REPUBLIC OF THE PHILIPPINES
NATIONAL IRRIGATION ADMINISTRATION

FEASIBILITY REPORT ON THE GUMAIN RIVER IRRIGATION PROJECT

MAIN REPORT

FEBRUARY 1985

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

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PREFACE

It is with great pleasure that I present this Feasibility Report on the Gumain River Irrigation Project to the Government of the Republic of the Philippines.

This report embodies the result of a feasibility sutdy which was carried out in the project area of the southwestern part of the Pampanga river basin in the central Luzon, starting in July 1983 by a Japanese survey team commissioned by the Japan International Cooperation Agency, following the request of the Government of the Republic of the Philippines to the Government of Japan.

The survey team, headed by Mr. Kensaku Takeda, had a series of close discussions with the officials concerned of the Government of the Philippines, conducted a wide ranging field survey and has prepared the present report.

I hope that this report will be useful as a basic reference for development of the Project and thereby contribute to the promotion of friendly relation between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of the Philippines for their close co-operation extended to the team.

February 1985

Keisuke ARITA
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Keisuke ARITA
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

We are pleased to submit the Feasibility Study Report on the Gumain River Irrigation Project, Central Luzon, Republic of the Philippines, in accordance with the Implementing Arrangement of the technical cooperation between the Japan International Cooperation Agency and National Irrigation Administration.

The project was formulated to increase productivity and production of rice, sugarcane and vegetables, and to stabilize farmers' livelihood in the project area of around 17,000 hectares through provision of a storage dam and irrigation and drainage facilities.

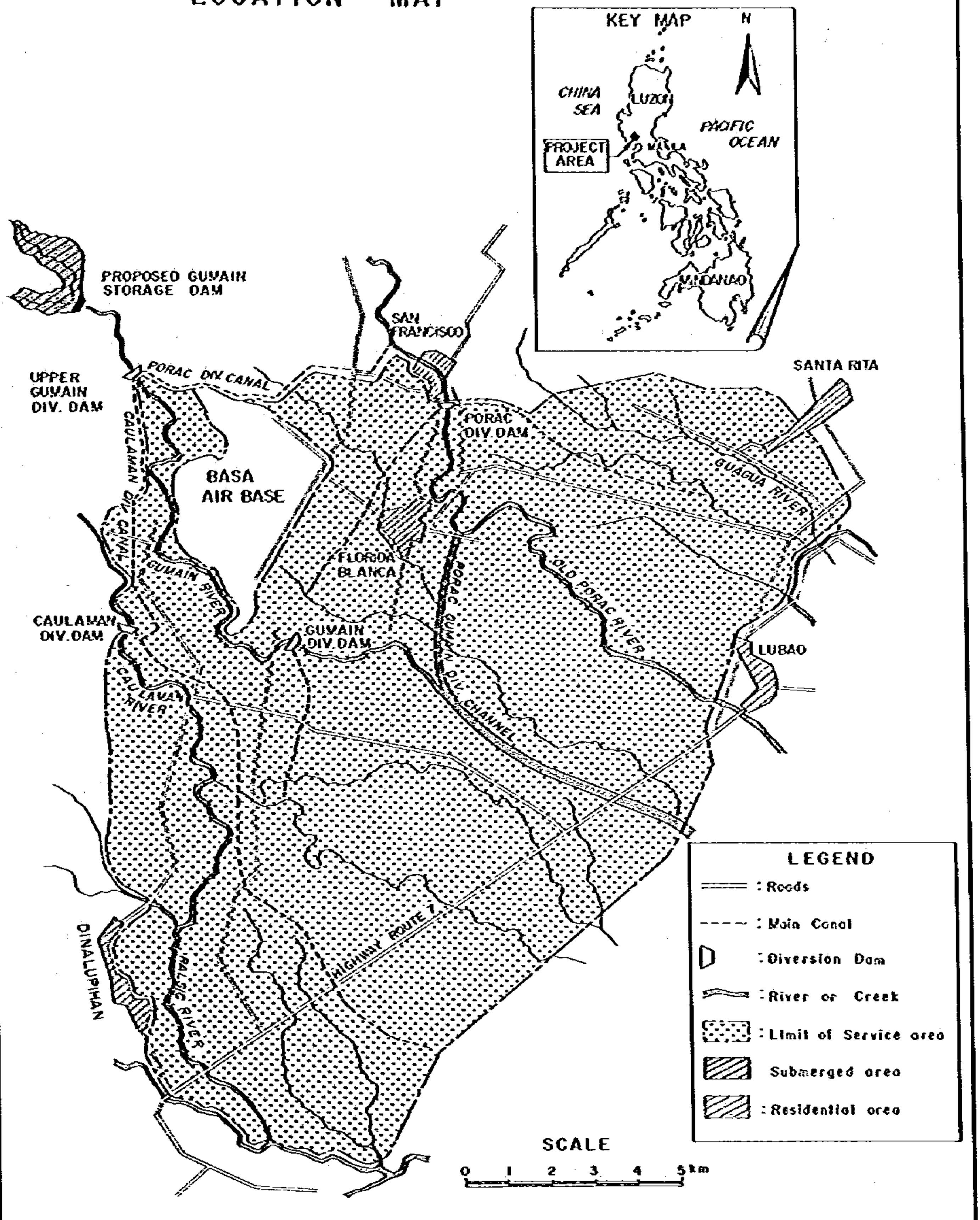
Results of study show that the project is technically feasible and economically viable and the increased amount of agricultural products would substantially contribute to the national economy as well as the regional economy in the project area. We would recommend that the project will be implemented soon in line with the conclusion presented in this report.

In submitting this report, we wish to express our deep appreciation and gratitude to the personnel concerned of your Agency, Ministry of Foreign Affairs, Ministry of Agriculture Forestry and Fisheries, National Irrigation Administration and other agencies concerned of Philippine Government for the courtesies and cooperation extended to us during our field survey and study period.

Sincerely yours,

Kensaku TAKEDA
Leader of the Study Team for the
Gumain River Irrigation Project

LOCATION MAP



PRINCIPAL FEATURES OF THE PROJECT

1. Location : Pampanga and Bataan Provinces
2. Water Resources : Gumain, Porac and Caulaman Rivers
3. Net Irrigation Area : 16,750 ha
   - Paddy fields : 11,000 ha
   - Sugarcane fields : 5,750 ha
4. Project Facilities

4-1 Gumain Dam and Reservoir (New)

(1) Reservoir

i)	Drainage Area	:	114 km^2
ii)	Gross Storage Capacity	:	110.4 MCM
iii)	Dead Storage Capacity	:	11.4 MCM
iv)	Active Storage Capacity	:	99.0 MCM
v)	Full Water Level	:	EL. 153.5 m
vi)	Low Water Level	:	EL. 100.0 m
vii)	Reservoir Area at Full Water Level	:	3.36×10^6 m^2

(2) Dam

i)	Dam Type	:	Zone Type Rockfill Dam
ii)	Dam Crest Elevation	:	EL. 160.0 m
iii)	Dam Crest Length	:	435.0 m
iv)	Dam Height	:	108.0 m
v)	Dam Embankment Volume	:	5.58 MCM

(3) Spillway

i)	Design Discharge	:	2,650 m^3/sec
ii)	Type	:	Side Channel
iii)	Overflow Depth	:	4.0 m
iv)	Side Channel Crest Length	:	155.0 m

(4) Diversion Tunnel

i)	Design Discharge	:	1,290 m^3/sec
ii)	Tunnel Section	:	R = 6.0 m
iii)	Tunnel Length	:	660.0 m

