REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS AND ELECTRIC POWER
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

FEASIBILITY REPORT ON THE WONOGIRI IRRIGATION AND UPPER SALA RIVER IMPROVEMENT PROJECT

MAIN REPORT

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO 1976

PREFACE

In order to solve shortage of foodstuff and electric power and also to overcome damages caused by flood in view of stabilized livelifood of people, the Government of Indonesia is seriously contemplating the construction of multi-purpose dams as national development projects.

Particularly, the development of the Sala basin in Central Java is recognized to be of most importance.

Under the circumstances, Overseas Technical Cooperation Agency (OTCA) of Japanese Government, at the request of the Government of Indonesia, carried out the survey and study for the preceding project and completed the Master Plan in 1974. Continuously, Japan International Cooperation Agency (JICA - the successor of OTCA) conducted the feasibility study of Wonogiri Multi-purpose Dam Project in 1975.

Furthermore, in order to improve the accuracy of this feasibility study especially in the areas of irrigation and river improvement, the Government of Indonesia requested the Government of Japan for the latter's cooperation.

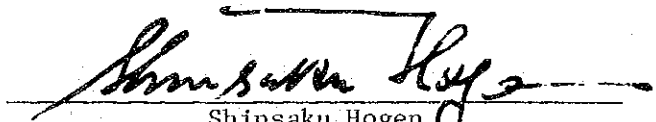
In response to this request, JICA dispatched a survey team consisting of fifteen members, headed by Mr. Yuzo Tokunaga, Chief of the Planning Department of Nippon Koei Co., Ltd. to the project area over a period of about four months from January 26, 1976 to May 19, 1976.

Hereby presented is a report based upon the findings attained in the field survey as well as the subsequent study in Japan.

I firmly believe that the implementation of this project will contribute much to the further agricultural development and flood control in the Sala basin in the near future, and to the promotion of friendship between the two countries.

Finally, I take this opportunity to express my hearty gratitude to the Government of Indonesia and other authorities concerned for the kind cooperation and assistance extended to the team, without which the survey work could not be carried out so successfully.

September 1976



Shinsaku Hogen
President
Japan International Cooperation Agency
Japan

LETTER OF TRANSMITTAL

Mr. Shinsaku Hogen
President,
Japan International Cooperation Agency,
Tokyo, Japan

September, 1976

Dear Sir,

We have the pleasure of submitting herewith the feasibility report on the Wonogiri Irrigation and Upper Sala River Improvement Project in compliance with the terms of reference agreed upon between the Government of Japan and the Government of Indonesia.

The primary purpose of the survey team was to raise the accuracy of the previous feasibility report made in 1975, particularly, in the field of irrigation and river improvement, by making full use of the 1/5,000 scale topographic map which was newly prepared after the completion of the said feasibility report.

To attain the above purpose, the survey team conducted the field investigation and preliminary studies from January to May, 1976, under the guidance of the Advisory Group. After its return to Tokyo, the team further made various detailed studies and prepared the Final Draft Report which was submitted to the Government of Indonesia in July. On the draft report final meeting was held both in Jakarta and Surakarta from the end of August to early September, 1976 with the staff of Directorate of Rivers and the Project Bengawan Sala Office. All findings and comments raised in the meeting were studied and fully incorporated in this report.

We are confident that the accuracy of the feasibility studies has been improved. The engineering and economic studies confirm that the project is technically sound and economically feasible. It is our sincere hope that the project will be proceeded to the next stage of the detailed design for the early realization of the project as soon as possible along the recommendations presented in this report.

In submitting this report, we wish to express our sincere appreciation and gratitude to the personnel of your Agency, the Japanese Embassy in Indonesia, and the authorities concerned of the Government of Indonesia for the courtesies and cooperation afforded us during our field survey and home office work.

Very truly yours,

Y. Tokunaga

Yuzo Tokunaga
Team Leader
JICA Survey Team for
the Wonogiri Irrigation and
Upper Sala River Improvement Project

S U M M A R Y

1. Introduction

This report presents the results of the feasibility studies on the Wonogiri Irrigation and Upper Sala River Improvement Project constituting a part of the Wonogiri Multi-purpose Dam Project.

The studies have been made with a view to identify the under-developed conditions prevailing in the project area and to envisage a prospective picture of the project area after the implementation of the project.

The report consists of a main report which describes the broad outlines of the study-results, and four appendices which present reason and justification of the outcomes of such studies in detail.

2. History

The Wonogiri Multi-Purpose Dam Project took shape in the overall development planning for the Sala river basin which was made in 1963 - 65. After a decade, the project was reviewed and its feasibility study was made in 1975.

While the dam and power sectors of the project have now proceeded to the stage of detailed design and construction, a set of new topographical map was later made available thus offering a chance to make further study of raising the credibility and exactitude of the previous feasibility study on the irrigation and river improvement sectors.

The Government of Indonesia requested the Government of Japan to render technical cooperation in making an additional study on these sectors. The Government of Japan agreed to its offer. The study has been executed during the period from January to July 1976 as presented in this report.

3. Scope of the Study

The scope of this study which has been taken up by the name of the "Wonogiri Irrigation and Upper Sala River Improvement Project" is as follows:

a) Feasibility study of the Wonogiri irrigation system covering an area of about 23,600 ha.,

b) Feasibility study for improvement works of upper Sala main river and tributaries extending between the Nguter bridge and Surakarta city, and

c) Reconnaissance for flood control of the Kali Dengkeng.

4. Background

The Government of Indonesia carried out the First Five-Year Development Plan in the period between 1969 and 1974. During the plan, the annual growth rate of rice production reached 3.5% and the amount of rice produced totalled 15.4 million tons in 1974.

But, population increased remarkably during the period at the rate of 2.1 % per annum. The demand for foodstuff exceeded the growth of the production of rice, and about one million tons of rice was imported annually.

The Second Five-Year Development Plan has been launched in 1974 and aims at the attainment of self-sufficiency in foodstuff. The Government of Indonesia directs its national effort toward an early introduction of the improved irrigation farming and also toward an improvement of flood control facilities.

5. Project Area

(Irrigation)

There are about fifty (50) independent irrigation systems in the project area, taking water from tributaries of the Sala river and K. Dengkeng. The irrigated area is 15,840 ha and the rain-fed area is 7,360 ha.

Planting extends over 95% of the whole farmland in wet season, while it decreases to 30 % in dry season. Unit yield of rice is ranging from 2 to 3.8 tons per ha per crop in dry stalked paddy. Annual farm income is from Rp.100,000 to Rp.140,000 per household and its capacity to pay, or net reserve, is less than Rp.3,000 per annum. Annual production of rice is 84,000 tons in dry stalked paddy and that of sugar cane is 168,000 tons.

The present irrigation systems include the main canals of 40 km and farm roads of 549 km.

The major reasons for such a low planting ratio in dry season, crop yield and poor farm income are as follows.

i) The amount of available water is not enough to irrigate the whole farmland in dry season.

ii) The irrigation and drainage facilities particularly in the non-technical and rainfed areas are considerably deteriorated, and canals are silted and weed-grown.

iii) Irrigation water for paddy production is not provided enough in volume and in time.

iv) Institutional activities are not satisfactory due to the shortage of well-trained staff and the lack of working fund and mutual communication and coordination among institutions, and

v) Generally farmers do not have proper knowledge of the improved irrigation farming technique.

(River Improvement)

At present, there is hardly any levee and revetment over the whole reach of the Sala river in the project area. A revetment is built for about one km along the Sala river on the east of Surakarta. Wooden groins are driven at two places for the total length of 0.5 km, and three sluiceways are provided.

Floods of more than 200 m^3/sec inundate riparian land. Inundation area amounts to 2,900 ha in the case of the flood of 500 m^3/sec which occurs a probability of 2.5 times a year, and to 20,200 ha for 2,000 m^3/sec corresponding to a 40-year probable flood. Annual damage in the project area amounts to US$6.6 million.

6. The Project

(Irrigation)

The construction of the Wonogiri dam has just been commenced. After the Wonogiri reservoir is completed, about 400 million m^3 of the water to be storaged will be made available for irrigation purpose.

A concrete weir with intake will be built at Colo about 14 km downstream from the dam, and the main canals totalling 94 km long on both banks of the Sala river will be constructed. The existing irrigation and drainage canals will be rehabilitated. 16 aqueducts, 28 syphons and 270 operation and maintenance bridges will be newly constructed. Farm road 549 km long will be improved and that 147 km long will be newly constructed.

The Colo weir is to be founded on the firm bedrock. The aqueducts and syphons are to be built under dry working conditions by the so-called Copure construction method.

Upon completion of the said works, the existing irrigation systems will be unified with the main canals to enable a year-round irrigation farming over the whole farmland of 23,200 ha. An intensive rice farming of five crops of paddy in two years is to be introduced. Agricultural supporting institutions are to be strengthened for attaining such an intensive farming. A pilot scheme or a pioneer project will also be implemented.

In seven years after the successful implementation of the above works, the crop yield of rice will reach 5.5 tons per ha. per crop in dry stalked paddy. Annual farm income will attain Rp.360,000 per household, while capacity to pay will be Rp.110,000 per household per annum. Annual production of rice will amount to 273,000 tons in dry stalked paddy, and that of sugar cane to 252,000 tons in the project area.

An increase in unit yield of rice will be 1.5 to 2.5 times the present yield, annual farm income 2.2 to 3.1 times, capacity to pay more than 40 times, annual production of rice 3 times, and annual production of sugar cane 1.5 times.

(River Improvement)

A levee of 33 km will be constructed on both banks of the Sala river and that 30.5 km long on both banks of eight tributaries. Two retarding basins about 4.5 million m^3 in total will be provided. A revetment will be constructed for 7 km long in total, and wooden or concrete groins will be provided at 395 places to protect levees over the length of 13 km. Thirty five (35) sluiceways and landside-water draiage channel totalling 70 km will be built.

The levees to be constructed along the main river and tributaries are designed to be low. Revetments and groins are planned to sufficiently guarantee the technical soundness of the levees. Gabions will be laid at the foundation of the revetments and around the groins for protecting them against scouring.

After the above construction works are completed, the floods with discharges less than 2,000 m^3/s will never cause inundation or riparian land. The expected decrease in the annual amount of damage will amount to US$5.54 million.

7. Evaluation

The construction works including the design works for the irrigation and river improvement are planned to be carried out during the periods from 1977 to 1982 and 1977 to 1983, respectively. The construction plan is so formulated that the irrigation benefit is raised from 1981, the following year of the Wonogiri dam completion, and that the flood control benefit is brought about from 1978 onward.

The economic construction cost for the two sectors of irrigation and river improvement amounts to US$79.6 million in total, while that for the whole project including dam and power sectors US$138 million.

Fund requirement for the construction or financial cost of the two sectors amounts to US$50.67 million in foreign currency portion and US$79.59 million in domestic currency portion, provided that the construction works are carried out on contract basis. If the works are implemented on force account basis, the fund requirement amounts to US$61.97 million in foreign currency portion and US$83.36 million in domestic currency portion. In view of the transfer of knowledge and experience in the similar project so far gained in Indonesia, the construction is to be carried out by Force Account Basis.

The annual cost necessary for operation, maintenance and replacement of the facilities for the two sectors is estimated at US$0.52 million, while that for the whole project including dam and power sectors US$0.84 million.

The irrigation benefit is US$17.77 million per annum and the flood control benefit US$5.54 million. The total project benefit including power benefit and negative benefit or loss of the expected benefit in the cultivated land to be submerged and to be acquired is US$23.45 million.

The internal rate of return of the whole project covering all the four sectors is 12.1 %. The rate of return is sensitive to delays in the benefit, decrease in rice price and increase in costs, but even if the build-up period of the irrigation benefit should extend to 12 years or price of rice should decrease by 20 % or the construction cost should increase by 30 %, the rate of return would be about 10 %.

8. Conclusion and Recommendation

The necessity of the Wonogiri Irrigation and Upper Sala River Improvement Project for regional economic development and public welfare in Indonesia is identified. The project is proved to be technically sound and economically feasible.

It is therefore recommended to implement the Wonogiri Irrigation and Upper Sala Improvement Project as soon as possible.

PRINCIPAL FEATURES OF THE PROJECT

I. Project Features

1.1 Irrigation Facilities

a) Colo Diversion Weir

Weir	Concrete weir, 9 m high x 108 m long
Intake	1 place on the right bank only, L.W.L. EL 107 m
Sand flash	7.5 m x 2 bays

b) Irrigation Canal

	Right Bank	Left Bank
Irrigation area (ha)	19,600	3,600
Irrigation practice	Year-round irrigation by gravity	
Cropping pattern	2-1/2 paddy crops per year, and sugar-cane cultivation	
Main canal, Length (km)	62.4	31.4
Gradient	1/2,500	1/6,000
Discharge, max. (m^3/sec)	24.3	5.2
Secondary canal, Length (km)	69.6	11.6
Farm canal, Length (km)	928 in total	

c) Crossing Facilities (along the main canals only on both banks)

Turnout	(Numbers)	48
Check Gate	(")	13
Siphon	(")	27
Aqueduct	(")	16
Culvert	(")	163
Bridge	(")	259

1.2 River Improvement Facilities

Improved section	From Nguter road bridge to Jurug road bridge in Surakarta
Improved river length	33 km along the Sala river, 30.5 km along eight tributaries

Design discharge	1,050 m^3/s at the Nguter bridge 2,000 m^3/s at the Jurug bridge
Retarding basin	2 places, 2.7 and 1.8 million m^3 of regulating capacity
Revetment	7 km long
Groin	395 places, 13 km long in total
Sluiceway	35 places
Landside water drainage channel	74 km long

1.3 Wonogiri Dam

Catchment area	1,350 km^2
Type of dam	Rockfill, center core type
Embankment volume	1.8 million m^3
Effective storage capacity for irrigation use	400 million m^3
Effective storage capacity for maintenance of river course	30 million m^3
Outlet valve	1.8 m dia. hollow-jet valve; Q = 35 m^3/s

1.4 Power /1

Turbine	2 units x 5,100 kW kaplan type
Generator	2 units x 6,375 kVA
Discharge, Maximum discharge	60 m^3/s
Output, Maximum discharge	10,200 kW
Annual energy output	28,200 MWh

II. Project Cost and Benefit

2.1 Economic Cost

(10^3 US$)

Item	Foreign Currency	Domestic Currency	Total
Irrigation	23,790	22,910	46,700
River improvement	15,300	17,600	32,900
Dam & reservoir	18,000	28,700	46,700
Hydropower	10,190	1,510	11,700
Total	67,280	70,720	138,000

/1 The operation of the power station will be base load supply instead of peak load supply which was originally planned in the previous feasibility study.

