 km^2. At the Cilawang dam site, the catchment area is 93 km^2 which receives mean annual precipitation of 3,760 mm and annual outflow is 244 million m^3, or the yearly mean discharge is 7.74 m^3/sec.

Hydrologic records of the Sajiira gauging station located upstream from the Karian dam site are unfit for the estimation of the outflow at the Karian dam site owing to low accuracy of discharge measurement. So the outflow at the Karian dam site is estimated based on the hydrologic records of the Rangkasbitung gauging station with reference to the rainfall records in the upper basin. The outflow of the Cilawang

dam site is estimated based also on the hydrologic records of the Rangkasbitung gauging station. Estimated monthly 10 days mean discharge at both the Karian and the Cilawang dam sites is shown on Table 3-6.

4.3.2 Irrigation Demands

For the use of water balance study between the water demands and runoffs of the Ciberang and Cibeureum rivers at the respective dam sites, irrigation water requirements are calculated for the recommended cropping pattern with a cropping intensity of 250% consisting of 100% of locally improved paddy, 140% of high yield varieties of paddy and 10% of palawija (for the Ciujung area) or red onion (for the Cicinta and K-C-C areas). The calculation of water requirements is made on 10-day basis for 12 years from 1972 to 1983 and the calculated results are shown in Tables G-1 to G-3 of Appendix-G.

4.3.3 Municipal and Industrial Water Supply

(1) Municipal water supply

For the projection of water demand for municipal water supply, the served population ratio and the unit average daily water demand are set based on the study results of the recent trends in the Project area and Jakarta. The assumed ratio of served population is 0.44 in 1980, 0.70 in 1990 and 0.80 in 2000 for the rural area. The assumed per-capita average daily water demand is 110 lit/day in 1980, 125 lit/day in 1990 and 160 lit/day in 2000 for the urban area, 75 lit/day in 1980, 94 lit/day in 1990 and 120 lit/day in 2000 for the I.K.K. area, and constant demand of 60 lit/day for the rural area. The water demands thus estimated and the available water sources are compared as follows:

(Unit: lit/sec)

	1985	1990	1995	2000
(a) Serang town				
- Raw water supply	303	303	303	303
- Raw water demand	88	30	188	259
- Balance	+215	+173	+115	+44

	1985	1990	1995	2000
(b) Pandeglang town				
- Raw water supply	105	105	105	105
- Raw water demand	26	32	40	51
- Balance	+79	+73	+65	+54
(c) Rangkasbitung town				
- Raw water supply	80	80	0	0
- Raw water demand	70	87	113	143
- Balance	+10	-7	-113	-143
(d) Cilegon town				
- Raw water supply	0	0	0	0
- Raw water demand	30	46	67	93
- Balance	-30	-46	-67	-93
(e) I.K.K. towns				
- Supply	0	0	0	0
- Demand	190	270	370	480
- Balance	-190	-270	-370	-480

From the above supply-demand study, it is cleared that Serang and Pandeglang towns are provided with sufficient water supply systems and there would not be any difficulties of water supply even in 2000, while, Cilegon and I.K.K. towns require new water supply systems even now and Rangkasbitung will require the supply from 1990. The required amounts in these towns in 2000 would be 93 lit/sec, 480 lit/sec and 143 lit/sec respectively. These shortages of water supply are planned to be fed from the proposed Karian reservoir.

(2) Industrial water supply

Industrial water supply to be considered as a Project component comprises the supplies to PT. Krakatau Steel Works, Anyer-Merak area, Suralaya Power Station (housing colony) and Cilegon Industrial Estate, all of which will be supplied from the proposed Karian reservoir through the Ciujung Left Primary Canal. The water demands for these industries are estimated based on the following information and assumption:

(a) Water demand for PT. Krakatau Steel Works

Based on the latest information given by PT. Krakatau Steel Works in August 1984, the water demands are estimated for the respective years; 1985, 1990, 1995 and 2000.

(b) Water demand for Anyer-Merak area

The water demands in this area consist of the municipal and industrial water demands for PT. Satya Raya Indah Woodbased Industries, PT. Statomer PVC Resin Factory and Port & Ferry Installations. The future water demand for PT. Satya Indah Woodbased Industries is assumed not to increase from the present demand of 4.1 lit/sec in future up to 2000. The industrial water demand for PT. Statomer PVC Resin Factory will fully be supplied by the desalination plant and its domestic demand will only be supplied from the proposed Karian reservoir. This demand is estimated based on the assumption that the water demand will be the same as the present consumption of 0.1 lit/sec up to 1990 and 0.2 lit/sec up to 2000. As for the projection of water demand for Port and Ferry Installations, the unit water demand for an employee is assumed to be the same as that for the per-capita consumption in the urban area, and the number of employees is assumed to be 200 persons throughout the projection period, while the number of the passengers is assumed to increase at the rate of 2.3% per annum, for whom the per-capita water consumption is assumed to be 13 lit/day.

(c) Water demand for Suralaya power station (PLN)

The water demand for this power station includes both industrial and domestic uses. Since the water demand for the industrial use will fully be supplied by desalination plant, the demand for the domestic use will only be supplied from the proposed Karian reservoir. The estimated demand for the domestic use is 30 lit/sec in 1985, 40 lit/sec in the period from 1990 to 1995 and 50 lit/sec in 2000.