4-2 Irrigation Facilities

(1) Upper Gumain Diversion Dam (New)

i)	Dam Type	:	Ogee Type
ii)	Dam Crest Length	:	80.0 m
iii)	Dam Height	:	4.0 m

(2) Porac Diversion Dam (Existing)

i)	Dam Type	:	Ogee with Flap Gate
ii)	Dam Crest Length	:	43.3 m
iii)	Dam Height	:	4.2 m

(3) Gumain Diversion Dam (Existing)

i)	Dam Type	:	Ogee Type
ii)	Dam Crest Length	:	224.0 m
iii)	Dam Height	:	2.0 m

(4) Caulaman Diversion Dam (Existing)

i)	Dam Type	:	Ogee Type
ii)	Dam Crest Length	:	72.0 m
iii)	Dam Height	:	1.8 m

(5) Irrigation Canals

i)	Porac Diversion Canal	:	6.9 km (New)
ii)	Caulaman Diversion Canal	:	6.7 km (New)
iii)	Main Canal	:	28.8 km (Existing)
iv)	Lateral and Sub-Lateral	:	169.6 km (Existing 65.8 km, New 103.8 km)
v)	Main Farm Ditch	:	246.3 km (New)
vi)	Supplementary Farm Ditch	:	615.4 km (New)

(6) Related Structures

i)	Head Gate	:	25 nos. (Existing 14 nos., New 11 nos.)
ii)	Turnout	:	312 nos. (Existing 76 nos., New 236 nos.)
iii)	Check Gate	:	17 nos. (Existing 10 nos., New 160 nos.)
iv)	Culvert	:	191 nos. (Existing 101 nos., New 90 nos.)

v) Bridge : 19 nos.
(Existing 5 nos., New 14 nos.)

vi) Siphon : 12 nos.
(Existing 10 nos., New 2 nos.)

vii) Drop : 18 nos.
(Existing 1 no., New 17 nos.)

viii) Waste Way & Spillway : 13 nos. (New)

ix) Cross Drain : 14 nos.
(Existing 6 nos., New 8 nos.)

x) Aqueduct : 2 nos. (New)

4-3 Drainage Facilities

(1) Drainage Canals

i) River and Creek : 131.4 km (Existing)

ii) Collector Drain : 64.8 km (New)

iii) Catch Drain : 9.3 km (New)

iv) Tertiary Drain : 58.0 km (New)

v) Drainage Ditch : 321.0 km (New)

(2) Related Structures

i) Bridge : 26 nos.
(Existing 9 nos., New 17 nos.)

ii) Culvert : 196 nos.
(Existing 14 nos., New 182 nos.)

5. Project Cost : ₱2,768 million as of March 1984
(US$1.0 = ₱14 = ¥240)

- Foreign Currency Portion : ₱1,635 million
- Local Currency Portion : ₱1,133 million

6. Project Evaluation

(1) Economic Cost : ₱1,252 million

(2) Economic Benefit : ₱276 million per annum

(3) Internal Rate of Return (IRR) : 12.8%

(4) Benefit-Cost Ratio (B/C) : 1.40
(Discount Rate - 10%)

(5) Benefit Minus Cost (B-C) : ₱341 million
(Discount Rate - 10%)

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

1. The Gumain River Irrigation Project Area is located in the south-western part of the Pampanga river basin in Central Luzon, the Philippines, and adjacent to San Fernando, the provincial capital of Pampanga. The project area is situated within easy access of Manila, about 70 km northwest, by means of the North Express Highway and National Highway Route 7. The area lies in the alluvial fan of the Gumain, Porac and Caulaman rivers which originate in the Zambales mountain range. It has an average annual rainfall of 2,000 mm to 2,600 mm with a predominant rainy season from May to October, in which about 90% of the annual rainfall concentrates.

2. Agriculture is the mainstay of the Philippine economy and the Pampanga river basin including the project area is the rice granary of Metro Manila. It is also one of the main sugar producing areas in the country. The major constraint which hinders agricultural development in the area is shortage of irrigation water particularly in the dry season due to inadequate irrigation facilities. The main objective of the development project is to provide a year-round supply of irrigation water by construction of a storage dam and providing irrigation and drainage facilities for agricultural development of the area. Through supply of irrigation water and proper drainage, production of rice, vegetables and sugarcane would be increased, and also the income and prosperity of the farmers in the area would be increased.

3. The total study area is approximately 23,700 hectares of which about 18,700 hectares is arable land comprizing 11,900 hectares of paddy field and 6,800 hectares of sugarcane land. About 6,000 hectares of paddy field are now provided with partial irrigation services under the existing irrigation systems. Out of 18,700 hecateres of arable lands, 16,750 hectares of lands are demarcated as the net irrigable

area by the proposed project. The projected net irrigable area consists of 11,000 hectares of paddy fields and 5,750 hectares of sugarcane lands.

4. The proposed development plan of the Gumain River Irrigation project was based on optimization of the capacity of Gumain reservoir and irrigable area taking account of available water, geology and topography of dam site, topography for canal alignment and construction cost. The proposed farming systems of the project are double cropping of paddy, sugarcane and vegetables. Irrigated paddy cultivation would be extended to 11,000 hectares in the rainy season and 6,000 hectares in the dry season. 5,750 hectares of sugarcane lands would be irrigated out of the existing 6,800 hectares. There would also be about 1,800 hectares of irrigated vegetable farming in the dry season.

5. The main project components would be a storage dam on the Gumain river, and irrigation and drainage facilities. Irrigation water for the area would be obtained from three rivers, namely the Porac, Gumain and Caulaman. Of these only the Gumain river has a suitable dam site from topographical and geological points of view. Under the proposed scheme of operation, regulated flows from the Gumain reservoir would be used to supplement the available streamflows at the headworks of the existing irrigation systems for providing adequate irrigation water supplies for the project area. The water released from the reservoir would be conveyed to the existing National Irrigation Systems by means of a new diversion dam and diversion canals. The existing irrigation systems would be rehabilitated and/or upgraded, and additional drainage facilities would also be provided. The main features of the project works are summarized in the table attached at the beginning of this report.

6. The total economic construction cost of the project is estimated at ₱1,252 million. On the other hand, benefits which would accrue from the net incremental production of crops will reach around ₱276 million per annum at the full development stage. The economic internal rate

of return is calculated at 12.8%, and B/C ratio with 10% of discount rate is calculated to be 1.40. Financially, the construction cost will total ₱2,768 million comprising, ₱1,635 million of foreign currency and ₱1,133 million of local currency. Cost estimation and economic evaluation was made based on the prices and exchange rate (US$1.0 = ₱14.0) prevailing in March, 1984.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations have been reached through studies of the Gumain River Irrigation Project conducted from July 1983 to September 1984.

1. The project is technically and economically feasible, and funds for project implementation should be sought at the earliest possible time.

2. No significant adverse effects are expected from the implementation of the project.

3. The Gumain reservoir would provide recreation opportunities and would provide a fishery habitat.

4. In order to make the most effective use of water from the Gumain reservoir, the possibility of hydropower generation at the Gumain dam was studied giving priority to irrigation water supply. Several operation studies were made along with the release of irrigation water to find out the most attractive hydropower scheme. The result shows that any firm power output cannot be secured and annual energy output is expected to be 27.3 GWh with the most advantageous installed capacity of 6,000 kW (3,000 kW x 2). The construction cost and annual benefit for the hydropower sector were estimated at ₱109.3 million and ₱15.6 million at March 1984 prices, respectively. The economic internal rate of return for hydropower sector itself is calculated at 10.6%.