2.2 Fund Requirement

(10^3 US$)

Item	Foreign Currency	Domestic Currency	Total
a) Contract base			
Irrigation	31,520	44,430	75,950
River improvement	19,150	35,160	54,310
Dam & reservoir	26,970	88,250	115,220
Hydropower	14,010	2,520	16,530
Total	91,650	170,360	262,010
b) Force-account base			
Irrigation	34,270	47,880	82,150
River improvement	27,700	35,480	63,180
Dam & reservoir /1	26,970	88,250	115,220
Hydropower/1	14,010	2,520	16,530
Total	102,950	174,130	277,080

(/1 The cost for the dam and the hydropower is estimated on contract base)

2.3 Benefit

(10^3 US$)

Item	Annual Benefit
Irrigation	17,770
Flood control	5,540
Hydropower	1,350
Negative benefit	-1,210
Total	23,450

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GROSSARY OF TERMS AND ABBREVIATION

1) Natural Features

G. = Gunung = Mountain
K. = Kali = River
Sawah = Rice field, Paddy field
Tegal = Upland field

2) Administrative Organization
(Local Administration)

Kares. = Karesidenan = Residency
Kab. = Kabupaten = Regency
Kec. = Kecamatan = Township
Desa = Village
BUPATI = Local governor
Lurah = Chief of Desa
Pamong Tani Desa = Village agricultural officer

(Organization for Water Resources Development)

DPUTL = Ministry of Public Work and Electric Power
DGWRD = Directorate General of Water Resources Development
DITSEI = Directorate of River
DITGASI = Directorate of Irrigation
Wilayah = Irrigation Office at Residency level
Seksi = Irrigation Office at Regency level
PLN = Public Corporation of Electricity
PBS PUSAT = Central Office of Bengawan Sala Project

(Organization for Agricultural Development)

BRI = Indonesia People's Bank
BIMAS/INMAS = Mass guidance for self-sufficiency in food
BAPEL = Executing committee for BIMAS program
PNP = State Estate Corporation
BULOG, DOLOG = Central and Provincial Rice Purchasing Agencies
BUUD, KUD = Agricultural Cooperative Organization
MPCS = Multipurpose Cooperative Society
Dharma Tirta = Farmers' organization for irrigation
PPL = Extension worker
Ulu-Ulu = Water master

3) Other Local Terms

Gotong Royong = Mutual cooperation

Polowijo = Upland crop

P.O.J. = Proef Station Oost Java (Variety of sugar cane)

Sewa, Mertelu, Maro = Share-cropping system

Pelita I = First five year development plan

Pelita II= Second five year development plan

Golonggan system = A kind of typical rotation system of irrigation water in Indonesia

Kampung = Residential area of village

4) Area and Volume

m^2 = square meter

ha = hectare = $10^4 m^2$

km^2 = square kilometer = $10^6 m^2$

ℓ = liter = 1,000 cm^3

m^3 = cubic meters

5) Derived Measures based on the Same Symbols

m^3/s, m^3/sec = cubic meter per second

t/ha, ton/ha = ton per hectare

m^3/km^2 = cubic meter per square kilometer

mm/day = millimeter per day

l/day = liter per day

m^3/km^2/year = cubic meters per square kilometers per year

6) Electric Measures

kV = kilovolt

kW = kilowatt

kWh = kilowatt-hour

kVA = kilovolt ampere

7) Currency

US$ = United States Dollar

Rp = Rupiah

US$ = 415 Rp

8) Previous report = Previous feasibility report (study) = Feasibility report on the Wonogiri multipurpose dam project in 1975

LEGEND

- Dam & Reservoir
- Power Station
- Intake Weir
- River Improvement
- Main Canal
- Secondary Canal
- Transmission Line
- Substation
- Watershed of the Sala river

N

TO SEMARANG

Irrigation Area 23,200ha

BENGAWAN SALA RIVER

GEMOLONG

SRAGEN

SIDOLAJU

NGAWI

MASARAN

K. Cemoro

K. Pepe

K. Mungkung

K. Grompol

K. Tempuran

K. Siyeluh

K. Sragen

K. Kanaran

K. Sawur

Jurug bridge

Jurug railroad bridge

KARANGANYAR

KARTOSURO

K. Wingko

SURAKARTA

K. Brambang

K. Buntungan

K. Kembangan

Bacem bridge

Mojo railroad bridge

K. Samin

K. Pusu

K. Gowa

SUKOHARJO

K. Ranjing

K. Jlantah

Nguter railroad bride

Nguter bridge

Colo Weir

K. Welikan

K. Dengkeng

PRAMBANAN

YOGYAKARTA

Wonogiri Hydropower
Max.output 10,200kw

WONOGIRI

DJATISRONO

MOJOSARI

MADIUN

K. MADIUN

PONOROGO

G. RAKITA 912

G. KEROK 522

G. PANGGUNG 785

WURYANTORO

Wonogiri Reservoir
730 million m³
(H.W.L 138.2m)

BATURETNO

G. MERBABU 3142

G. MERAPI 2911

G. LAWU 3265

G. TULAH 1734

1004

1177

1243

803

815

912

SUMATRA

KALIMANTAN

DJAWA SEA

DJAKARTA

BANDUNG

SEMARANG

JAWA

SURABAJA

YOGYAKARTA

INDONESIAN OCEAN

WONOGIRI IRRIGATION AND UPPER SALA RIVER IMPROVEMENT INDONESIA

Fig. 1 GENERAL MAP

Scale 0 10km

1. INTRODUCTION

1.1 PROJECT HISTORY

The Bengawan Sala river, having a total length of approximately 600 km, is a huge river with a drainage area of 16,100 km^2 or about 12% of the entire Java Island. Although some 10 million inhabitants in the Sala river basin are making their living by cultivating about 9,000 km^2 farmland, they suffer a great deal of damages from floods during every wet season, while considerable shortage of irrigation water occurs in dry season, which reduces the planted acreage to less than 12%. Due to these flood damages annually occurred and the limited agricultural activity their livelihood has been kept low.

It was under such circumstances that Nippon Koei Co., Ltd., conducted investigations for the development of the Bengawan Sala river basin from 1963 to 1965 and formulated the Wonogiri Multipurpose Dam Project as a part of the overall plan for the entire Bengawan Sala river basin development. Thereafter, serious damages were brought about to the Sala river basin by the large floods occurring in 1966 and 1968 which made the authorities concerned realize the urgent necessity of implementing the flood control work in this basin. Unfortunately, realization of the project was hampered by the deteriorated Indonesia's national economy which was aggravated, with long aftereffects, by the political instability since 1965.

In 1969, the First Five-Year Development Plan was launched with the primary purpose of attaining the country's self-sufficiency in foodstuff, placing emphasis on rehabilitation of agricultural infrastructures. Under this plan, levees were constructed along the Sala river, though partially, for the purpose of flood control, but such proved to be quite inadequate both in reducing the flood discharge in the wet season and in solving the problems of low cropping intensity due to shortage of water in the dry season.

With these backgrounds, re-study of the Sala river basin was carried out and the Master Plan for the basin development was formulated with the technical assistance of the Japanese Government during the period of 1972 to 1974. The Wonogiri Multipurpose Dam Project in the upper Sala river basin was selected as a top priority project with its high economic return and was recommended to be implemented first for the basin development.

In 1974, the Second Five-Year Plan which succeeded the First Five-Year Plan was formulated mainly for the rehabilitation of agricultural infrastructures, development of new water resources, sediment control, and flood control. Along with this plan the

Indonesian Government took up the aforementioned Multipurpose Dam Project and carried out the feasibility study from November 1974 with the technical assistance provided by the Japan International Cooperation Agency. In the feasibility report, the project is proved to be technically sound and economically feasible.

The present feasibility study was conducted in 1976 on the basis of the new 1/5,000 scale topographical map with the purpose of raising the accuracy of the study contents, particularly with regard to the irrigation and river improvement.

1.2 SCOPE OF WORKS

In respose to the request made by the Government of Indonesia, the Japanese Government dispatched a survey team to conduct a feasibility study of the Wonogiri Irrigation and Upper Sala River Improvement Project, during the period of January to May, 1976.

The survey team, headed by Mr. Tokunaga and consisting of 15 experts recruited from the Nippon Koei Co., Ltd., Japan Engineering Consultants Co., Ltd. and C.T.I. Engineering Co., Ltd., made investigation and compiled the report with the advices given by the Advisory Group. The names of the experts and their counterparts are listed in Table 1.

The summary of the scope of works which was agreed upon between the Government of Indonesia and the Japanese survey team at the meeting held on January 28, 1976 is as follows:

(1) Feasibility study for the Wonogiri irrigation system, covering the area of approximately 23,600 ha ;

(2) Feasibility study for the river improvement works on 23.2 km of the upper Sala main river and 17.5 km confluences of tributaries extending between Nguter bridge and Surakarta city; and

(3) Investigation for flood control of the Dengkeng river including sand control study and drainage of the Dengkeng valley.

The results of the investigation and studies were presented in the feasibility report of the following five separate volumes:

(i)	Main Report	
(ii)	Appendix I	Irrigation
(iii)	Appendix II	River Improvement
(iv)	Appendix III	Agriculture, Institutions and Project Economy
(v)	Appendix IV	Data

This volume is the Main Report giving the summary of the Appendices.

2. GENERAL BACKGROUND

Indonesia is located in the tropical zone having a territory of 1.9 million km^2 and a population about 130 million. The natural conditions are very favorable for agricultural production. About 7% or 14 million ha are being used as farmland, and nearly 60% of the population are engaged in agriculture.

In 1969, Indonesia launched out on the first Five-Year Development plan (Pelita I) aiming at rehabilitation of the national economy. The national economy showed a rapid growth during this period. In 1960's, the annual growth rate of CDP was only about 2%, but the growth rate increased to about 7% per annum during this period. In the final year of the Pelita I (1974), the growth rate was as high as 8.2%.

The agricultural sector, as a mainstay of the Indonesian economy supporting about 40% of the GDP increased at the annual rate of 4% during the period of the Pelita I. With the exception of 1972 which was a drought year, rice production during the period of 1970 to 1974 recorded a high average annual growth rate of 3.5% due to the improved unit yield and increased planted area. The total rice production in 1974 reached the level of 15.4 million tons.

In spite of the remarkable increase of rice production, it could not catch up with the demand during the period, due to the increase in population (annual growth rate about 2.1%) together with increase in rice consumption per capita induced by raised living standard. The annual import of rice reached the high level of one million tons in 1974. The sugar production was also insufficient to meet the increasing national demand, although the production increased at an annual rate of about 20%. About 0.2 million tons of sugar had to be imported in 1975.

Following the Pelita I, the Second Five-Year Plan (Pelita II) was started in the 1974/75 fiscal year. This plan has been formulated with the aim of increasing the actual GDP at an average annual growth rate of 7.5%, or an increase of 44% by the final year of the Plan. In the plan, high priority has been given to the agricultural sector. It has been planned that the share of the agricultural production in the GDP would come to be 36% in the final year of the plan, 1978/79 fiscal year, assuming the production increase at the annual growth rate of 4.6%.

What has been strongly advocated in this plan as the specific sectorial object is the attainment of self-sufficiency in foodgrain, laying particular emphasis on increase in productivity of rice production. The attainment of rapid growth of the agricultural sector under the Pelita II through an early introduction of the improved irrigation farming is one of the Indonesian Government's strategies.

Along with the Plan, targets of agricultural production are set for the main food crops and estate crops in Central Java, which is the third largest rice producing area in Indonesia producing about 17% of the total national rice product on its 1.2 million ha of farmland. According to the plan, intensified production of rice is emphasized and annual increase of rice production is anticipated at the rate of 5.3% by the intensive method. Sugar production is also expected to grow relatively high with the annual increase ratio of 5.6%.

The project area, situated in the eastern part of the Central Java Province, is an important area for rice production increase campaign under the Pelita II. Since the Pelita II is directing the national efforts toward an improvement of flood control and irrigation facilities for attainment of self-sufficiency in foodstuff and improvement of the welfare, the Wonogiri Irrigation and Upper Sala River Improvement Project is given an important strategical role to play under the Plan.

3. THE PROJECT AREA

3.1 LOCATION

The project area is situated in the upper Sala basin. The irrigation project area is about 5 km in width and 60 km in length, extending from north to south along the upper Sala river, having Surakarta city in the center (Refer to Fig. 1). Administratively, a major part of the project area comes under the Regency Surakarta (including a part of Regency Klaten in the west), consisting of Kabupaten Sukoharjo and Wonogiri in the south, and Kabupaten Karanganyar and Sragen in the north.

3.2 POPULATION

The population of the project area is estimated at about 0.25 million with the population density of about 800 persons/km^2 excluding the population of Surakarta city, 414,000. Annual population growth rate in the Kabupatens involved during the past decade is ranging from 1.5 to 1.8%.

Although urbanization is progressing, rural population is predominant in the project area and a large part of the population is still engaged in agricultural activity. According to the recent population census, about 64% of the working population is involved in agricultural sector, while the remaining 36% in nonagricultural sector.

Although any reliable statistics for employment are not available, it is considered that there exist substantial unemployment and under-employment in the project area.

3.3 NATURAL RESOURCES

3.3.1 Topography

The project area extends over a very flat alluvial plain along the Sala river, roughly between Mt. Lawu and Mt. Merapi, at elevations between 75 m and 105 m. Microrelief has developed quite often therein. The main stream of the Sala river which frequently causes floods, meanders with a gentle gradient. The mean slope is 1/2,000 above Surakarta city, and 1/2,800 downward.

The tributaries like K. Jlantah, K. Samin, K. Gawe, K. Dengkeng, K. Gondang and K. Sawur which rise in Mt. Lawu and Mt. Merapi run into the mainflow of the Sala river. In the wet season, the run-off of these tributaries, coinciding with the high river water of the mainflow of the Sala river, inhibits the surface drainage in the project area.

3.3.2 Climate

Climatic conditions in the project area are dominated by the tropical monsoons. The average annual rainfall is about 2,200 mm, but varies widely from year to year between 1,600 mm and 2,870 mm. About 80% of the rainfall occurs in the form of intense local storm during the wet season, which extends from November to May. Rains fall only occasionally during the rest of the year which are insufficient to support crop growth.

The monthly mean temperature is about $28^{o}C$ which varies only slightly throughout the year. However, the daily fluctuation shows a wide range of about 8 to $10^{o}C$. The monthly mean of the relative humidity is about 70%, ranging from 76.9% during the wet season to 59.4% during the dry season. The rate of monthly sunshine hours averages at about 50%, and the estimated annual mean evaporation is about 1,100 mm.

3.3.3 Run-off, Flood and Sediment

The run-off of the main course of the Sala river has been observed since 1965 at Juranggempal (Wonogiri) and Jurug (Surakarta). An annual mean run-off at Juranggempal and Jurug is 28.4 m^3/s and 64.1 m^3/s, respectively.

Flood of 500 m^3/s occurs in the project area with the frequency of 2.5 times per year. The largest flood ever recorded occurred in 1966. According to the record, the flood discharge at Juranggempal and Jurug was 4,000 m^3/s and 2,160 m^3/s, respectively.

Sediment load

The sediment load which should be taken into account for the river improvement consists of silt and sand. But, the silt occupies a large percentage of the sediment load.

Most of the silts coming both from the upper reach and the basin of the river improvement reach are carried away to the down stream of the river improvement reach by the flow. Therefore, it has not caused the bed formation.

The sand is considered to be a main cause for the river bed formation from the fact that the river bed material along the river consists of only the sand with 0.5 mm in diameter. However, the river bed evolution by the sand seems to be rather small since tractive force along the river is estimated to be balanced.

3.3.4 Soils

The soils in the project area are classified into four great soil groups, namely, "Grumusols," "Alluvial soils," "Hydromorphic soils" and "Lithosols."

The grumusols mainly extend over the southern part of the project area. Alluvial soils occupy the natural levee and flood plain along the Sala river and its tributaries. Hydromorphic soils extend over the poorly drained or depressed land on the skirt of Mt. Lawu. Lithosols develop over the isolated highly elevated land in the southern part of the project area.

Grumusols, alluvial soils and hydromorphic soils are relatively deep in effective soil depth, fine in soil texture, high in base saturation degree, high in cation exchange capacity and low in soil permeability. These soils are poor in their nutrient status, but are suitable for irrigation farming of rice, sugar cane and polowijo crops. It is essential for increased agricultural production on these soils to provide irrigation farming including proper fertilization, proper irrigation water management, etc. The land covered with Lithosols is the stony land with very shallow effective soil depth. Therefore, Lithosols are not suitable for irrigation farming. (Details of the soils are explained in Appendix III, Agriculture.)

3.3.5 Geology and Soil Mechanics

Geology

(Geology of Colo weir-site)

The geology of the Colo weir-site is divided into two layers; one is the bed rock of the volcanic clastic rock of the Miocene epoch, and the other is the upper layer of similarly volcanic clastic rock presumed to be of the Pliocene-Pleistocene formation.

The bed rock consists of lapilli tuff, tuff breccia and volcanic breccia, and the upper layer tuff breccia. The tuff breccia of the upper layer is less solidified and accordingly, softer than the bed rock.

(Geology of the proposed sites for aqueducts, syphons and gate facilities)

The geological structure of the sub-surface formation of the project area has a remarkable local variation brought in the process of its formation.

In relatively large tributaries such as K. Dengkeng and K. Samin, fluvial deposit is sorted into sand and clay of alluvial nature in the thickness of several meters, overlying the volcanic products. In other areas except the fluvial-deposit area, unconsolidated tuffaceous clay spreads immediately below the thin top soil. As it goes lower, the tuffaceous clay turns into stiffer tuff or tuff breccia. The tuffaceous clay does not seem to have a bearing capacity large enough to support a concrete structure. A semi-consolidated tuff or tuff breccia also has a varying degree of stiffness.

Soil Mechanics

The physical and strength properties of the soil prevalent in the project area have been studied for the design and construction planning of the main canals for irrigation and levees for river improvement. It has been confirmed that the soils in the project area are usable as banking materials.

3.3.6 Water Resources and Water Quality

Six principal tributaries /1 of the Sala river originating from Mt. Lawu and three tributaries /2 of K. Dengkeng with small watersheds are the main irrigation water resources at present in the project area.

The specific drought discharge in the dry season at the watershed of the said tributaries is estimated at 30 l /s/km^2 on the basis of the water measurement data obtained at a similar watershed in Madiun (Refer to Appendix I). From this, total amount of drought discharges is estimated at about 9.2 m^3/s in Karanganyar-Sragen Region, and 1.2 m^3/s in Dengkeng Region. The figures indicate that only a limited area of the project area can be irrigated by the said water resources.

With regard to water quality of the Sala river, there are no problems for its irrigation use. The pH value is relatively high at about 7 being influenced by the high content of calcium. (Details are shown in Appendix IV).

/1 K. Jlantah, K. Samin, K. Grompol, K. Mungkung, K. Sragen and K. Kenaten

/2 K. Paciman, K. Jatimalang and K. Dengkeng

3.4 IRRIGATION, DRAINAGE AND OTHER INFRASTRUCTURE

3.4.1 Irrigation and Drainage Systems

The cultivated land in the project area is classified into three categories in terms of the installed irrigation facilities, namely, technical irrigation area, semi-technical irrigation area and non-technical irrigation area. About 14,440 ha of the land belongs to the technical irrigation area well provided with irrigation facilities, while about 1,700 ha of the land belongs to the semi-technical irrigation area having irrigation facilities without distribution and water measuring devices. The remaining land of about 7,060 ha is non-technical or rainfed area which has only temporary irrigation canals or no canal system. Details of the classification are presented in Table 2.

Six reservoirs constructed in and around the project area provide the irrigation water. In addition, about 40 diversion weirs and about 30 major pumps exist in the project area. Details are shown in Table 3 and 4. However, their capacity is limited as to cover only a part of the cultivated land, particularly in the dry season.

Although the main canals and the secondary canals in the technical irrigation area and semi-technical irrigation area are relatively well maintained, the canals in non-technical irrigation area are seriously deteriorated by silting and scouring on their side-slopes throughout their entire length.

The density of the existing farm ditches (tertiary canals and quaternary canals) is approximately 30 m/ha in technical irrigation area and semi-technical irrigation area. There exist no farm ditches in non-technical irrigation area and rainfed area. The density of these farm ditches is not adequate so as to supply irrigation water equitably on farm. In non-technical irrigation area and rainfed area, paddy-to-paddy irrigation without farm ditches is prevailing in the area.

As regards the drainage system, the farm drains have not been developed over the entire area. The low-lying areas along the Sala and K. Dengkeng are fairly well equipped with drainage system, mainly consisting of the main and secondary drainage canals. The density of the drainage system on farm is 30 m/ha in the technical irrigation area and the semi-technical irrigation area, and almost none in the non-technical irrigation area and rainfed area. These are not enough to drain heavy rain and excess irrigation water.

Most of the existing farm roads in the project area are not only poorly maintained but are not jeepable. The density of farm roads, including the maintenance road is 30 m/ha in the technical irrigation area and the semi-technical irrigation area and 10 m/ha in the non-technical irrigation area and the rainfed area.

3.4.2 Transportation and Communications

Transportation services available in the project area consist of those by road, railway, and air line. They are fairly well established.

A paved, national road runds through the project area, which links Surakarta with Yogyakarta, Semarang, Madiun, Jakarta and Surabaja. Tree two-lane, paved, provincial roads are leading from Surakarta respectively to Purwodadi, Wonogiri, and Madiun via Magelan.

The southern trunk line of the national railway, which connects Jakarta with Surabaja, is available in Surakarta and a few towns in the project area. In addition, a local railway line runs between Surakarta and Wonogiri.

Garuda Indonesia Airway, a national carrier, operates daily services between Surakarta and Jakarta.

Telecommunication system is well established in Java Island. Both domestic and international telephone and telegram services are avaialble in Surakarta.

3.4.3 Electric Power Supply

Major towns in the project area get electric power from the isolated diesel power plants; 600 kW in Sragen and 120 kW each in Karanganyar, Sukoharjo, and Wonogiri, summing up to 960 kW in their total capacity. Surakarta city is fed by the Tuntang power supply system having the total capacity of 80,000 kW, which also supplies power to other major towns in the eastern part of the Central Java such as Yogyakarta, Kutoharjo, Magelang, Semarang and Kudus. The per-capita consumption of electric enegry and the peak power in the project area is about 300 kWh and 70 W, respectively.

Power requirement of the waiting consumers in Central Java has amounted to 240,000 kVA since1976, while the total capacity of power facilities installed has been only 30,000 kVA. There are thus a large number of waiting customers in Central Java. Power stations now under construction by PLN and those in the planning stage are 6,800 kW in diesel power and 10,200 kW in hydro-power, and power development is substantially required to satisfy the demand in the region.

3.5 LAND USE AND AGRICULTURAL PRODUCTION

3.5.1 Land Holding and Land Tenure

Land holding in the project area is characterized by its smallness in scale. Some 80% of the farmers are classified into small farmers who own less than 1.0 ha each. The average land holding per farmer is estimated at 0.52 ha in the project area.

With respect to land tenure, about 80% of the land is cultivated by landowner while some 20% by tenant in the project area. There exist two kinds of land tenant system, namely, Sewa (lease with fixed cash rent) and crop sharing system. In the project area, Sewa is the most popular tenant system and the crop sharing systems such as Mertelu and Maro are almost neglegible.

3.5.2 Land Use

Out of the total area of about 31,000 ha in the project area, about 76% or 23,500 ha is the farm land, while the remaining 7,500 ha is used as village area, roads, river, etc. The cultivated land comprises 23,200 ha of paddy field and 300 ha of upland field.

The irrigation facilities have been istalled relatively well although considerably deteriorated. The land under irrigation accounts for 67% of the cultivated area and the rest is rainfed area.

The main crop grown in the project area is paddy, which occupies about 80% of the total cultivated area in wet season. However, the cultivation area of paddy decreases to only about 5,920 ha in dry season due to the limited available irrigation water. This is attributable to the uneven precipitation in the region and to the lack of complete irrigation facilities, although partieal repair and improvement of the existing irrigation systems were carried out during the Pelita 1.

Sugar cane is planted as another important crop on about 1,800 ha of the irrigated area. Polowijo crops such as maize, cassava, peanut and soybean are planted both on the irrigated area and the rainfed area. The multi-cropping index /1 at present is relatively low at 1.5 in the project area as shown in Table 5.

/1 Multi-cropping index = total planted area/total farm land

3.5.3 Irrigation Practice and Water Use

The irrigation water in the project area is not suffieient even in the wet season. Particularly, in the dry season an extreme shortage of the irrigation water occurs. Under such situation, the Golonggan system /1 has been prevailing in the project area to utilize the limited available water to the maximum extent.

On the basis of the available data processed by the Pasten method as well as the results of the current field survey, water consumptive use on farm is estimated at about 0.3 to 0.6 l/s/ha. This seemingly low unit consumptive use on farm in the project area is due to the use of the return flow.

3.5.4 Cropping Pattern and Farming Practices

Typical cropping pattern and cropping calender are estimated for the three regions of the project area on the basis of the collected data, which are shown in Figs. 2 to 4.

As illustrated in the figures, paddy is the most important crop cultivated on the paddy field followed by sugar cane, while polowijo crops are planted both in the wet season and dry season for producing supplemental staple food.

As paddy cultivation depends mainly on the rainfall at present, seeding time differs every year. In normal year, the wet season paddy is planted between October and December and harvested in February to April. The dry season paddy is planted immediately after the harvest of the wet season paddy and harvested in July. On about 900 ha in Dengkeng area, planting of paddy is commenced in April because of flooding.

In the project area, improved high yielding varieties (IR series) have been widely spread along with local varieties. Fertilizer dosage is relatively high at present ranging from 110 to 190 kg of urea and 40 to 65 kg of triple superphosphate per ha. Application of agricultural chemical is extended relatively well over the project area. Farming in the project area is labor intensive from the stage of seeding to harvest although draft animals such as buffaloes and oxen are used for land preparation.

In spite of the relatively large inputs amount provided, the yield is not as high as expected due to improper timing in the application of fertilizers and chemicals and the lack of sufficient irrigation water. Other factors such as non-availability of inputs in time and the lack of proper water management and cultivation techniques are the constraints on the high yield.

/1 A typical rotation system of the irrigation water in Indonesia

Sugar cane is cultivated only on the irrigated land under the contract with PNP XVI. Planting is carried out from March to May, and harvesting in May to July of the following year. The variety applied in the project area is P.O.J., the growing period of which is 14 months.

Polowijo crops are planted both in the dry season and wet season, using soil moisture which remains after the wet season paddy is harvested and rainfall at the onset of the wet season. Major crops are cassava, peanut, soybean and maize. The yields are generally low since no fertilizers or chemicals are used.

3.5.5 Agricultural Production

Unit crop yield and the total crop production in the project area are assessed from the data obtained at the agricultural offices, PNP XVI and from the current farm survey, and are presented in Table 6.

As shown in the table, unit yields are generally low except for sugar cane. The unit yield of paddy/1 is ranging from 2.0 to 3.8 t/ha depending on the land condition while the unit yield of sugar cane is relatively high of 92 t/ha. Total production of farm crops are 83,600 tons of paddy, 168,000 tons of sugar cane, 500 tons of soybean, 300 tons of peanut, 1,500 tons of maize and 11,900 tons of cassava.

Livestock raising is not a main line of the agricultural activity in the project area, but plays an important role in view of protein food supply and providing animal power for cultivation.

3.5.6 Marketing

Distribution of farm inputs

Most of the necessary inputs for paddy production such as seed, fertilizers and chemicals are provided by the cooperatives (BUUD/KUD) at the subsidized prices through BIMAS/INMAS programs. The distribution system of farm inputs for paddy through BIMAS program is illustrated in Appendix III, Agriculture.