5. The rainfall and water level gauges which were installed during the study period should be well maintained and operated, and in addition, new water level gauging stations in the Porac and Caulaman rivers and rainfall gauging stations in their watersheds are recommended to be installed in order to provide more reliable hydrological data for future stages of the project.

6. Since the proposed Gumain dam has a relatively large scale, more detailed investigations on the geology at the dam site and soil mechanical tests of dam embankment materials should be made to ensure the stability and most economic design of the dam.

REPUBLIC OF THE PHILIPPINES
NATIONAL IRRIGATION ADMINISTRATION

FEASIBILITY REPORT
ON
THE GUMAIN RIVER IRRIGATION PROJECT

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ABBREVIATION AND GLOSSARY OF TERMS

Abbreviations used in this report are listed below:

1. Length and Height

mm : millimeter
cm : centimeter
m : meter
km : kilometer
MSL : mean sea level
EL : elevation above MSL

2. Area

cm^2 : square centimeter
m^2 : square meter
km^2 : square kilometer
ha : hectare
MSM : million square meter

3. Volume

lit, ℓ : liter (= 1,000 cm^3)
m^3 : cubic meter
MCM : million cubic meter

4. Weight

mg : milligram
g : gram
kg : kilogram
t (ton) = 1,000 kg

5. Time

sec : second
min : minute
hr : hour
yr : year

6. Electric Measures

kV : kilovolt
kW : kilowatt
kWh : kilowatt-hour
MW : megawatt
MWh : megawatt-hour
GWh : gigawatt-hour

7. Other Measures

% : percent
PS : horse power
°C : centigrade
m^3/sec, m^3/s : cubic meter per second
lit/sec/ha, lit/s/ha : liter per second per hectare
cm/sec, cm/s : centimeter per second
t/ha: ton per hectare
ppm : part per million
No(s), no(s) : number(s)
SPT : standard penetration test

8. Currency

US$: US Dollar
₱ : Philippine Peso
(US$1.00 = ₱14.0 = ¥240)

9. Other Abbreviations

(A)

ACA - Agricultural Credit Administration
AD - Agriculture Division
ADB - Asian Development Bank
AMC - Area Marketing Cooperative
APIP - Aurora Peñaranda Irrigation Project
ARBA - Agrarian Reform Beneficiaries Association
AW - Association Worker
AWMT - Assistant Water Management Technician

(B)

BAEcon - Bureau of Agricultural Economic
BAEx - Bureau of Agricultural Extension
BAI - Bureau of Animal Industry
BC - Billing Clerk
BCD - Bureau of Cooperative Development
BFAR - Bureau of Fisheries and Aquatic Resources
BFCD - Bureau of Flood Control and Drainage
BISA - Barangay Irrigation Service Association
BPI - Bureau of Plant Industry
BPW - Bureau of Public Works
BS - Bureau of Soils

(C)

CBP - Central Bank of the Philippines
CDLF - Cooperatives Development Loan Fund
CIA - Communal Irrigators Association
CIS - Communal Irrigation System
CISP - Cooperative Insurance System of the Philippines
CLSU - Central Luzon State University
CMSP - Cooperative Marketing System of the Philippines
COA - Commission of Audit
CRB - Cooperative Rural Bank
CRIS - Caulaman River Irrigation System

(D)

DPB - Development Bank of the Philippines
DT - Ditchtender
DCSPCMAI - Del Carmen Sugar Producer's Cooperation Marketing Association Inc.

(E)

EOD - Engineering and Operations Division

(F)

FACOMA - Farmers' Cooperative Marketing Association
FAD - Farmers' Assistance Division
FAO - Food and Agricultural Organizaiton
FBC - Farmers' Barrio Cooperative
FIA - Farmer-Irrigators' Association or Farmer-Irrigation Association
FIG - Farmer-Irrigators' Group or Farmer-Irrigation Group
FIO - Farmer-Irrigators' Organization
FL - Farmers' Leader
FSDC - Farm Systems Development Corporation

(G)

GK - Gatekeeper
GOP - Government of the Philippines

(I)

IA - Irrigation Association
IAO - Irrigation Association Organizer
IBRD - International Bank for Reconstruction and Development
IGL - Irrigators' Group Leader
IOMP - Input and Output Monitoring Program
IRRI - International Rice Research Institute
ISA - Integrated Services Association
ISF - Irrigation Service Fee

(J)

JICA - Japan International Cooperation Agency

(K)

KAISA - Kalipunan Ng Mga Integrated Service Association
KKK - Kilusang Kabuhayan at Kaunlaran

(L)

LBP - Land Bank of the Philippines
LES - Luzon Experimental Station

(M)

MA - Ministry of Agriculture
MAR - Ministry of Agrarian Reform
MEC - Ministry of Education and Culture
MF - Ministry of Finance
MHS - Ministry of Human Settlements
MITI - Ministry of Industry, Trade and Investment
MLG - Ministry of Local Government
M-99 - Masagana 99 Program (national rice program)
MPWH - Ministry of Public Works and Highways
MRRTC - Maligaya Rice Research and Training Center

(N)

NASUTRA	-	National Sugar Trading Corporation
NASUDECO	-	National Sugar Development Corporation
NCSO	-	National Census and Statistics Office
NEA	-	National Electrification Administration
NEDA	-	National Economic and Development Authority
NFA	-	National Food Authority
NFAC	-	National Food and Agriculture Council
NIA	-	National Irrigation Administration
NIS	-	National Irrigation System
NPC	-	National Power Corporation
NSDB	-	National Science Development Board
NWRC	-	National Water Resources Council

(O)

OECF	-	Overseas Economic Cooperative Fund, Japan

(P)

PAGASA	-	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PATC	-	Philippine Agricultural Training Council
PCARR	-	Philippine Council for Agricultural Research Resources
PCIC	-	Philippine Crop Insurance Corporation
PDA-ADCC	-	Provincial Development Committee - Agricultural Development Coordinating Council
PDSO	-	Provincial Development Staff Office
PELCO-II	-	Pampanga II Electric Cooperative, Inc.
PGRIS	-	Porac Gumain River Irrigation System
PHILSUCOM	-	Philippine Sugar Commission
PIS	-	Pump Irrigation System
PNB	-	Philippine National Bank
PPA	-	Philippine Port Authority
PSPCMAI	-	Porac Sugar Producer's Cooperative Marketing Association Inc.

(R)

RIS	-	River Irrigation System
RP	-	Republic of the Philippines
RUG	-	Rotation Unit Group

(S)

SEC	-	Securities and Exchange Commission

(U)

UNDP	-	United Nations Development Program
UPLB	-	University of the Philippines, Los Baños
UPRIIS	-	Upper Pampanga River Integrated Irrigation System
USAID	-	United States Agency for International Development
USBR	-	United States Bureau of Reclamation

(W)

WCCC - Water Control Coordinating Center
WM - Watermaster
WMT - Water Management Technologist
WMTC - Water Management Training Center

(Z)

ZE - Zone Engineer

CHAPTER 1 INTRODUCTION

1.1 Authority

This Report was prepared in accordance with the Article IV-3 of the scope of works stipulated in the "Implementing Arrangement for Technical Cooperation for Feasibility Study on the Gumain River Irrigation Project in the Republic of the Philippines" agreed upon between the National Irrigation Administration (NIA) and the Japan International Cooperation Agency (JICA) on 3rd February, 1983.

This report presents the results of studies on the technical and economic feasibility of the proposed Gumain River Irrigation Project. The report covers the present physical and economic condition of the study area, the proposed development plan, and economic and financial analysis of the project. All comments on the Draft Final Report which was prepared at the middle of October 1984 has been incorporated in this report.

This Main Report is supported by the following Appendixes:

APPENDIXES VOLUME 1

Appendix I	Hydrology
Appendix II	Geology and Dam Construction Materials
Appendix III	Soils and Land Classification
Appendix IV	Agriculture and Agro-Economy

APPENDIXES VOLUME 2

Appendix V	Optimization of Project Scale
Appendix VI	Dam and Reservoir
Appendix VII	Irrigation and Drainage
Appendix VIII	Hydropower
Appendix IX	Organization and Management
Appendix X	Construction Plan and Cost Estimate
Appendix XI	Project Evaluation

APPENDIXES VOLUME 3

Appendix XII	Drawings

1.2 Project History

The proposed Gumain river irrigation project area is situated in the south-western part of Pampanga river basin, Central Luzon.

In view of the importance of the Pampanga river basin for agricultural production in the country, NIA has been making provision for irrigation water in the area. Already most of the arable land in the Pampanga river basin, except for the west bank area of the lower Pampanga river, is provided with year-round irrigation water through completion of the Upper Pampanga River Integrated Irrigation System (UPRIIS), Angat-Maasim River Irrigation System (AMRIS) and Tarlac River Irrigation System (TRIS). Furthermore the Balog-Balog Irrigation Project, the Casecnan Transbasin Diversion Project and the Pampanga Delta Development Project are now in the planning stage.

Although agricultural productivity will be increased considerably by these measures, it will still remain low in the west bank area of the lower reaches of the Pampanga river due to: (i) absence of a storage reservoir to provide irrigation water during the dry season, (ii) deterioration of existing irrigation systems, and (iii) inadequate drainage systems and road networks.

In order to cope with these constraints, the Government of the Philippines contemplated the Gumain River Irrigation Project and requested the Government of Japan to extend their technical cooperation for a Feasibility Study on the project. The project is expected to provide irrigation water to the whole alluvial fan of the Gumain, Porac and Caulaman rivers including the existing Porac-Gumain River Irrigation System and Caulaman River Irrigation System, and will contribute to increase agricultural productivity in the area.

In response to the request of the Government of the Philippines, the Government of Japan decided to provide the technical assistance for a Feasibility Study of the Gumain River Irrigation Project. Prior to the Feasibility Study, JICA dispatched the Preliminary Study Team to the Philippines from 24th January to 5th February 1983. The Preliminary Study

Team made a field reconnaissance of the study area and discussed implementation of the Feasibility Study with staff of NIA and other officials concerned. On 3rd February 1983, the Implementing Arrangement for Technical Cooperation for a Feasibility Study on the Gumain River Irrigation Project was agreed on by NIA and JICA, and on 17th July 1983 a study team was dispatched to the Philippines to commence field investigations in and around the study area.

1.3 Objective of the Study and Summary of the Scope of Works

The study aimed to formulate a viable irrigation project having a storage dam in the Gumain river, and to verify the technical and economic feasibility of the project.

The scope of the study in the first stage was to carry out data collection and field survey for project formulation, and in the second stage to conduct supplementary field survey, analysis and project formulation.

The detailed "Scope of Works" is shown in the Attachment of this report.

1.4 Activities of the Study Team

JICA Study Team arrived in Manila on 17th July 1983 to carry out the first stage works. The first stage of the study was divided into two phases, namely first field works and second field works, in line with the schedule in the preparation of new topographic maps with a scale of 1/4,000 by JICA.

The first phase field works were carried out from 17th July to 3rd September 1983, and the second phase field works were conducted from 5th January to 29th March 1984. While JICA Study Team did not have field activities from September to December 1983, investigations on hydrology, geology and yield survey of paddy were carried out by NIA.

The new topographic maps with a scele of 1/4,000 were completed and delivered at the end of December 1983. The maps were fully utilized during the course of the second phase field works of the study.

At the beginning of the first phase field works, an Inception Report including the plan of operation for the whole study was submitted to NIA, and the Field Report was prepared at the end of the first phase field works. The Interim Report which presented the interim result of the first stage of the study, was prepared at the end of March 1984.

The second stage works comprised supplementary field works and home office works in Japan. The supplementary field works were executed for about one month from June 3 to 30, 1984. Following these, a Second Field Report presented the results of works and confirmation on certain outstanding matters in the Interim Report. After completing the supplementary field works, detailed analysis of data, study of the optimized plan, formulation of the final plan and evaluation of the project were carried out in Japan for about three months from July to September 1984, and these study results were compiled in the Draft Final Report at the middle of October. A discussion meeting on the Draft Final Report was held at the end of October 1984 at the NIA central office. Based on the comments at the meeting, this Final Report was prepared and submitted in accordance with the scope of works.

JICA Advisory Committee, Study Team and the Philippine Counterpart Group who have taken part in the survey and study are listed in Table 1.

1.5 Acknowledgement

The JICA study team wishes to take this opportunity to acknowledge their gratitude to the staff of the National Irrigation Administration with special thanks to the counterpart personnel for their kind cooperation and invaluable support during the study period. Throughout the entire period of the field works, the team received valuable assistance and cooperation from various institutions in the Philippines. The team wishes to express their appreciation to the officials of government agencies concerned for their help in activities being carried out by the team. And, of course, the team remains grateful to all those who have helped during the study period.

CHAPTER 2 GENERAL ECONOMIC AND AGRICULTURAL BACKGROUND

2.1 Land and Population

The Philippines is located between latitude 5° and 21° north, and between longitude 117° and 127° east with an area of 300,000 km^2. The Philippines comprises a great diversity of cultures and languages in an archipelago consisting of about 7,000 islands stretching over a distance of 2,000 km. The total population of the country was about 52 million in 1983 with the population density of about 173 persons/km^2, which had increased at an average growth rate of 2.5% per annum during the period from 1975 to 1980. In recent years, Metropolitan Manila has grown disproportionally compared with other parts of the country; between 1970 and 1980, its population increased by 60% and reached 6.5 million in 1980. The working population in the whole country in 1983 was estimated at about 19.5 million.

2.2 National and Regional Economy

Basic data for the national economy are presented in Table 2. The Gross National Product (GNP) in 1983 is ₱377 billion at current market prices or the equivalent of US$34.3/1 billion, and per capita GNP is approximately ₱7,300 or US$660/1. During the past four years from 1979 to 1983, GNP in real terms increased by 3.0% per annum. Of the Gross Domestic Product (GDP) in 1983 about 39% of GDP was derived from the services sector, followed by 36% from the industrial sector. The agricultural sector only account for 25% of GDP.

The gross regional domestic product at 1972 constant prices is shown in Table 2. In 1982, Region III which includes the study area accounted for 8.1% of GDP in the whole country. Of the GDP in Region III, about 38% is derived from the services sector, followed by 34% from the industrial sector, and remaining 28% is from the agricultural sector. Distribution by industrial origin follows almost same pattern as the GDP in the whole country. Economic growth from 1980 to 1982 was estimated to have averaged annual real growth in GDP of 3.8%.

/1: Exchange rate: US$1.0 = ₱11.0 (June, 1983)

2.3 Agriculture

The agricultural sector has a dominant role in the Philippine economy. About 70% of the total population or 36 million people lives in rural areas; two-thirds of them are depending on agriculture for their livelihood. Overall, more than half of the labor force is engaged in agriculture. In 1983, the sector contributed about 25% to GDP, and accounted for about 34% of total exports in 1982. Crop production is the major subsector constituting about 61% of the total value added in agriculture. Fisheries account for 18%, livestock and poultry 12% and forestry 9%.