/1 In this report, the term "paddy" refers to "dry stalked paddy" unless otherwise specified. The rates of conversion from dry stalk paddy to dry grain and milled rice are as follows:

dry stalked paddy - dry grain ; 77%

dry stalked paddy - milled rice ; 52%

In the project area, BUUD/KUD was established in most of the irrigated areas and began functioning under the BIMAS/INMAS programs. However, these inputs are often not distributed timely and enough in volume partly due to the lack of transportation and storage facilities and partly due to unsatisfactory management.

For sugar cane production, all inputs are supplied by PNP in case of contract cultivation.

Marketing of outputs

Marketing of rice is handled by Tebasan (middleman who purchases standing paddy in the field), middleman, rice miller and BUUD/KUD in the project area. General market flow of rice is presented in Appendix III, Agriculture.

Most of the products are distributed through Tebasan, middleman and local market. The share of distribution by BUUD/KUD is very limited due to its high quality standard for purchasing paddy and relatively low purchase price. BULOG purchases rice mainly from BUUD/KUD for stabilizing the price at a floor price and sell it when the market price goes up above a ceiling price. However, the operation of BULOG is limited to the control of rice imports and to the supply to the military and Government employees due to still inadequate organization, insufficient staffing and storing capacity.

With respect to sugar cane, the products are brought to PNP factory for processing. Refined sugar is sold at the market through BULOG, which is a sole agent for sugar processed by PNP. BULOG undertakes market operation for stabilizing the price as in the case of rice.

Most of the polowijo crops harvested in the project area are distributed through middlemen including Tebasan or brought to local market directly by farmers.

3.5.7 Farm Economy

Farmers in the project area get their income mainly from farming activities particularly the paddy production, partly supplemented by the sale of polowijo crops. As animal husbandry is not a main line of agriculture in the project area, income from the sale of livestock is very limited. Total annual farm income is estimated at Rp. 106,000 to Rp. 149,000 for the average farmer holding 0.52 ha. In addition, farmers get income from non-farm activities such as Sewa (lending land), off-farm labor, trade and others which account for 10-20% of gross income for the average farmer.

Farming expenses are about 40% of the farm income for the average farmer. Farm investments on livestock and farm equipment are not large in the project area.

High ratio of food expenditure to total living cost is a characteristic of the consumption in the project area. Total living expenditure is ranging from Rp. 90,000 to Rp.110,000 .

The resulting net reserves of the average farmer are negligibly small as shown in the typical farm budget in Appendix III, Agriculture. This indicates that agricultural production in the project area is relatively low and the farm economy is on the subsistence level.

3.6 AGRICULTURAL SUPPORT SYSTEM

3.6.1 Operation and Management of Irrigation Facilities

Operation and maintenance of the existing irrigation system down to secondary canals come under the responsibility of Seksi with the coordination of provincial Public Works Department (Wilayah). Operation and maintenance of the irrigation and drainage facilities below the tertiary canals are taken care of by the cultivating farmer's own organization called "Dharma Tirta", which exists in each village in the irrigated area. In Dharma Tirta, all the works are conducted through voluntary contribution of labor. There is one Ulu-Ulu (water master) in each village who is in charge of allocation of the irrigation water from tertiary canals. Farmers contribute 10-30 kg of paddy per ha in each season for operation and maintenance and as remuneration for the labor of the assistant Ulu-Ulu.

3.6.2 Research and Extension Service

In Central Java, research work is conducted by the Research Division of Dinas Pertanian, Central Java, under the technical guidance and supervision of the Central Research Institute of Agriculture, Bogor and the Division of Agricultural Technique of the Ministry of Agriculture.

There is no research station in the project area, but one seed center exists in Tegalgondo near Surakarta city, which plays an important role in providing rice seed in the project area.

Agricultural extension service in Central Java is operated through the systematic organization from the Ministry of Agriculture to Dinas Pertanian, and downward to Kecamatan. There are 20 Agricultural Offices at Kecamatan level in the project

area, where about two or three extension workers (PPL) are stationed for promoting the extension work.

The extension activities are carried out in the form of mass, group and individual contacts by about 40 PPLs in the Kecamatans which come either wholly or partially under the project. However, the service area of one PPL is about 1,200 ha of paddy field far below the recommended density of one PPL per 400 ha. Furthermore, due to the acute shortage of trained staffs and the lack of transportation and communication facilities, the extension service is quite insufficient in its effect. Another problem in the extension service is that the service is not well linked up with input supply.

3.6.3 Agricultural Cooperatives and Credit

During 1975, BUUD (Budan Usaha Unit Desa) was up-graded to KUD (Koperasi Unit Desa) in the project area and about 40 KUD are engaged in input supply and marketing. However, the activity of the cooperatives is hampered mainly by the lack of capital and insufficient number of trained staff. Distribution of farm inputs handled by KUD is not satisfactory and the share of rice marketing is quite limited.

The Indonesian People's Bank (BRI) provides rural credit all over the country. Since 1964, BIMAS program has been introduced for attaining self-sufficiency in foodstuff. Under the program, the activity of the Bank has been considerably strengthened to offer special short term package loan for paddy production with the monthly interest rate of 1.0 % for the six months.

In the project area, the package loan has been operated relatively well so far through the network of Unit Desa to the extent of 80% and 45% of the rice planted area in the wet season and dry season, respectively. However, the recovery rate of the loan was particularly low in the wet season of 1975/1976 when serious crop damages occurred.

3.6.4 Rural Development Mechanism

A number of Ministries are directly concerned with socio-economic development of the rural Indonesia, in particular, the followings:

(i) Ministry of Public Works & Electric Power in charge of river control, electric power, irrigation and drainage; (ii) Ministry of Agriculture in charge of Bimas production, agricultural extension, and water management under tertiary/ quaternary channels, etc; (iii) Ministry of Transmigration,

Cooperatives and Manpower in charge of development of BUUD/KUD; (iv) Ministry of Finance in charge of rural credit through BRI, and (v) BULOG in charge of rice price stabilization through market operations.

Their perpendicular organizational structures and functional system as well as the lateral coordination among each other at different levels are shown in Appendix II, Institutions.

However, the rural development mechanism does not always function well, due to the lack of mutual communication among these organizations.

3.7 PRESENT CONDITION OF THE SALA RIVER

3.7.1 River Basin

The Sala river rising in Mt. Seribu runs northward among the low hills. After turning its course northwestward near the Nguter bridge and then northeastward below confluencing with the K. Dengkeng, the river passes through Surakarta and flows into the Java Sea.

The river stretch of the upper Sala, from the Nguter bridge to Surakarta, has several main tributaries. K. Dengkeng, K. Pusur, K. Bentugan, K. Brambang and K. Kembangan are rising in Mt. Merapi, an active volcano which bursts into eruption every three to five years and sends out a huge amount of eruptive products. Other main tributaries such as K. Jlantah and K. Samin originate in Mt. Lawu. Highly cultivated lands are found on both banks of the river stretch. The gradient of the right bank basin is approximately 1/1,200 and the left bank approximately 1/700. The catchment area of the river is 1,350 km^2 at the Wonogiri dam site and 3,320 km^2 at Surakarta, respectively, as shown in Fig. 5.

The Sala river causes inundation during every wet season causing much damage to agricultural products and properties. In particular, the people who live in the district along the river near the confluences with K. Jlantah and K. Dengkeng have been afflicted by the habitual inundation during the wet season when they are compelled to abandon farming.

In the 1966 flood, which was the largest in the past 10 years, the flood lasted for about a week in the area upstream of Surakarta, and the inundation depth reached 2.5 m on an average. The flood attacked Surakarta city by breaking the dyke surrounding it causing many deaths and injuries and also an enormous amount of damages. After this flood, the dyke was repaired and heightened for assurance of enough safety against a flood as large as the 1966 flood. Inundation areas in the 1958, 1966 and 1975 floods are shown in Fig. 6.

3.7.2 River Condition

Discharge

The runoff characteristics of the Sala river at Juranggempal and Jurug are as shown in Table 7.

River channel

The Sala river is almost a natural river except the stretch with a levee of about 30 m long and about 3.0 m high constructed on the left bank downstream of its confluence with K. Brambang. In addition there are continuous levees which were constructed by the local government on some main tributaries such as K. Dengkeng and K. Jlantah, but these are not well maintained.

Although the flow capacity of the upper Sala is about 500 m^3/s, that in the stretch upper from its confluence with K. Jlantah is only about 200 m^3/s as the channel is rather shallow, and its neighborhood is habitually inundated.

The causes of inundation of the areas along the tributaries are classified into two factors: one is the back water of the Sala river and the other is the small discharge capacity of the tributaries.

Existing river facilities

Fig. 7 shows the location of the existing facilities on the projected river stretch. There are a levee, pump stations and boat ramps along the Sala river. Pump stations with the capacity of 0.2 - 0.5 m^3/s are installed along the Sala river for irrigation purpose. On the tributaries, there are intake weirs, intake gates and drainage gates for irrigation.

There are six bridges on the projected river stretch such as the Nguter railway and road bridges, Bacem road bridge, Mojo railway bridge and Jurug railway and road bridges. All of them were constructed to span the existing river course. But they are quite old, especially the Bacem bridge was deteriorated due to submerge during the extraordinary large flood of 1966. The discharge capacity of the river course in the neighborhood of the bridge is rather limited, which is shown in Table 8.

Administration of the river

The Sala river is under the administration of the Central Office of the Project Bengawan Sala, while its tributaries under the local Governments concerned. Since the administration system is not unified, so far, river improvement works have been performed without any regard to the connection between the main river and its tributaries.

3.7.3 River Utilizations

The main river and its tributaries are utilized not only for irrigation water supply and drainage of excess irrigation water but also for bathing by the inhabitants and washing of cattles, etc. The Sala river is also used as a sewerage from Surakarta city and other towns and villages, which contaminates the river water. Besides, a great deal of floating dirts and a drift wood are found in the downstream of Surakarta.

Sand collecting activities are seen at places along the river but the quantity collected is negligible at present. In addition, fishing is a common practice which provides the inhabitants with a supply source of protein. The Sala river is also utilized as a waterway for small boats to transport people and commodities between villages.

3.7.4 Flood Damage

The project area is highly developed and there are many village settlements on the vast flat fertile lands along the Sala river and its tributaries. However, since there are no proper river improvement works executed so far, a considerable amount of flood damage occurs annually throughout the area. Flood damages are severe in the overflow areas of the upper reaches of the Sala.

Flood damage consists of direct damage, indirect damage and intangible damage. Direct damage involves damages to building and crops plus damages to transportation and utility facilities. Indirect damages include the travel cost of detouring around the flood area, and the net loss of normal profit and earning to capital management and labor in the identifiable zone of flood influence, and net increase in the cost of forecasting and warning, evacuating and reoccupying flood-threatened areas are also included. Intangible damages comprise loss of human life, impairment of public health due to the outbreak of diseases, and adverse effect on national economy resulting from temporary closure of major transportation arteries.

In this study, only the direct damages to building and farm crops assessed and indirect damage which is estimated by applying a fixed percentage to the direct damage are included, while intangible damage is excluded.

For estimation of annual flood damage, the present flood potential loss is firstly calculated on the basis of the inundation area, damage rate and value of the properties newly evaluated. The same damage rate as used in the "Feasibility Study on Surabaya River Improvement" is applied for the estimate

of the flood potential loss. Then, annual flood damage is worked out by using the discharge-frequency relation of the flood events. The mean annual flood damages/1 in the Surakarta area and the Sragen area estimated is US$6.56 million and US$3.56 million respectively.

/1 Details of the estimate are presented in Appendix II, River Improvement.

4. IRRIGATION PLAN

4.1 GENERAL

The irrigation plan for the Wonogiri Multipurpose Dam Project was formulated principally to maximize the irrigation benefit under the condition that the effective storage of the Wonogiri reservoir for irrigation use is 400 million m^3 which was determined as the result of the optimization study of the reservoir capacity during the previous feasibility study.

For selecting the most optimum irrigation plan, the following three cropping patterns were compared taking into account the national economic policy and the impacts on the regional socio-economy.

i) Two paddy crops per year

ii) Two paddy crops plus one polowijo crop per year

iii) Five paddy crops in two years (or 2 1/2 paddy crops per year)

Water requirement for the assumed irrigable area was calculated for each plan, based on which preliminary design and layout were made. Construction cost and expected benefit were also estimated for each plan

Through the economic comparison, including cost benefit analysis as well as the technical comparison, the third alternative of five paddy crops per two years was selected as the most optimum plan and 23,200 ha of the irrigable area was chosen as the project area for the irrigation project. The project area consists of three regions in terms of the existing irrigation system, namely, Sragen area of 9,500 ha, Karanganyar area of 10,100 ha and Dengkeng area of 3,600 ha.

In order to enable five paddy crops in two years on the whole project area, necessary infrastructures and supporting services are provided for as follows:

i) Construction of Colo intake weir;

ii) Construction of the main and the secondary irrigation canals;

iii) Rehabilitation of the existing drainage ditches and construction

iv) Construction of other structures related to the irrigation canals;

v) Construction and rehabilitation of the farm roads, and

vi) Operation and maintenance of irrigation and drainage facilities and other supporting services such as water users' association, agricultural cooperatives and pilot scheme.

4.2 AGRICULTURAL DEVELOPMENT PLAN

4.2.1 Land Use and Cropping Pattern

Land use

Upon completion of the irrigation facilities, all the project area will be turned into technical irrigation area and the land use is expected to become more intensive with the introduction of year-round irrigation farming.

Predominant crop in the project area will continue to be paddy, but its production is anticipated to become more intensive. Sugar cane area will be increased from the present 1,800 ha to 2,100 ha, while the cultivation of polowijo crops will be discontinued in the project area in view of its low profitability.

The land use expected in future with the irrigation project is presented in the Table 9, in which multi-cropping index is estimated at 2.23.

Cropping pattern

From the three alternative cropping patterns mentioned in the preceding section, the cropping pattern of five paddy crops in two years is selected as most optimum through the economic comparison as well as technical comparison. The proposed cropping pattern is illustrated in Fig. 8.

In determining the optimum cropping pattern, selection of crops to be planted is made in due consideration of the demand supply condition and profitability. Agronomic considerations are given on such aspects as temperature, required sunshine for the heading period, water consumption and fallow period for introducing the intensive paddy production. Prevailing intensive cultivation of paddy in Klaten, adjacent to the project area is also investigated for ascertaining the feasibility of the intensive farming.

From these studies and investigations, it is confirmed that this intensive cropping pattern will be adopted all over the project area provided that enough irrigation water is available.

4.2.2 Farm Inputs and Farming Practices

Proper application of fertilizers and chemicals is most essential for full exploitation of the agricultural potential under the irrigation farming. Since the soil in the project area lacks such major nutritious elements as nitrogen and phosphate, these elements need to be supplied in the form of chemical fertilizers.

The estimated total fertilizer requirements are 250 kg/ha of urea for nitrogen, and 100 kg/ha of triple super phosphate for phosphate in case of rice, and 600 kg/ha of ammonium sulphate and 200 kg/ha of triple super phosphate in case of sugar cane.

As to the damages to rice, the disease caused by grassy stant virus carried by leaf hopper was conspicuous in 1975/76. The principal damage was due to that caused by rice-borer. In due consideration of these aspects 4 litre/ha of insecticides such as diazinon is proposed to be applied.

Proper water management during the growing stage of rice is also very important in order to attain the target yield by using the high yielding variety. The required techniques are drying practice, the intermittent irrigation, and an application of deep or shallow water, etc.

4.2.3 Anticipated Yield and Crop Production

The present crop yield is low, mainly because of the shortage of irrigation water. Substantial increase in crop production is not expected without improvement in irrigation condition, though slight increase will be possible through extensive use of inputs and expansion of improved farming technics.

An introduction of the improved and advanced irrigation farming as recommended, however, will help raise the present low yield of crops year after year under with-project condition. The estimate of the future yield of crops has been made on the basis of the results of the experiments made at the Bogor Agricultural Experimental Station and IRRI as well as the practical cultivations on the well-irrigated land in the adjacent areas. The yield is expected to reach the maximum in the seventh year after introducing the improved irrigation farming. The anticipated unit yields and productions are as summarized in Table 10.

4.2.4 Marketing and Price Prospects

Marketing prospects of farm products

Future prospects of the demand-supply condition of rice and sugar cane are projected for the period of 1974 - 1990. (Details are described in Appendix III, Agriculture.)

Although the projection is made on the basis of the rather simple assumptions and comparison, the results suggest that the shortage of rice will continue in the future if the production increase rate per year is less than 3%, and at least 4% annual increase is required for attaining self-sufficiency on the national level by around 1990.

As the expected annual increase ratio of 4% for rice is a relatively high rate, its realization will not be as easy, and therefore, the anticipated rice production increase by about 0.1 million tons (about 0.19 million tons in dry stalked paddy) in the project area is expected to find outlets in the domestic market.

The forecasted production increase of sugar is also expected to be marketable in the domestic market by the comparative study between the anticipated per-capita consumption increase and the anticipated production in the future.

Price prospect of farm products

Prices of the farm products in the future are estimated for the purpose of evaluating the expected irrigation benefit and farm budget.

Economic farm gate price is estimated on the basis of the projected international market price/1 taking into account the transportation, processing and other costs and expenses. Financial price of farm products at farm gate is estimated by using the actual historical prices in the local market.

The forecasted prices are presented in Table 11, and details of the estimation are briefly described in Appendix III, Agriculture.

4.3 IRRIGATION PLAN

4.3.1 Water Resources

Irrigation water required in the project area will be supplied by the Wonogiri reservoir having a total storage capacity of 440 million m^3. This storage capacity was justified by the previous feasibility study in 1975. In the total storage capacity about 10 million m^3 is allocated to the pondage loss at Colo reservoir and about 30 million m^3 to river maintenance. The irrigation plan is, therefore, formulated on the basis of 400 million m^3.

/1 The international price as forecasted by IBRD for the period of 1980 to 1985 is used.

4.3.2 Basic Year for Irrigation Plan

In the Master Plan worked out during 1972 to 1974, the year 1967/1968 was chosen as the basic year, which falls on the year of the seven year probability rainfall. The selected basic year was applied to the previous feasibility study.

After reviewing the available data and referring to the same kind of irrigation projects in Indonesia, the year of 1967/1968 was finally selected as the basic year for the present irrigation plan.

4.3.3 Water Requirement

As there were no data available on the consumptive use of water for the crops, the irrigation water requirement has been estimated on the basis of both climatic and soil conditions as follows:

i) The consumptive use of water for crops is calculated by using the Hargreaves method,

ii) Assessment of percolation loss and farm waste,

iii) Deduction of effective rainfall from the summation of the amounts obtained in the item i) and ii), and

iv) Irrigation water requirement is assessed as the summation of the amounts obtained in the item iii) and conveyance loss.

Upon the comparative study among the three alternative cropping patterns as mentioned in Section 4.1, the most intensive cropping pattern of 2-1/2 paddy crops a year was selected for the entire irrigable area of 23,200 ha in view of utilizing the available water resources of 400 million m^3 from the Wonogiri reservoir to its maximum extent.

The maximum diversion discharge is thus estimated at 29.4 m^3/s. The design discharges for the Upper Sala Main Canal and the Dengkeng Main Canal are determined as shown in Table 12.

4.3.4 Irrigation System

The water released from the Wonogiri reservoir through the power station will be re-regulated at Colo weir, located at about 14 km downstream, and distributed to the project area through two main canals, the Upper Sala Main Canal and the Dengkeng Main Canal.

Colo diversion weir

For the selection of the optimal site for the weir, a field survey was carried out at four alternative sites from such aspects as geology, topography and hydraulics. As a result, Alternative-D/1 has been newly recommended as the most optimum site, which is shown in Fig. 9. The selection has been made after considering such as the afterbay function for the power station, the regulating capacity for irrigation, the height of the weir, the foundation conditions, and the compensation.

The Colo reservoir has been so planned as to have a dead capacity accommodating the expected sediments coming from its catchment area for a period of 100 years; it will function effectively as an afterbay of the power station, as well as a re-regulating reservoir of irrigation water. It will not be necessary for the Colo weir to have large scale gates, on its full width, for sand flashing purpose. One intake system with one sluice on the right side of the weir has been selected from sedimentation, operation and maintenance and economic points of view.

No particular consideration has been given to the installation of a silting pond, since major parts of sediment such as bed-load runoff from the Colo catchment area can be wholly trapped and silted at Wonogiri reservoir and Colo reservoir.

Irrigation canals

With additional technical information and newly prepared topographical map on hand, review and assessment of the results of the comparative studies made in the previous feasibility study was carried out, and consequently the long canal system consisting of 62.4 km of the Upper Sala Main Canal and 31.4 km of Dengkeng Main Canal has been adopted. The pumping system to make the long canal shorter which is proposed in the alternative plans was also compared with the adopted plan and the long canal system was eventually proved to be economically justifiable. (See Fig. 10.)

Alignment of the main canals has been made to satisfy the basic principle for the canal designing, that is, the assurance of the safety at the minimum cost for its construction and maintenance.

On this principle, the route of the Upper Sala Main Canal which will irrigate about 19,600 on the right bank of the Sala river is shifted towards the higher elevation by about 0.5 km compared with the route suggested in the previous report.

/1 Alternative-D is located on the right bank of the Sala river, farthest downstream among the said four sites.

The Dengkeng Main Canal which will irrigate 3,600 ha on the left bank of the Sala river is realigned and shifted about 1 km southwestward in view of enlarging the command area.

Since the proposed main canals, the Upper Sala Main Canal, in particular, cross many tributaries of the Sala river and the existing irrigation canals, it will be necessary to construct the crossing structures such as siphons, aqueducts and culverts.

In addition, turnouts, water measuring devices and checks will be provided for distribution of the irrigation water, while spillways and drains will be installed to protect the canals. Roads and bridges will also be constructed for the operation and maintenance purposes.

(Secondary canal)

The irrigation water diverted from the proposed main canals will be led by the secondary canals to the minimum service unit area of 150 ha. The existing irrigation canals in the project area will be rehabilitated to be used as the secondary canals by being connected with the proposed main canals. The rainfed and non-technical areas in the project area will have to be provided with new secondary canals.

(Farm network)

The entire irrigable area with an extent of 23,200 ha is divided into 49 service blocks: 39 in Upper Sala area and 10 in Dengkeng area. Taking into consideration the size and general shape of the farm blocks and also, on the assumption that each farm block will have a ditch at least on one side of it for equitable distribution of water, the farm ditch network was designed to have ditch density of 40 m/ha. For proper water management and effective farming practice, the density of farm road is designed at about 30 m/ha.

(Drainage system)

To provide a suitable drainage facility is one of the most important factors for increasing agricultural productivity in the project area. The density of drainage channels required for this purpose will be 40 m/ha. The proposed drainage network is planned in such a manner that each farm block has a drainage ditch at least on one side of it. As far as the main drainage canal is concerned, its rehabilitation and new construction is proposed as one of the river improvement facilities along the Sala river (Refer to Appendix II). Once the river improvement project along the Sala river will be completed, most part of the low-lying area is expected to be relieved from annual inundation and the main drainage canals will function much more efficiently than at present.

4.4 PROPOSED IRRIGATION WORKS

4.4.1 Colo Diversion Weir

Hydraulic and structural designs of Colo weir are to be made on the basis of SHFD (1,600 m^3/sec) with 100 year return period which is the past maximum discharge estimated in 1966 at Colo weir site.

Based on the hydraulic design of the main canals, the water levels required at the starting points of the Upper Sala Main Canal and the Dengkeng Main Canal are set at maximum El.106.38 and El.105.45, respectively. The intake water level of the Colo weir is, therefore, set at El.107.00 in consideration of the intake losses of about 60 cm.

The water of the Wonogiri dam is released through the power station. The peak discharge of 60 m^3/s released from the power station will be re-regulated so as to meet the diversion requirement for irrigation. The required re-regulating capacity to be provided for at the Colo weir is about 1.2 million m^3. The elevation of the crest of the weir is determined at El.108.00. The principal dimensions of the Colo weir are summarized below, and the general layout is illustrated in the attached drawing.

Width of fixed weir	89.0 m
Height of weir from the proposed river bed	9.0 m
Width of sand flash	15.0 m
Type and size of sand flash gates	Sluice gate with rollers 7.5 m x 6.6 m
Width of intake (for the Upper Sala Main Canal)	5.0 m x 3 bays
Width of intake (for the Dengkeng Main Canal)	4.5 m
Type of intake gates	Sluice gates

4.4.2 Irrigation Canal Network

The design discharges for the main and the secondary canals are decided on the basis of the calculated water requirements for the project area. The design discharges are 24.3 m^3/sec and 5.2 m^3/sec for the Upper Sala Main Canal and the Dengkeng Main Canal, respectively. Total length of the main canal is 94 km which consists of 62.4 km of the Upper Sala Main Canal and 31.4 km of the Dengkeng Main Canal, while total length of the secondary canals is 81.2 km including 41.2 km of the canals to be newly constructed.

The profile of main canals is determined in consideration of the topographic condition and hydraulic requirement.

Preliminary design of the canals is prepared based on the following conditions:

i)	Type of canal	:	unlined, excavated or earth-embanked canal with trapezoidal section
ii)	Maximum velocity	:	less than 0.8 m/sec to protect the unlined canal banks from scouring
iii)	Longitudinal gradient	:	to provide enough diverting head at turnouts and to give sufficient head at siphons to wash down sediment and drifts

The typical cross sections and longitudinal profiles of the canals as well as their types and lengths are shown in Appendix I.

4.4.3 Drainage Canal (Farm Drain)

The drainage requirement in the project area was assessed at $0.6m^3/s/50$ ha., on the basis of the daily rainfall intensity of 150 mm/day given in the guide line manual for drainage works recommended by PROSIDA. Total length of the newly proposed farm drain is about 611 km. In addition, the existing farm drain of about 317km is to be rehabilitated by desilting in the technical and semi-technical irrigation areas. All the farm drains are designed to be unlined earth canal, with the bottom width of 1.0 m, the canal depth of 0.80 m and the side slope of 1:1.0 (vertical to horizontal), which are illustrated in Appendix I.

4.4.4 Related Structures

Inverted siphon and aqueduct

Large inverted siphons and aqueducts are provided for each with a control gate, spillway and wasteway at the inlet side to drain out rainwater and the excess irrigation water into the tributaries of the Sala river. Total numbers of the siphon and the aqueduct are 28 and 16, respectively. The design velocities of the siphon and the aqueduct are determined in correspondence with their discharges, as follows:

Discharge (m^3/sec)	Design Velocity (m/sec)
30 - 10	2.0 - 2.5
10 - 5	1.8 - 2.0
5 - 2	1.5 - 1.8
less than 2	1.0 - 1.5

The barrels and the shapes of the siphon and aqueduct are classified according to the discharge.

Culvert

For the portion of existing canals passing under the main canals, a small sized culvert with a single barrel reinforced concrete pipe or a double barrel rectangular concrete conduit is designed. Where the culvert barrel passes under the earth canal, the barrel-top will be set at least 1.0 m below the invert. Total number of the culvert proposed is 14.

Turnout

While a large-scaled turnout with a sluice gate and water measuring devices (Parshall flume) is provided for the main canal, an ordinary or small-scaled turnout equipped with Romain gate is proposed for the secondary or tertiary canals for an equitable water management. Total number of the turnout is 151.

Check structure

Check structures are proposed for the purpose of obtaining necessary hydraulic head for distribution of irrigation water at turnouts. The proposed type of the check gate is a combination of the fixed overflow weir and manually operatable gate.

Maintenance road and bridge

The width of the maintenance road along the main canal and the secondary canal is decided at 5.0 m and 3.5 m respectively. The maintenance bridge is designed as the composite of H-steel beam and planks as is prevalent in and around the project area. For structural design of the maintenance bridge, T-9 wheel-load is applied.

A composite girder bridge with a width of 9.0 m is designed where the main canal intersects the highway.
T-20 wheel-load is applied for the structural design of the highway bridge.