Major crop products in the country are rice, corn, banana, rootcrops, coconut and sugar, as shown in Table 3. As main food crops, the production of rice and corn amounted to about 8.1/1 million tons and 3.3 million tons, respectively in 1982. Commercial crops such as sugar, coconut, banana and tobacco are major export goods. The export of sugar and coconut is particularly important. The production of sugar and coconut in 1982 was estimated at 7.3 million tons, and the export value of these two crops was US$1.0 billion or 20% of the value of all exports as shown in Table 4.

The government of the Philippines has embarked on the five-year development plan (1983-1987) of which the development plan for the agricultural sector places primary emphasis on the following major objectives:

(1) To improve and stabilize farmers' income and welfare through better marketing, higher productivity, and a rationalized land tenure system;

(2) To enhance landless rural workers' welfare by assuring them of better access to agricultural resources and a fair share of national income through higher returns to farmers, intensified resettlement activities, or by provision of more gainful off-farm employment;

/1: Rough rice (paddy)

(3) To carry out a rational land use policy whereby lands suitable for agriculture are retained in agricultural use and their diversion to other uses prevented;

(4) To stimulate the growth of food production with special emphasis on food products for the nutritionally deprived population group, to ensure the availability of essential food supplies; and

(5) To step up productivity and expand production to support domestic food requirements, export promotion, import-substitution, and agroenergy requirements.

The government considers that these basic development objectives can be achieved through crop diversification, expanded irrigation, and the use of more appropriate and high yielding technology such as fertilizers and improved soil preparation techniques and fish cultural practices.

CHAPTER 3 PRESENT CONDITION OF THE STUDY AREA

3.1 Location

The study area is located in the southwestern part of the Pampanga River Basin in the Central Luzon about 70 km northwest of Manila, the capital of Philippines. It is bounded generally in the west by the Cabusilan mountains, both in the east and south by the National Highway Route 7, and in the north by the Guagua river. The gross area of the study area is about 23,700 ha, which is covered by the new topographic maps on a scale of 1/4,000 with 1 m contour interval prepared by JICA on December 1983.

Administratively, the study area overlaps two Provinces, Pampanga and Bataan of Region III, and includes six municipalities as shown below (see Fig. 1).

Pampanga Province

1) Guagua
2) Floridablanca
3) Lubao
4) Santa Rita

Bataan Province

1) Dinalupihan
2) Hermosa

About 80% of the study area belongs to the Pampanga Province.

3.2 Physical Features

3.2.1 Topography

The study area extends over the alluvial fans and plains created by the Gumain, Porac and Caulaman rivers with slopes ranging from 0.2% to 2.5% south-eastward. Generally, land below EL. 20 m is very flat with an average slope of 0.2% to 0.3%, however land above EL. 20 m is relatively steep with slopes ranging from 0.5% to 2.5%. The elevation of irrigable lands in the study area ranges from 5 m to 40 m above MSL.

3.2.2. Climate and Meteorology

The climate in Philippines is characterized in terms of precipitation during different seasons of the year. On this basis there are four climate types in Philippines as shown in Fig. 2, but the study area all belongs to Type-I which is characterized by distinct dry and wet seasons: a dry season from November to April and a wet season during the rest of the year.

In and around the study area, there are two meteorological stations, namely Basa Air Base and Hacienda Luisita. General climatic characteristics in the area are summarized in Table 5. The annual mean temperature is 27.1 °C, with a maximum monthly mean of 28.7 °C in May and a minimum of 25.6 °C in January. The relative humidity varies between about 79% during the wet season and about 69% during the dry season. The annual mean percentage of sunshine is about 55.8% with a monthly mean ranging from 31.7% in August to 75.6% in April. The monthly mean wind velocity varies from 2.5 m/sec in October to 3.5 m/sec in February with an annual mean of 3.2 m/sec. The annual mean A-pan evaporation is 1,785 mm equivalent to a daily mean of about 4.9 mm. The maximum monthly mean evaporation of 221 mm (7.4 mm/day) occurs in April and the minimum of 102 mm (3.3 mm/day) in August.

There are 24 rainfall stations including two stations installed by the JICA Study Team in and around the study area. Table 6 shows the mean monthly rainfall at each station. In the study area, the mean annual rainfall is about 2,400 mm in the north-western part, about 2,000 mm in the eastern part and about 2,600 mm in the southern part. The mean annual rainfall increases gradually toward the west. In the western mountain range including the Gumain, Porac and Caulaman river basins, it is likely that the annual rainfall reaches about 3,000 mm on the basis of the prevailing wind system and the rainfall of Iba and San Marcelino. About 90% of the annual rainfall occurs during the wet season and the heavy precipitation generally falls in August.

3.2.3 Geology

The study area is located between the Central Luzon Plain and the Western Cordillera. An agricultural land zone is in the south-west of the plain, and the proposed Gumain dam site and reservoir are in the vicinity of the Western Cordillera known as the Zambales Range. The Central Luzon Plain extends from Manila on the south to Lingayen Gulf on the north. The plain consists of flat alluvial materials which are composed mostly of loosely compacted gravel, sand and clay derived from volcanic tuff and pyroclastics. The Western Cordillera extends two parallel mountain ranges from Bataan, northward to Pangasinan Province. The rocks in these mountain ranges, in general, are volcanic extrusives and the south-eastern part of the range including the dam site is largely formed by phroclastics.

The geology of the proposed reservoir area is composed of pyroclastic of Pliocene-Pleistocene age such as volcanic breccia containing various ratios of gravels. Upstream of the reservoir, lapilli tuff and tuff breccia are dominantly distributed. At the dam site area, tuff breccia with rhyolite gravels and agglomerate predominate. Overburden layers are composed of alluvial deposits, talus deposits, residual soils and extensively weathered rocks. At the river bed, alluvial deposits consist of a well-compacted mixture of sand, gravels and boulders derived mainly from hard andesite and basalt of a maximum thickness of about 8 m. Many great outcrops are observed around the dam site area, and most of them are massive rocks without open cracks. Reflecting the massive structure, foundation rocks of the dam site area have relatively low permeability.

A series of faults and joints are found around the dam site, and lineaments are also found. In the proposed reservoir area, faults were observed crossing the river, columnar joints at interval of about 100 m and a few platy-joints along the flow beddings. These faults and joints are not considered to have any significance for dam and reservoir planning since most of them are crossing against river channels and their scales are relatively small.

3.2.4 Soils

In the study area, only one soil group was identified as being derived from recent alluvial deposits and it is represented by four soil series, namely the San Fernando soil series, La Paz soil series, San Manuel soil series and Quingua soil series.

Soils of San Fernando series extend over the flat low-lying flood plain located along the lower parts of the Guagua, Porac and Gumain rivers. The land covered with these soils is poorly drained and affected by flooding or ponding water during the wet season. The total land area amounts to 1,700 ha or 7.2% of the study area and at present is used for paddy cultivation. In general, these soils have a moderately high inherent soil fertility and a neutral pH value.

Soils of La Paz series extend over the flat to slightly depressed land on the alluvial terrace developed along the Porac, Gumain and Caulaman rivers. The land covered with these soils is well drained and presently used for paddy in the slightly depressed portion and for sugarcane in the flat portion. This land amounts to 5,550 ha or 23.4% of the study area. With regard to chemical properties, pH values are neutral and inherent soil fertility appears to be poor.