4.4.5 Farm Ditch and Farm Road

Total length of the farm-ditches requiring rehabilitation is 475.2 km, and that requiring new construction work is 452.8 km. All farm ditches are designed as unlined earth canals with a bottom width of 0.5 m, canal depth of 0.5 m and a side slope of 1:1.0 (vertical to horizontal). The typical cross sections are illustrated in Appendix I.

5. RIVER IMPROVEMENT PLAN

5.1 GENERAL

The proposed river stretches for river improvement works were originally selected in the Master Plan for the development of the Sala river basin prepared in 1974, since the flood prevention of the areas along the river stretches is most urgent with the highest priority among the river improvement works in the Sala river basin. The proposed river stretches include the main stream of the Sala river of 33 Km between the Nguter railway bridge (located at the point of 33 Km) and the Jurug bridge (located at 0 Km)/1, and river stretches of the eight tributaries of 30.5 Km in total, such as K. Jlantah, K. Dengkeng, K. Pusur, K. Buntungan, K. Brambang, K. Kembangan, K. Wingko and K. Samin, which are affected by the backwater of the main stream.

The plan for the river improvement works is formulated on the principle that probable flood damages on the areas along the said river stretches will be alleviated to an extent acceptable from technical, economical and social points of view. Especially it is also taken into account that the improvement works for the proposed river stretches will not have adverse effects on the areas along the downstream reaches where improvement works will not be provided under the project.

For attaining the planned effect of the flood prevention in these principles, it is planned to build levees, to dredge river bed and to provide flood control facilities such as retarding basins and emergency inundation areas. Furthermore, for stabilizing the river channel, revetment, groin, sodding and groundsill will be provided. Sluiceway and drainage channel will also be provided for the drainage of the landside water.

5.2 DESIGN FLOOD

The design flood for the proposed river improvement works is the 1966 flood (the largest flood recorded in the past), having a peak discharge of 2,000 m^3/s at Surakarta, under the condition with flood regulation by the Wonogiri reservoir, which corresponds to a flood with return period of 40 years. The discharge distribution of the design flood is as shown in Table 13 and Fig. 11.

/1 The distance is measured from the starting point (Jurug road bridge) to the upstream.

5.3 PROPOSED HIGH WATER LEVEL

It is advisable that the design high water level of the river channel be planned as low as possible to reduce potential damages. With this in view, a completely-excavated channel is preferable, but, which requires much excavation and high construction cost.

From the viewpoints of the safety of the levees and cost economization, the design high water level is set at two (2) m/1 or less above the elevation of natural river banks.

The river channel planned on the basis of the said design high water level has another advantage of facilitating the drainage of landside water. Fig. 12 presents the design high water level at every reach of the proposed river channel.

5.4 RIVER IMPROVEMENT WORKS

5.4.1 Alignment

The existing river channel meanders heavily in several locations. To secure the stability of the proposed river channel, it is planned to moderate excessive meandering by means of short-cutting, in due consideration of the amount of excavation, number of houses to be removed, and convenience for construction.

The total length of meandering portions to be short-cut is 13 Km out of the entire river length of 33 Km. As the areas for the short-cutting works are densely populated, the short-cutting works will result in removal of the people or splitting of the existing villages. The proposed alignment of the river channel is shown in Fig. 13.

5.4.2 Profile

Generally the most suitable profile is decided based on the existing river profile and in due consideration of the stability of the river channel. Furthermore the foundation condition of the existing bridge piers, the profile of downstream reaches from Surakarta, the elevation of natural river banks, and the profiles and discharge capacities of both Sala river and its tributaries are taken into account.

/1 Exceptions are the reaches being affected with the backwater caused by the existing bridges and narrow unimproved river channel downstream from Surakarta.

Table 14 and Fig. 12 show the proposed profile for the entire distance of the river improvement section.

Although the proposed profile is set as the most suitable one, the river bed in the reach upstream from the confluence of the Sala river with the K. Dengkeng still involves some scouring tendency because most of sediment load coming from the Wonogiri and Colo basins is to be trapped both in the Wonogiri reservoir and the Colo afterbay. Also in the reaches of the river between the Jurug road bridge and the confluence with the K. Samin, where the backwater occurs, tractive force will decrease and some sediment load will deposit.

5.4.3 Cross Section

Single cross section usually requires the least flow area, and is therefore generally economical. However, for the Sala river with extremely large seasonal fluctuation of discharge, composite-type cross section is recommendable in view of stabilizing the low-water channel against medium or small floods.

The inundation along the Sala river takes place mainly due to the insufficient discharge capacity of both the Sala river and its tributaries. In order to reduce the inundated area, it is desirable to make the cross section of the low-water channel larger. The design discharge for the low-water channel is decided at 900 m^3/s at Surakarta which corresponds to two-year probable flood. Table 15 and Fig. 11 present the design discharges for low-water channel at each of four reaches of the river.

The width of the proposed river channel is so decided that the levees will be sufficiently safe against scouring at the time of flood.

Fig. 14 shows the proposed standard cross sections.

5.4.4 Required Earthwork

The main work in the river improvement is the construction of continuous levees along both banks of the river.

The excavated materials from the river bed which are mainly sand are not to be used for levee embankment but for road embankment.

The total volumes of excavation and embankment are 6.8 and 6 million m^3, respectively.

5.4.5 Retarding Basin and Emergency Inundation Area

Retarding basin

Retarding basin has a function to regulate the flood discharge, protecting the proposed river channel and, at the same time, alleviating the flood influence to the area downstream of Surakarta. Two (2) retarding basins with the respective area of 1.35 and 0.95 km^2 and regulating capacity of 2.7 and 1.8 million m^3 are planned in the downstream of the confluence with the K. Dengkeng by utilizing the existing river channel, as shown in Fig. 13.

The regulation by the basins starts its function above the discharge of 1,100 m^3/s. The river-side levees in the retarding basins are planned to be 0.5 m high.

Emergency inundation area

As the K. Walikan flows through valleys, the rainfall over the basin will be directly discharged to the main river without being retained for a significant time. Therefore, intense local rainfalls in the upstream of the Nguter bridge would result in a flood of a larger discharge than the design flood discharge. The downstream area of the projected river stretch is a flat cultivated land including Surakarta city which has invaluable properties and assets. To protect these areas from unusual floods, construction of three emergency inundation areas are planned in the upstream of the confluence with K. Dengkeng. For all the emergency inundation areas, the overflow part of the levees having a crest length of 1 km is proposed.

The locations of the emergency inundation areas are shown in Fig. 13.

5.4.6 Riparian Structure

Bank protection

The proposed river improvement works involve the construction of continuous levees along both banks of the river. Both the levees and low-water banks will be protected mainly by sodding. The stone pitching is planned at the confluences with the main tributaries and also at bridge sites for protection against erosion. The wire mattress for bank protection is proposed for the places where the existing river will be closed as the result of the short cuts.

The bank protection of the low-water channel, excepting the reaches where the stone pitching is proposed, will be made mainly by groins. The interval of the groins is designed at 30 m in the sections of excessive meandering, 40 m in those of milder meandering and 60 m in the straight sections.

Wooden and concrete groins will be constructed at 259 places and 136 places, respectively. The total extension of the stone pitching is 6.8 km. Locations of the groins and the stone pitching are shown in Fig. 13.

Landside water drainage facilities

(Main drainage channel)

Since the Sala river has had no levee along most of its course, water is drained to the main river and tributaries directly. In the river course improvements of the Sala river, the main discharge channels running along the levees to gather and discharge landside water are planned for the distance of 74 km. The proposed route of the main drainage channel is shown in Fig. 13.

(Sluiceway)

The landside water gathered by ditches and drainage channels will be drained to the main stream and tributaries through the sluiceways. In view of safety of levee during flood, number of the sluiceways is reduced to the minimum extent. The sluiceways will be constructed at 35 sites including small sluiceways in the retarding basins, as shown in Fig. 13. The sluiceway will be provided with gates to shut off the reverse flow from the river into the landside area.

Groundsill

Most of the sediment load which is sent down to the Nguter railway bridge at present will be deposited in the Wonogiri reservoir and the Colo afterbay after the construction of the Wonogiri dam and Colo weir, accordingly it is anticipated that river bed below the Nguter railway bridge will be lowered. The groundsills are planned to be constructed at the two sites, each 20 m downstream of the Nguter railway and road bridge to protect their foundations. The location of the groundsills are shown in Fig. 13.

Bridge

There are six (6) existing bridges over the proposed river channel. The river stretches of each of these bridge sites excepting the Bacem bridge will have the discharge capacities enough to flow down the design discharge as shown in Table 16.

Two new bridges are being planned to be constructed in parallel with the Nguter road bridge and the Jurug bridge by Bina Marga. From the view point of river improvement work, some observations are made for the three bridges as follows:

(New road bridge at Nguter)

New road bridge planned by Bina Marga is to cross the existing river channel in parallel with the Nguter road bridge at its immediate downstream.

Under the present river improvement project, however, short-cutting is planned at the reach near the Nguter road bridge on the ground that the river channel is heavily meandering at that place and the flood flows had often over-topped the river banks running into farm lands, roads, etc. The bridge planned is located at the river section to be cut from the river course by short-cutting.

In view of the importance of the short-cutting in the river improvement work, it is recommended that the location of the bridge is changed to the site to cross the planned short-cut section of the river as shown in Fig. 13. Principal design features of the new Nguter bridge are shown in Table 17.

(New road bridge at Jurug)

A new road bridge is planned to be constructed by Bina Marga at a site immediately upstream from the existing Jurug road bridge.

It is no problem to build the bridge to span over the present river width of 168 m for the time being. It is, however, anticipated that the river improvement work is extended further downstream in the future. At that time, the river width at the site will be 318 m. With this in view, it is advisable to build the bridge so that it can easily be extended.

(Bacem bridge)

The discharge capacity of the river channel at the site of Bacem bridge site is not sufficient for the design flood. Moreover, the bottom of the bridge beam is 1.0 m lower than the crest elevation of proposed levee crest. Besides, the length of the existing bridge is 115 m, while the proposed river channel is 300 m wide. Bacem bridge should, therefore, be reconstructed in parallel with the implementation of the river improvement work.

The dimensions recommended for the new bridge are shown in Table 18.

Access ramps and steps

At present, there are 26 access ramps along the river for crossing. At these places, bamboo landing stages are to be provided.

Steps will be provided on up- and downstream sides of the sluiceway for inspection and as passage for buffalo for bathing.

5.4.7 Influence on Downstream Reaches

When a flood protection by levees is completed, though it secures the safety of the protected area against flood, it generally increase in flood discharge over the unimproved downstream reaches, thus increases the flood damage in the areas. In order to eliminate the said adverse effects on the downstream reaches, two retarding basins and three emergency inundation areas are planned in this river improvement project.

The retarding basins function for the flood discharge of more than 1,100 m^3/s corresponding to about 1,300 m^3/s at Surakarta and the emergency inundation areas, more than 1,050 m^3/s at the overflow sections of levees, corresponding to 2,000 m^3/s at Surakarta.

With these facilities, for the flood discharge of less than 1,100 m^3/s, adverse effect might be observed in the unimproved downstream river channel, however, the damages over the same area caused by floods with the discharge more than 1,100 m^3/s will be greatly reduced. With the results of comparison of average annual flood damage over the said area under the conditions with and without project, it is confirmed that the proposed river improvement plan will not give adverse effect on the unimproved downstream river course on the whole.

5.5 LAND ACQUISITION

Land

The land to be acquired for the implementation of the river improvement works is approximately 660 ha in the reaches of the Sala river and 200 ha in the reaches of the tributaries, totaling 860 ha. Of the total area of 860 ha, Sawah is 420 ha and Kampung, 440 ha.

The land to be compensated before construction is only the areas to be newly used for the proposed low-water channel and levees. The area for the proposed high-water channel is left out from compensation.

Houses

Total number of houses situated in the area of the proposed river channel is 2,300, of which about 850 houses located on the area of the proposed levees are required to be acquired immediately for the implementation of the river improvement project (Details are explained in Appendix, River Improvement).

6. CONSTRUCTION SCHEDULE

6.1 GENERAL

The Wonogiri Multipurpose Dam Project consists of dam and power sector, irrigation sector and river improvement sector.

The construction schedule of dam and power sector was prepared in the previous feasibility study. The preparatory works for the dam construction were already started since 1976 and now being proceeded by the Government.

The construction schedule of irrigation and river improvement sectors were prepared in this study in due consideration of the construction schedule of dam and power sector assuming that the construction works are carried out principally during dry seasons of 6 to 7 months in each year.

6.2 IRRIGATION WORKS

Total construction period is estimated at six years, including the preparatory works, from 1977 to 1982.

The construction of the Colo weir will start immediately after the wet season of the third construction year (1979) will be over, and the entire works will be completed by the end of the dry season of the fourth construction year (1980).

The construction of the main canal is divided into 5 sections: 4 along the Upper Sala Main Canal and 1 for the Dengkeng Main Canal. The construction period of their earth work is limited to the dry season. The construction of the Colo weir and the main canals is conducted by using machinery intensive method.

The construction of the crossing structures across the tributaries such as syphons and culverts will be executed by Copure Method /1. Most of the secondary chanals will be built by manpower.

Three years are required for constructing the farm ditches and farm drains, and four years for farm road construction. These works will depend mainly on manpower in and around the project area.

The construction schedule proposed for the irrigation project is given in bar-chart as illustrated in Fig. 15.

/1 Copure method is one of the dry work methods on a meandering river, prevailing in Indonesia.

6.3 RIVER IMPROVEMENT WORKS

Total construction period is estimated at seven years, including the preparatory works, from 1977 to 1983.

The river improvement works will be conducted in six work sections, the location of which are shown in Fig. 16. The improvement works will be performed in the order of Section No. 1 to No. 6, taking into account the impacts on the flood protection area.

Particularly, river improvement works in the heavily meandering areas of the confluence of the Sala river and the Dengkeng river will be initiated in view of the serious bank of erosion.

The construction schedule is illustrated in Fig. 17.

7. COST ESTIMATE

7.1 GENERAL

Economic construction cost for the project is estimated for the economic evaluation based on the following conditions.

(a) The cost estimate is made on the basis of the estimated quantities and volume of the works required for the project in such a manner that the cost shall reasonably reflect social opportunity costs excluding the effects of import duties and subsidies. The price level applied in the estimate is early 1976.