Soils of San Manuel series are found on the flat to very gently undulating alluvial terrace mainly between the Guagua and Gumain rivers. The land covered with these soils is well drained and amounts to 4,630 ha or 19.5% of the study area. At present, most of this land is used for paddy. These soils have a slightly acid pH value and moderately high inherent soil fertility.

Soils of Quingua series are found on the nearly level to very gently undulating alluvial terrace located along the middle reaches of the Porac river and the middle to lower reaches of the Gumain and Caulaman rivers. The land covered with these soils is well drained, but depressed areas along the middle reaches of the Gumain and Caulaman rivers and the Palcarangan creek are lightly affected by flooding. This land amounts to 7,170 ha or 30.3% of the study area. Presently, this lands is used mainly for paddy cultivation but with some sugarcane cultivation. The soils have a slightly acid to neutral pH value and a moderately high inherent soil fertility.

3.3 Human Resources

The population of the study area in 1983 was estimated to have been about 168,000 comprising 51% of male and 49% of female. The annual population growth rate averages 2.24% between 1975 and 1980. Population density is 710 persons per km^2. As for the age distribution, 29% of the total population is fourteen years old and under, and only 5% is sixty years old and over. Total household and average family size in 1983 were estimated to be about 27,100 and 6.2 persons respectively as shown in Table 7.

Out of total households, farm households account for 20%, and 18% are landless laborer households who make their living primarily as farm laborers with emphasis on farming of paddy and sugarcane. These landless workers play an important role in the supply of labor. The remaining 62% are government servants, private employees, businessmen, vendors, ordinary laborers, etc.

On the assumption that the age of farm laborer ranges between 15 and 59 years old, the family labor force per farm household is estimated to be 4 persons. Furthermore, school children and students of ten years old and over who amount to about 15% of the average family, usually do part time farm work, so that the average farm family labor force is rather more than 4.

3.4 Water Resources

3.4.1 River Runoff

There are three major rivers in the study area, namely the Gumain, Porac and Caulaman rivers which all originate in the Cabusilan Mountains of the western mountainous range. The Gumain river lies between Porac and Caulaman rivers flowing from the northwest to the southeast and joins the Porac river around the center of the study area. Thereafter the Porac-Gumain diversion channel joins the Guagua river in the lower reaches of the Pampanga delta. The Caulaman river whose name is changed to Balsic river near its mouth, flows directly into the Pampanga Bay.

Although the available discharge records of these rivers are quite long, the records for the Porac and Caulaman rivers are not considered to be reliable. Those of Gumain river are judged to be reliable and useful for checking the existing data. The reasons for this are as follows:

- The rating curves of Gumain river at the Pabanlag Station used for estimating discharge coincide with actual discharge measurements.
- The discharge records at the Summer Place made by JICA Study Team on the Gumain river show correlate well with records of the Gumain river at the Pabanlag Station.
- The river beds of Porac river at the Del Carmen Station and Caulaman river at the Pabanlag Station change with the frequent flooding of these rivers, but no modifications are made to their rating curves.

From the above, it is clear that the discharges of the Porac and Caulaman rivers should be estimated from those of the Gumain river.

The monthly mean discharges of the Gumain, Porac and Caulaman rivers are shown below based on the hydrological analysis.

(Unit: m^3/sec)

Month	Gumain River Pabanlag Station (C.A = 122 km^2)	Porac River Del Carmen Station (C.A = 111 km^2)	Caulaman River Pabanlag Station (C.A = 72 km^2)
Jan.	1.94	1.23	1.03
Feb.	1.76	1.12	0.93
Mar.	1.66	1.06	0.88
Apr.	1.69	1.08	0.90
May	5.03	3.20	2.67
Jun.	9.74	6.20	5.17
Jul.	17.21	10.96	9.14
Aug.	24.03	15.30	12.76
Sep.	18.98	12.09	10.08
Oct.	10.27	6.54	5.46
Nov.	5.24	3.34	2.79
Dec.	2.69	1.71	1.43
Average	8.40	5.35	4.46

3.4.2 Water Quality

For the purpose of checking water qualities of the Gumain, Porac and Caulaman rivers for irrigation, water samples were collected at the following locations:

i) Gumain River - at the water level gauging station near Summer Place

ii) Porac River - at the existing Porac Diversion Dam site and Del Carmen Bridge site located at about 1 km upstream of the dam

iii) Caulaman River - at the existing Caulaman Diversion Dam site

Water samples taken from the above places were analysed at the NIA Laboratory, Muñoz, N.E. and the result of water quality analysis showed that the water are suitable for irrigation.

3.5 Infrastructure

3.5.1 Transportation and Communication

Roads in the study area are the main means of transportation to prospective market places of Metro Manila, San Fernando, Angeles, etc. Trunk roads, National Highway Route 3 and the Express Highway running near the study area, link Angeles to Metro Manila. National Highway Route 7 linking the above trunk roads to Layac runs through the southern boundary of the study area. It is paved and relatively well-maintained. Moreover, paved roads of Route 306 and 310 run through the study area. These roads become the most important marketing and transportation artery for the agricultural products and required inputs.

Telecommunication systems are available in the major towns along the National Highway Route 7, but elsewhere there are none, even in the NIA Porac-Gumain River Irrigation System Office.

3.5.2 Electricity and Water Supply

The study area has some electricity supply system. Five municipalities, namely Guagua, Lubao, Santa Rita, Dinalupihan and Hermosa, are supplied by Pampanga II Electric Cooperative, Inc. (PELCO-II) and Floridablanca is supplied by Mansons Corporation. Both suppliers are franchised by National Electrification Administration (NEA) and purchase the power from National Power Corporation (NPC) through their nearby transmission line.

The water for domestic use in the study area mainly depends on groundwater. Small-scale domestic water supply systems are found in the major towns, but most of the villages have to depend on shallow wells.

3.6 Irrigation and Drainage Systems

3.6.1 Irrigation Systems

In the study area there are two national irrigation systems, the Porac-Gumain River Irrigation System (PGRIS) and the Caulaman River Irrigation System (CRIS), as well as various communal and pump irrigation systems. The general features of these systems are summarised as follows:

(1) Porac-Gumain River Irrigation System (PGRIS)

The Porac-Gumain River Irrigation System (PGRIS), completed in 1957, was originally designed to irrigate 6,000 ha of land located in the municipalities of Floridablance, Lubao, Guagua and Santa Rita, all in the province of Pampanga. Due to shortage of irrigation water and deterioration of some facilities in the system, it is now only capable of servicing 4,890 ha during the wet season and 3,810 ha during the dry season.

This system has two diversion dams, the Porac Diversion Dam of a falling shutter type located at Pulangmasle in Guagua and the Gumain Diversion Dam of an ogee type located at San Pedro in Floridablanca. These dams contain two main irrigation canals, Porac-East and West canals and Gumain-North and South canals. The total length of main irrigation canals, laterals and sub-laterals is about 65 km.

(2) Caulaman River Irrigation System (CRIS)

The Caulaman River Irrigation System (CRIS), completed in 1968, was originally designed to irrigate 2,000 ha of riceland in the municipalities of Floridablanca and Lubao in Pampanga Province and in the municipalities of Dinalupihan and Hermosa in Bataan Province. It is now only capable of irrigating 540 ha during the wet season and 480 ha during the dry season. Some parts of the original service area were taken for residential use or conversion to sugarcane fields, while some are now being served by communal irrigation systems.

The main diversion structure on the Caulaman river consists of an ogee type dam with a length of 72 meters. There are also supplementary dams and checkgates for diverting additional water supply independent of the main diversion dam. Total length of main irrigation canals, laterals and sub-laterals is about 42 km, but some canals and canal structures are in need of repair.

(3) Communal Irrigation System (CIS) and Pump Irrigation System (PIS)

The Communal Irrigation Systems (CIS) are operated by gravity with the small-scale diversion dams and canal systems to make use of small rivers and streams. These systems have been constructed by NIA on provincial basis, and operation and maintenance are conducted by irrigators associations with guidance of Farm Systems Development Corporation (FSDC) and NIA. There are about seven such CISs in the study area. Although most of these were originally designed as parts of the national irrigation system, they are now operated as the communal irrigation systems.

The small-scale pump irrigation systems (PIS) have been developed by NIA and FSDC to further increase the irrigable area. In the study area there are many pump irrigation systems for use of surface water and ground water, however these service areas are not always irrigated mainly due to the high cost of operation and maintenance, especially of fuel.

3.6.2 Drainage Condition

There are four major rivers and many drainage creeks in the study area, namely Gumain, Porac, Caulaman, Guagua rivers and Mababayan, Sapang Matua, Santa Catalina, Santor, Palcarangan, Lauc Pao Creeks, etc. The Porac river has been connected with the Gumain river by the Porac-Gumain diversion channel. Flood protection dikes have been constructed for about 8.0 km downstream of the confluence with the Porac-Gumain diversion channel, which has a carrying capacity of more than 1,000 m3/sec.

The drainage capacities of the existing rivers and creeks except for the Porac-Gumain diversion channel are in some cases insufficient and the checkgate structures constructed in the creeks are not properly operated. Furthermore, the road crossing structures over rivers and creeks have insufficient carrying capacities, which cause some drainage problems at lower areas along Highway Route 7. The density of farm drains and drainage ditches at on-farm level in most of the study area also remains low.

3.7 Water Permits

According to the information of the National Water Resources Council (NWRC), the water permits for the existing irrigation systems in the study area are as follows:

Name		:	NIA	FSDC (CIS)
Address		:	Floridablanca	Dinalupihan
Source		:	Gumain R., Porac R.	Caulaman R.
Coordinates	Lat.	:	14°57'05", 14°59'32"	14°52'17"
	Long.	:	120°30'07", 120°32'06"	120°28'24"
Permit No.		:	6419	3584
Date Granted		:	Dec. 11, 1957	Feb. 23, 1978
Method of Diversion		:	Overflow Dam	Pump
Irrigable Area (ha)		:	6,610	60
Amount Available (ℓ/s)		:	6,910	-
Amount Granted (ℓ/s)		:	6,910	60

There are no water permits given to the existing private systems as well as the Caulaman River Irrigation System. The proposed Gumain River Irrigation Project will integrate the existing Porac-Gumain River Irrigation System, Caulaman River Irrigation System and other communal and private irrigation systems.

3.8 Agriculture

3.8.1 Land Use

The land in the study area is classified into five land use categories, namely paddy field, upland field, grass/bush land, residential area and miscellaneous area including rivers, creeks, roads, etc. as shown below.

Land Use Category	Area (ha)	Proportional Extent (%)
Paddy Field	11,900	50.2
- Irrigated area	7,240	30.5
- Rainfed area	4,660	19.7
Upland Field	6,850	28.0
- Sugarcane area	6,800	28.7
- Perennial crop area	50	0.2
Grass/Bush Land	300	1.3
Residential Area	1,300	5.5
Miscellaneous Area	3,350	14.1
Total	23,700	100.0

The farm land comprising paddy field and upland field amounts to 18,750 ha or 79% of the total. Paddy field occupies 11,900 ha or 50% of the total of which 7,240 ha or 61% are under irrigation and the remaining 4,660 ha or 39% are rainfed. The irrigated paddy fields are presently served by the three types of irrigation system as follows:

(Unit: ha)

Irrigation System	Wet Season	Dry Season	Total
1) National Irrigation System			
- Porac-Gumain	4,890	3,810	8,700
- Caulaman	540	480	1,020
2) Communal Irrigation System	540	250	790
3) Pump Irrigation System	1,270	1,140	2,410
Total	7,240	5,680	12,920

The upland fields are mostly used for sugarcane or perennial crops such as mango, coconut and banana, which are grown in very limited areas and are located in and around the residential areas.

3.8.2 Land Tenure and Land Holding

Farmers in the study area are classified into two farming types, namely rice cultivation farmer and sugarcane planter. Out of the total farm household, rice cultivation farmer accounts for 95% or 5,230 households and the remaining 5% or 250 households are sugarcane planter.

The typical farm size is 1.3 ha for rice cultivation farmer and 4.0 ha for sugarcane planter. On the other hand, their average farm sizes are estimated at 2.3 ha and 27.0 ha, respectively. As for land tenurial status in the study area, about 54% of total rice cultivation farmers are occupied by lessees and 77% of total sugarcane planters are owner operators. Therefore, it can be said that the representative or typical farmers in the study area are the lessee having 1.3 ha for rice cultivation farmer and the owner operator having 4.0 ha for sugarcane planter.

3.8.3 Cropping Pattern and Farming Practices

The main crops grown in the study area are rice, followed by sugarcane. Diversified crops such as vegetables, mongo beans, corn are found in limited areas. The cropping seasons of these crops are affected by the seasonal distribution of rainfall, and planting and harvesting vary from year to year depending on availability of water.

In the wet season, rice is planted at the onset of the monsoon, generally from June to August, and harvested from October to November. In the dry season, it is planted in the period between December and January, and harvested from March to April. The cropping pattern of sugarcane includes plant cane and ratoon cane, and the harvesting period lasts from November to early April. As far as diversified crops in the study area are concerned, most of these are fruit vegetables which are grown in paddy fields in the dry season under irrigation with the use of pumps. Mongo beans and corn are cultivated under rainfed condition, and planted just after harvest of wet season paddy to take advantage of the soil which is still moist. The present cropping pattern in the study area is illustrated in Fig. 3.

Cropping areas by crops are summarized in the following table. The present multi-cropping index is estimated at 1.3.

(Unit: ha)

Crops	Cropping Area			Land Area	Multi-cropping Index
	Wet Season	Dry Season	Total		
I) Paddy Field	11,900	5,680	17,580	11,900	1.48
Paddy	11,900	5,480	17,380		
- Gravity Irrigation	(5,970)	(4,540)	(10,510)		
- Pump Irrigation	(1,270)	(940)	(2,210)		
- Rainfed Area	(4,660)	(-)	(4,660)		
Diversified Crops		200	200		
II) Sugarcane Field			6,800	6,800	1.00
- Plant Cane			(2,940)		
- Ratoon Cane			(3,860)		
Total/Average			24,380	18,700	1.30

Rice cultivation is carried out in labor extensive form from the stage of seeding to harvesting. Improved high yielding varieties of rice have been widely grown through the extension of Masagana 99. The predominant varieties are IR 36, IR 42 and IR 46 which are early maturing and high yielding varieties. Local varieties such as Milagrosa, Dacut Manuel, etc. are still used mainly for home consumption and the local market. Application of fertilizers and agro-chemicals in the area is estimated as follows: fertilizer range from 46 kg to 79 kg for N and 3 kg to 6 kg for P_2O_5 and K_2O per ha, agro-chemicals, average 2.3 ℓ for liquid type and 5.5 kg for granular type per ha, all applied by use of Knapsack type sprayers. In spite of such a relatively high dosage of fertilizers and agro-chemicals, productivity is still low, because the application timing and volume of these inputs are not appropriate. Land preparation consists of plowing, harrowing and puddling of the field using both animal power and machine power. Threshing is mostly carried out by machine but other farming work is done by manpower. Hired labor accounts about 50% of the total labor input. In particular more than 90% of farm work on transplanting and harvesting is carried out by hired labor.