(b) Major construction machinery and materials such as cement, steel and lubricant will be procured from abroad. In the estimate of the machinery cost, only the depreciation cost is included instead of the purchasing cost.

(c) Cost of the imported plant, equipment and services to be procured by international competitive bidding is estimated based on international price level. The local cost such as materials and labor is estimated taking into account the experience of similar on-going projects in Central Java.

(d) In land acquisition cost, the cost for the cultivated land to be acquired for the implementation of the project is excluded from the economic construction cost, which is evaluated in terms of negative benefit. Only the cost for yards and houses to be acquired is included in the land acquisition cost.

(e) Physical contingency of the cost estimate is about 15% of the direct cost. Price contingency, or price escalation is excluded in the estimate of the economic construction cost.

(f) All the conversion from Rupiah to Dollar is made at the exchange rate of Rp.415 = US$1.

Fund requirement for the construction, or financial cost of the project is estimated for two different contract system, which is explained in Chapter 9 Economic and Financial Evaluation of the report.

7.2 ECONOMIC CONSTRUCTION COST

Economic construction cost for the irrigation and river improvement is estimated at US$79.6 million equivalent, which consists of US$40.51 million equivalent of local currency portion and US$39.09 million of foreign currency portion. The costs for irrigation and river improvement sectors are US$46.7 million and US$32.9 million respectively. Details are shown in Table 19.

8. ORGANIZATION AND MANAGEMENT

8.1 ORGANIZATION FOR THE PROJECT EXECUTION

The Directorate-General of Water Resources Development (DGWRD) will be the executing agency for this irrigation and river improvement project as a part of the Wonogiri Multipurpose Dam Project. It will be responsible for the design, supervision and construction of the project works and will coordinate the activities of all the relevant government agencies and regional administrative organizations in connection with the implementation of the project.

The Central Office of Bengawan Sala Project (PBS PUSAT) has been in existence in the project area under DGWRD. Necessary staff for PBS PUSAT have been provided by the Directorate of River (DITSEI) and the Directorate of Irrigation (DITGAST). PBS PUSAT is now undertaking the preparatory works such as the design, construction of field office, land acquisition and resettlement of the inhabitants for the construction of the Wonogiri Dam.

The Project Office of the Wonogiri Dam (PRO WONOGIRI) under PBS PUSAT is being established at the work site for smooth execution of the project construction. PRO WONOGIRI will operate field works such as design and supervision of field works, procurement of necessary construction materials, maintenance of the plant and equipment, operation of field and laboratory tests and administrative works.

It is assumed that the construction of the irrigation systems and river improvement works will be executed by local contractors or foreign contractors through the international tender in case of contract basis, while most of the construction works will be mostly undertaken by the Government itself in case of force account. Besides, for the execution of such a big project technical guidance services will be required. The overall construction organization is presented in Fig. 18.

8.2 ORGANIZATION FOR OPERATION AND MAINTENANCE OF THE PROJECT

8.2.1 Irrigation

The operation and maintenance, as well as management of the irrigation facilities in the project area, including the Colo weir, two main canals and secondary canals will be the responsibility of the Wonogiri O&M Office which is to be established under the provincial Public Works Service.

The Wonogiri O&M Office will consist of one head office in Surakarta and 4 branch offices at Colo, Jaten, Sragen and Tawangsari. The branch offices will have 15 field outposts althogether except the Colo branch office. The head office will have an overall command of operation and management of irrigation water and maintenance of the irrigation and drainage facilities in the entire project area. As for the branch offices, the Colo branch office will be mainly responsible for O&M of the Colo weir itself, while O&M of the Upper Sala Main Canal will be shared between two branch offices, one at Jaten and another at Sragen. Dengkeng Main Canal will be looked after for its entire distance by the branch office at Tawangsari. Liaison between the head office and the four branch offices and that among these five will be maintained by wireless system.

Field outposts will be held responsible for: (i) operation and maintenance of the network of the secondary canals in its command area (about 1,500 to 1,700 ha) and (ii) collection of necessary information on the on farm water issues from Dharma-Tirta under its command and transfer of these information to the branch office to which it belongs. Organization and function of the Dharma Tirta will be dealt with later.

Total number of staffs required is 70 for the head office and the branch office and 230 for the field outposts.

8.2.2 River Improvement

The operation and maintenance of the Sala river and major tributaries will be held responsible by the Office of Bengawan Sala Project.

The main works will consist of gate operation at flooding time during the wet season, maintenance of the wooden groins which will be replaced every couple of years and maintenance and administration of the embankment.

The staff required will be about 10 engineers and 15 assistants.

8.3 OTHER AGRICULTURAL SUPPORT SERVICES

8.3.1 General

For the purpose of attaining the expected paddy production through the introduction of 2-1/2 paddy crops a year with the target yield of 5.5 tons per ha, intensive agricultural support services shall be provided, in addition to operation and maintenance services related to the irrigation facilities.

The proposed agricultural support services will consist of the water user's association for an adequate irrigation water management and operation below the tertiary canals, the agricultural cooperatives for credit, input supply, processing and marketing, and the extension services through implementation of the Pilot Scheme.

8.3.2 Water User's Association

For the management, operation and maintenance of the irrigation and drainage system below the tertiary canals, Dharma Tirta will be organized by the cultivating farmers themselves in each desa and Dharma Tirta Federation will be established through affiliation of all the desa-Dharma Tirtas for good coordination and cooperation among the desa-Dharma Tirtas at both Kecamatan- and Kabupaten-levels.

For the smooth and efficient operation of the project-wide irrigation water control, both administrative and technical aspects will need to be well integrated into a workable network within which the Government agencies concerned and the cultivating farmers' Dharma Tirta will be closely interlinked. Such inter-linkage between the Government agencies and the cultivating farmers' irrigation water management bodies will be practised through the liaison between the Field Outposts and the desa-Dharma Tirta, in the technical aspect. In the administrative aspect, the inter-linkage will be realized through the participation of the representatives of the desa-Dharma Tirta and their Kabupaten Federation in the Irrigation Committee meetings at both Kecamatan- and Kabupaten levels.

More concretely speaking, in the technical aspect, each desa-Dharma Tirta is requested to keep the Field Outpost well informed of the on-farm water issues including the periodical reporting on land use and cropping patterns in its own village so that the Field Outpost can transfer such information to the Branch Office and, through which, to the Wonogiri O&M Office. In the administrative aspect, the representative of the desa-Dharma Tirta will be admitted as a full member of the Irrigation Committee at Kecamatan level, and the representative of the Dharma Tirta Federation at Kabupaten level, a full member of the Kabupaten Irrigation Committee. The Irrigation Committee will thus function as a coordinating body between the actual water using farmers and the Government agencies concerned at both levels of Kecamatan and Kabupaten. An overall organization chart for the water user's association is illustrated in Fig. 19.

8.3.3 Agricultural Cooperatives and Credit

In order to realize the full benefit from the Project, it will be indispensable to make rehabilitation of the existing institutional framework.

As a primary agricultural cooperative, the multi-purpose cooperative society (MPCS) will be organized at the village level as a branch office of the existing KUD; the function of the village MPCS is to provide credit, input supply and marketing (processing) services on behalf of the member farmers. The activities of the village MPCS will be carried out with the support of other organizations in such way that the credit service of the village MPCS will be backed up by BRI through the Kabupaten MPCS Federation and its marketing services by the Sub-Dolog likewise through its Kabupaten Federation; the technical guidance in agricultural production will be given by PPL whose service will be hired by the village MPCS.

The village MPCS, to cover its weakness in the scale of economy, will have to be affiliated through its KUD with the Agricultural Cooperative Federation at Kabupaten level. Agricultural Cooperative Federation at Kabupaten level may be either multi-purpose or separated into two independent bodies, the one for economic purposes and the other for education and training of the cooperative staff and auditing of the financial documents, on behalf of the village MPCSs which are affiliated with it.

The multi-purposed Federation of the agricultural cooperatives or the Economic Federation of the village MPCSs will maintain smooth contact with BRI which will furnish the credit to procure the input supplies to be distributed among the affiliated village MPCSs. The Federation will also help marketing, through its warehousing, drying and processing services, the farmers' marketable surplus of the paddy which will be collected by the village MPCSs. Education and training of the managers and employees of the agricultural cooperatives and auditing of the financial documents are the important functions of the Kabupaten Federation of the agricultural cooperatives.

It is expected that the MPCS as a genuine farmers' organization will be given a more positive role to play in fulfilling the national target of self-sufficiency in foodstuff. From such a point of view, it would be quite advisable to participate the president of the village MPCS in the BAPEL executive committee at the village level which consists of Lurah and Pamong Tani Desa. In the same way, the representative elected from amongst the presidents of the village MPCSs in a Kecamatan should sit in the Kecamatan executive committee meetings of BAPEL, and the representative of the MPCS Federation at Kabupaten level should do the same with the Kabupaten executive committee meetings of BAPEL.

For supporting the agricultural cooperatives and their Federations, the Cooperative Office (under the Ministry of Transmigration, Co-op., & Manpower) will need to be considerably strengthened at each level of Kabupaten and Kecamatan. To cover the cost of the operation including the salaries of the personnel to be employed in the cooperatives and their Federations, some subsidies may be provided for the first couple of years of their organization, by the

Cooperative Office. The proposed organization of agricultural cooperatives at desa-, Kecamatan-, and Kabupaten-levels with their relevant institutions is illustrated in Fig. 20.

8.3.4 Research, Extension and the Pilot Scheme

The Pilot Scheme will be implemented for promotion of research and extension work aimed at the successful introduction of 2 1/2 paddy crops a year on the entire project area, with the target unit yields of 5.5 tons/ha. The Pilot Scheme will be implemented in three phases, namely, Experiment Farm, Pilot Area Program, and Pioneer Project.

The Experiment Farm will be established as early as possible, at the latest within 1978 to find and confirm the technical nucleus for attaining the aforesaid target and to train PPLs and the leading farmers in the project area. It will cover about 5 - 10 ha, in a perennially irrigated area within the project area, probably in Sragen. The major research works to be performed on the Experiment Farm are to determine the optimum use of fertilizers and chemicals, to select the most suitable varieties of seed, and to decide the optimum water requirement corresponding to the growing stages of paddy, as well as to determine the minimum necessary infrastructural facilities in the paddy fields.

The Pilot Area Program is meant for extension of such techniques and knowledge as established by the Experiment Farm within an area which roughly corresponds to desa. It shall be started immediately after the Experiment Farm will have established the paddy cultivation technology required for realizing the project's target, in the area adjacent to the Experiment Farm. The farmers in the Pilot Area will organize themselves into both the village MPCS and the village Dharma Tirta; they must be taught to adopt the intensive paddy cultivation techniques through joint water management efforts institutionalized into their village Dharma Tirta as successfully experimented in the Experiment Farm.

The Pioneer Project aims at extension and spill-over of the results obtained in the Pilot Area to the extent of Kecamatan under the perennial irrigation conditions. Therefore, it may be implemented in one of the Kecamatans of the Dengkeng Region in 1980 and then, somewhere in Sukoharjo by 1981, in Karanganyar (Jaten) by 1982, and in Sragen by 1983. The farmers in the Kecamatan selected for implementation of the Pioneer Project will have to be encouraged to organize themselves into the village MPCS as well as the village Dharma Tirta in adopting the improved paddy cultivation technology which has been established by the Experiment Farm and proved to be workable under the Pilot Area Program. The Dharma Tirta organized in each desa will have to be affiliated with their Kecamatan Federations. Extension services

in the Kecamatans selected for the Pioneer Project should be so intensified that each PPL will be allocated with paddy field not larger than 400 - 500 ha.

For the successful operation of the Pilot Scheme in each phase or stage of the Experiment Farm, the Pilot Area Program, and the Pioneer Project, good coordination and co-operation among the three related Government agencies, namely, the Dinas Pertanian Rakyat, the Cooperative Office and the Wonogiri O&M Office (for the time being, Wilajah) will be essential. Particularly, the careful guidance of the farmers organizing their village Dharma Tirta and its affiliation with Kecamatan Federation, as well as the intensive extension services shall be provided through the doubled efforts of the Dinas Pertanian Rakyat, while the concentrated attention and positive action of the Cooperative Office is indispensable for the village MPCS and their affiliation with Kabupaten Federation. The Wonogiri O&M Office can do a great deal in determining water management techniques and identifying the Irrigation facilities required in the paddy fields below the tertiary channel in the Experiment Farm, and in their realization both in the Pilot Area and the Pioneer Project area.

The research and extension work under the Pilot Scheme, therefore, will need to be carried out under the joint responsibility of the aforementioned three Government agencies: the Dinas Pertanian Rakyat, the Cooperative Office, and the Wonogiri O&M Office. With respect to the staff to be recruited for implementation of the Pilot Scheme, 3 to 9 specialists consisting of agronomists, irrigation engineers, institutional experts and agricultural economist will be required in addition to the regular officials belonging to the three Government agencies, depending on its stages. Details of the scope of work and the required number of specialists to be assigned will be determined through further investigation and study.

9. ECONOMIC AND FINANCIAL EVALUATION

9.1 GENERAL

In this chapter, evaluation of the whole Wonogiri Multi-purpose Dam Project with purposes of power, irrigation and flood control is made. The Wonogiri irrigation and upper Sala river improvement project for which studies are made in this report so far is included in the multi-purpose project as its functions of irrigation and flood control. The project evaluation is made to ascertain the feasibility of the project in view of economic, financial and socio-economic aspects.

The economic feasibility of the multi-purpose dam project is firstly evaluated by calculating the internal rate of return, which includes the economic evaluation of each purpose of the project. Sensitivity analysis is also made with respect to change in the economic construction cost, price of rice and build-up period of the irrigation benefit.

Secondly, financial evaluation is conducted by analyzing typical farm budgets and by repayment analysis. Farm budget analysis is designed to confirm the soundness of the project from the farmers' point of view. Repayment analysis is made to evaluate repayment capability of the project on the basis of the estimated fund requirement with assumed financial terms of the conceivable loan and the expected revenue from the project.

Finally, socio-economic impacts of the project are briefly assessed in due consideration of the effect of the project on the regional development.

All the conversions from Rupiah to Dollar are made at the exchange rate of Rp.415 = US$1 and the project life assumed for the economic evaluation is 50 years from 1976 to 2025.

9.2 ECONOMIC EVALUATION

9.2.1 Project Benefit

Project benefit consists of two kinds of benefits, namely, primary benefit and secondary benefit. Primary benefit includes irrigation benefit, flood control benefit and hydro-power benefit. Negative benefit or loss of the expected agricultural benefit on the land to be submerged or to be acquired for the implementation of the project is also included

in the primary benefit. Secondary benefit comprises the expected benefit from fishery, recreation and tourism and municipal water supply. Savings in foreign currency attributable to reduced import of rice is also another important secondary benefit on the national economy. However only the primary benefit is incorporated in the calculation of the internal rate of return for conservativeness of the analysis.

Irrigation benefit

The irrigation benefit is evaluated as the difference of net income from crops between future-without project and -with project conditions.

The irrigation benefit will come out immediately after the completion of the construction of the Colo weir in 1981. The benefit will be expected to increase linearly year by year and attain its maximum level of Rp.7,673 million (US$18.49 million) in and after the 7th year after the implementation of the Colo weir or 1989, as shown in Table 20.

However, since flood condition in Sragen area will remain unchanged even after the implementation of the Wonogiri dam and river improvement work, the expected crop damages by floods in Sragen should be deducted from the irrigation benefit. The expected crop damages there are calculated at US$ 0.72 million in the 7th year after implementation of the Colo weir. The irrigation benefit is estimated at US$17.77 million annually in and after the 7th year.

Besides the benefit mentioned above, additional benefits will come from outside the project area and by abolishing the existing pumps in the project area.

With the completion of irrigation facilities, the area outside the project which will remain under the existing irrigation system will benefit from an exclusive use of the irrigation water a part of which has been consumed in the project area. The expected ancillary benefit on outside the project area will accrue through the intensive land use, the intensity of which will increase to 65 - 75% from the present 40%.

An additional benefit will come out from the abolishment of about 60 existing irrigation pumps in the project area; their annual operation and maintenance costs are estimated at about US$70 thousand. These costs as well as the replacement cost will be saved by the construction of the irrigation project, which are also included in the irrigation benefit.

Although these ancillary benefits are relatively large, they are not incorporated in the calculation of the economic internal rate of return.

Flood control benefit

Flood control benefit is the expected reduction of the flood damage, which is the difference between the annual flood damage at present and expected flood damage under the condition of the completion of the dam and river improvement works.

Since the river improvement work will be confined to the reaches upstream of the Surakarta city, the expected reduction of flood damages will arise only in Surakarta area (from Wonogiri to Jurug including Surakarta city), while the present damage will remain in the future in Sragen area (from Jurug to the confluence of K. Sawur). The expected damage reduction in Surakarta area is estimated at US$6.41 million as the river improvement works will make the same area free from flood damages as long as the discharge at Surakarta remains less than 2,000 m^3/s or 40 year probability.

However, damages caused by landside water will occur even upon completion of the river improvement works. These expected damages are estimated at US$0.87 million conservatively. The expected flood control benefit is finally estimated at US$5.54 million by deducting the landside water damages from the expected reduced damage in Surakarta area. (Details of the calculation are presented in Appendix II, River Improvement.)

Flood control benefit is expected to accrue, to some extent, after the coffer dam is completed and continue to increase stepwise corresponding to the river improvement works until 1983.

Hydropower benefit

The hydropower benefit was estimated at US$1.35 million per year by means of alternative cost method in the previous feasibility study, which is applied to the present study since there are no substantial changes in the project features. The benefit is expected to attain its maximum extent of US$1.35 million after completion of the construction of the power station in 1981.

Negative benefit

Negative benefit is the loss of benefit which is expected to accrue on the cultivated land to be acquired for the construction of dam and reservoir, Colo weir, irrigation canals and levees.

In order to estimate the negative benefit, cropping areas for each crop and their yields on the cultivated land are estimated. By applying the same method used in the estimate

of the irrigation benefit, the negative benefit expected annually is estimated at US$1.21 million, details of which are presented in Appendix III, Project Economy.

Negative benefit will arise from the wet season of 1977 when the cultivated land is partly purchased for the construction of the dam and increase in proportion to the progress of the construction of the irrigation and river improvement works to attain its maximum level of US$1.21 million in 1982.

Summary of project benefit

Total primary benefit is estimated at US$23.45 million per annum at its full development stage as summarized into Table 21.

9.2.2 Project Cost (Economic Cost)

Economic construction cost

Economic construction cost for irrigation and river improvement sectors is already mentioned in chapter 7. For the costs of the dam and the hydropower sectors, the same costs as estimated in the previous feasibility study are applied to the present study, since there are no substantial changes in the project features of them.

Total economic construction cost of the project is estimated at US$138 million, comprising the foreign currency portion of US$67.28 million and the local currency portion of Rp.29,348.8 million (equivalent to US$70.72 million).

The economic cost is summarized into Table 22 and its disbursement schedule is presented in Table 24.

Operation, maintenance and replacement cost

Annual cost for operation, maintenance and replacement is estimated for each sector on the basis of the required manpower and materials. Total annual cost is calculated at US$0.84 million as shown in Table 23.

Cost allocation

For the economic evaluation of each sector of the multi-purpose dam project, cost allocation is made principally by means of "Separable Cost - Remaining Benefit Method."

The result of the cost allocation is presented in Table 25 and the details of the calculation is explained in Appendix III, Project Economy.

9.2.3 Evaluation

Internal rate of return is calculated at 12.1% on the basis of the benefits and costs estimated above. The rate of return indicates the economic soundness of the project.

Internal rate of return is also calculated for each sector of the project by using the allocated cost. The results of the calculation are presented in Table 26.

The calculated internal rates of return indicate that both irrigation sector and river, having the high rates of around 12%, possess substantial economic viability, although the power sector is proved to be less economical since it is the secondary purpose subordinate to the irrigation.

Sensitivity analysis

Project sensitivity is analyzed with respect to change in the build-up period of the irrigation benefit, the price of rice and the economic construction cost.

As summarized in Table 27 and Fig. 21, the sensitivity analysis indicates that the project maintains a relatively high internal rate of return of about 10% for the case of 5 years' extension of the build-up period, 20% decrease in the rice price and 30% increase in the construction cost, respectively.

9.3 FINANCIAL EVALUATION

9.3.1 Farm Budget Analysis

For evaluating the project feasibility from farmers' household economy, typical farm budgets are prepared for the future without-project condition and future with-project condition as shown in Tables 28 and 29.

Upon completion of the irrigation project, farm income is expected to increase considerably. The expected increases in the farm income will be about 2.2 times in the currently irrigated area and about 3.1 times in the rainfed area.

The net farm income, which is defined as the difference between farm income and farm expenses, will also grow substantially under the project. While the net income in the future without-project is about Rp.90,000 (US$218) for the irrigated area, and about Rp.66,000 (US$158) for the rainfed area, it is expected to increase to about Rp.217,000 (US$523) with the project.

Annual net reserve or capacity to pay will rise from about Rp.3,000 (irrigated area) and Rp.250 (rainfed area) to Rp.111,720. The increased net reserve will offer incentives to the farmers to be involved and substantial capacity to pay will enable them to pay some charges for the irrigation water. (The expected water charge is briefly explained in Appendix III, Project Economy).

9.3.2 Fund Requirement and Repayment

Fund requirement

Fund requirement for the project construction is estimated for two different systems of the construction, that is, contract base and force account base.

For the estimate of the fund requirement, actual purchasing cost of the land acquisition to be acquired for the implementation of the project and expected cost escalation/1 are included for both construction systems. With respect to the cost of construction machinery, only the depreciation cost is included in the estimate for the contract base, while all the purchasing cost is included for the force account base.

Estimated fund requirements are US$262.01 million for the contract base and US$277.08 million for the force account base, which are presented by each sector in Tables 30 and 31.

Repayment capability

On the basis of the estimated fund requirement under force account base, repayment capability is analyzed by preparing cash flow assuming the following financial conditions.

Foreign currency portion:	Financed by bilateral or international organization with the interest rate of 3% per annum. Repayment period is 30 years including the grace period of 10 years.
Local currency portion :	Financed by the budget allocation of the Government with no interest or no repayment.

/1 The rates of cost escalation are estimated on the basis of "Price Forecast for Major Commodities" prepared by the World Bank, July 1975 and the past trends of domestic price indecies in Indonesia as follows:

Foreign currency portion:	8.0% per annum from 1976-1979 7.0% per annum on and after 1980
Local currency portion :	15% per annum from 1976-1979 10% per annum on and after 1980

In the cash flow table prepared on the above conditions, it is indicated that the expected direct revenue such as water charges and power tariff will be able to cover the required cost for operation, maintenance and replacement but not the repayment. Required amount for the repayment should be provided by the Government subsidy because the measurable direct revenue is very limited. However, the expected indirect revenue such as the increased tax income and reduced expenses on flood protection and the amount of flood damages is considerable. In particular, when the anticipated savings of foreign exchange by reducing imports of rice is taken into consideration, Such indirect revenue would cover most of the amount for the repayment.

9.4 SOCIO-ECONOMIC IMPACTS

In addition to the benefits stipulated in the economic evaluation, favourable socio-economic impacts are anticipated from the implementation of the project.

Employment opportunity to be created by the project implementation will give a favourable impact on the national economy. More than 13,000 men will be employed yearly during the construction period of the irrigation and river improvement works, while about 400 persons will be required permanently for the operation and maintenance works. Considerable job opportunity will also be created on farm by the introduction of all the year-round irrigation farming.

Along with the increase in employment opportunity, technical knowledge is expected to be transferred to the Indonesian staff through the construction work in various fields, which will facilitate realization of other water resources development projects in the future.

Improvement of local transportation will result from the construction of the operation and maintenance roads for the irrigation canals (about 170 km) and levees along the main Sala river (33 km) and tributaries (26 km). The expanded road system will not only promote the economic activity in the region but also contribute to inter-regional transportation and communications.

The enhanced economic activity through the increased agricultural production and farm income, and the improved living condition by the completion of the flood control measures and electrification, will also substantially facilitate socio-economic stability in the region.

However, implementation of the project requires considerable land acquisition for the area of dam and reservoir, Colo weir and levees and resettlement. Particularly, the reservoir construction will submerge approximately 7,000 ha of the cultivated land and over 11,000 families will have to be moved out elsewhere although they will be fully compensated for their lands and quarters. The community life of the people living in the adjacent area will also be seriously affected.

It is, therefore, contemplated that reconstruction of the local communities and resettlement of the displaced people which involve the problems of securing alternative employment opportunities are very important for the successful implementation of the project.

10. CONCLUSIONS AND RECOMMENDATIONS

10. 1 GENERAL

As the results of this detailed study, it has been concluded that the Project is technically sound and economically feasible with 12.1% of the internal rate of return.

It is therefore, recommended that the project will be taken up at the earliest moment.

10. 2 CONCLUSIONS

(Irrigation)

1) Irrigation plan is determined to utilize the available water resources of 400 million m3 from the Wonogiri reservoir at its maximum extent and 23,200 ha of the land is selected as the project area for irrigation.

2) Soils in the project area are suitable for agricultural production under proper irrigation farming on which cultivation of 2-1/2 paddy crops a year plus sugar cane will be extended all over the project area.

3) The year 1967/68 was selected as the basic year for irrigation planning and maximum diversion water requirement is estimated at 29.5 m3/s or 1.2 ℓ/s/ha.

4) Colo weir is planned to be constructed about 14 km down stream from the Wonogiri dam. From the geological survey, the site of the weir is shifted to the right bank of the Sala river and a flat foundation (without piling) is proposed.
One intake system with one sand flash is adopted for the layout of the Colo weir.

5) The canal alignment is determined based on the levelling survey over the entire length of the main canals. Long canal system is adopted as the most feasible one through the comparative studies.

6) Farm ponds or regulating reservoir were planned in the midway of the main canals in the previous feasibility study for control of the irrigation water supply. However, the plan of the farm ponds is discarded in this study because no proper site is available in the project area. Instead, wireless communication equipments are provided along the main canals for proper control of the irrigation water.

7) In the rainfed area and non-technical areas in the project area, secondary and tertiary canals are newly constructed, while in the technical and semi-technical areas only a few additional secondary and tertiary canals will be installed as these areas already have sufficient density of irrigation canals.

8) As for the institutional aspect water-management and O & M of the irrigation facilities in the paddy fields below the tertiary and quaternary channels are held responsible by the cultivating farmers but not quite satisfactorily. Desas which are irrigable only during wet season are usually looked after by their Ulu-Ulu Desas with the assistance of Pembantu Ulu-Ulus. Only those Desas irrigable either wholly or partially even during dry season have Dharma Tirta with a more systematic organization and in better function.

9) Total economic construction cost for the irrigation sector is estimated at US$46.7 million consisting of the foreign currency portion of US$23.79 million and the local currency portion equivalent to US$22.91 million.

10) The expected irrigation benefit is estimated at US$17.77 million per annum.

(River Improvement)

1) The proposed river improvement work is planned for the design flood having the magnitude of the 1966 flood. The design flood at Surakarta after being regulated by the Wonogiri reservoir is estimated at 2,000 m3/s under the condition that levees are constructed along the river. The design flood corresponds to a flood of 40 year recurrence probability.

2) The river improvement work will be carried out in the section of 33 km between Nguter and Surakarta along the main stream of the Sala river. Its tributaries, such as the K. Jlantah, the K. Dengkeng (including the K. Gawe), the K. Wingko, the K. Bentungan, the K. Brambang, the K. Kembangan, and the K. Samin, will also come under the improvement work for total length of about 30.5 km, within the reach of the back water of the Sala river. The work consists of the improvement of the river channel, the construction of levees along the course of the main river and tributaries. Other related riparian structures such as stone pitching, groins, sluiceways, groundsills, bridge, drainage channels, retarding basins and emergency inundation areas will also provided for.

3) Construction of new Nguter road bridge across the short cut section is included in the project. As the capacity of the river flow at the Bacem bridge is insufficient to allow the design discharge and the bridge itself is considerably worn-out, it should be replaced by a new one.