The present cropping pattern for sugarcane in the study area consists of plant cane and one ratoon. Plowing and harrowing are the most important elements in land preparations for plant cane, comprising one plowing and two harrowings done with the use of a moldboard or disc plows and a disc harrow pulled by a tractor. Land preparation by the use of animal power is common for small holders. Planting is carried out immediately after furrowing to conserve moisture. Furrows are spaced 1 to 1.2 m apart. The most prevalent variety is PHIL 58260 which accounts for 75% of total planted area. Cultivation of plant cane after planting is the same with ratoon cane except for stable shaving. Fertilizing consists of basal and side applications, and the total application fertilizers range from 100 kg to 110 kg for N per ha. No agro-chemicals are used, since no significant damage from pests and diseases is found in the study area. Cultivation is carried out usually 3 to 4 times either by use of machine or manually, during the 3 months after planting or stable shaving for ratoon cane. Sugarcane in the study area is usually harvested manually by cane knife. After harvesting, stable shaving is usually done manually in order to ensure ratooning.

Vegetables are cultivated labor intensively under irrigation. Use of pump irrigation is wide spread in the study area but irrigation period is very limited to ensuring high yields because of high operation costs. Fertilizer and agro-chemicals are commonly applied at 370 kg/ha for N, 110 kg/ha for P_2O_5, 80 kg/ha for K_2O and 6.8 ℓ/ha for liquid type chemicals. For the diversified crops such as mongo beans, corn, etc. simple farming is still common without use of fertilizers or agro-chemicals.

3.8.4 Agricultural Production

Crop yields and production in the study area fluctuate from year to year due to variations in rainfall and unexpected damage caused by pests and diseases. The average yields and production during the past five years from 1978 to 1982 were estimated as shown below.

Crops	Harvested Area (ha)	Unit Yield (t/ha)	Total Production (ton)
1) Paddy	17,380	2.53	44,020
Wet Season Paddy			
- Irrigated	7,240	2.70	19,550
- Rainfed	4,660	1.96	9,130
Dry Season Paddy			
- Irrigated	5,480	2.80	15,340
2) Sugarcane	6,800	34.22	232,700
- Plant Cane	2,940	38.13	112,100
- Ratoon Cane	3,860	31.25	120,600
3) Diversified Crops (Ampalaya)	200	10.90	2,180

The average unit yield of paddy is estimated at 2.53 t/ha which is higher than the national average yield of 2.4 t/ha in 1982. This unit yield, however, is still on the low side as compared with the targeted yield of the Masagana 99 Program of 5.0 t/ha. The unit yield of sugarcane averages about 34 tons cane per ha for both plant cane and ratoon cane, and these yields are extremely low as compared with national average yield of 57 tons cane per ha. With regard to diversified crops, ampalaya was taken up as the representative crop, being widely grown in the study area. The unit yield of ampalaya was estimated to be 10.9 t/ha after pests and diseases have inflicted considerable damage estimated to be more than 20% of the yield.

The number of livestock raised per farm household in the study area is estimated as follows:

Livestock	No./Farm Household
Carabao	1.5
Cattle	0.1
Hogs	1.5
Chicken	8.6
Ducks	1.8

Livestock production in the study area is still insignificant and is not an important activity in the agricultural sector. Most livestock is grazed on a small scale in and around the farm land or home yard.

3.8.5 Marketing and Prices

There are three marketing channels for rice distribution from farmers to consumers. The first is through National Food Authority (NFA), the government agency primarily responsible for price and supply stabilization, and the overall marketing phase of cereal industry. The second is through farmers' cooperatives, such as the Area Marketing Cooperative (AMC), Farm Cooperative Marketing Association (FACOMA), etc. These organizations are composed of small farmers, and the farmers deliver rice to AMC or FACOMA which in turn sells it through its supermarket or Kadiwa Centers or directly to consumers. The third is through commercial channel via middlemen. There are about 400 rice wholesalers and retailers in and around the study area. About 10% to 15% of the total rice is marketed through NFA and the remainder through commercial and other organizations.

Marketing of sugar in the Philippines consists of withdrawal by traders/industrial users for the domestic market and withdrawal by the National Sugar Trading Corporation (NASUTRA) for the export merket. Domestic sugar distribution is handled by accredited domestic traders, and marketing is under government control. The domestic trader is the primary distributor of sugar for the local market and obtains his stock from mill warehouses and/or refineries upon presentation of delivery order issued by NASUTRA. In addition, industrial users are also given sugar allocation by PHILSUCOM/NASUTRA for the manufacture of sugar-containing products. All sugar for export is handled by NASUTRA which is the government agency having overall responsibility for organizing sugar movement from mill site warehouse to final buyer.

For vegetables produced in the study area, there are two marketing channels: one through local markets in and around the project area, and the other to Metro Manila through middlemen. No government agency or organizations exist for vegetable marketing.

The prices of agricultural inputs and outputs are as follows:

Item	Unit	Price (₱)
Paddy/1 (farm gate price)	(kg)	1.74
Rice/1 (retail price)	(kg)	3.06
Sugar/2 (producer price)	(kg)	2.64
Sugarcane/2 (farm gate price)	(kg)	0.184
Ampalaya/3 (farm gate price)	(kg)	2.60
Tomato/3 (farm gate price)	(kg)	2.00
Fertilizer/3 - (45 : 0 : 0)	(kg)	3.30
- (21 : 0 : 0)	(kg)	2.30
- (16 : 20 : 0)	(kg)	2.88
- (14 : 14 : 14)	(kg)	2.96
Agro-chemicals/3		
- Furadan 3G	(kg)	14.1
- Machete 5G	(ℓ)	86.3
- Azodrin 202R	(ℓ)	90.9
- 2-4 D	(ℓ)	49.7
Hired labor/3	(day)	25.0
Hired animal/3	(day)	35.0
Hired machinery/3		
- Hand tractor	(day)	175.0
- 4-wheel tractor	(day)	400.0

Remarks: /1: Average price in 1983

/2: Controlled price by NASUTRA in 1983/1984 (sugar year)

/3: As of Feb., 1984

The farm gate price of paddy has been raised from ₱1.56/kg in 1982 to ₱1.74/kg in 1983. The producer price of sugar controlled by NASUTRA, on the other hand, still remains at the level of ₱2.6/kg, due to the low world market price. The prices of ampalaya and tomato fluctuate monthly depending on supply and demand. The highest price appears in July to August and the lowest in January to March.

3.8.6 Processing and Storage Facilities

There are 86 rice mills in and around the study area with a milling capacity of about 607 t/day which is sufficient for present outputs. The total number of warehouses located in and around the study area is 77, and total storage capacity is about 33,900 tons. In the study area, there is one sugar mill owned by National Sugar Development Corporation (NASUDECO) and managed by the government through the Philippine National Bank (PNB). This sugar mill has a maximum milling capacity of 5,000 ton per day or 126,600 ton cane per month. Annual sugarcane ground and production of sugar are estimated to have averaged 268,000 tons and 24,000 tons from 1978/79 to 1982/83. Due to inactivity of the export market and shortage of raw materials (sugarcane), the capacity utilization or rate of operation of the sugar mill remains at around 41% of capacity.

3.8.7 Farmers' Economy and Intentions

Typical farmers in the study area are the lessee having 1.3 ha for paddy fields and the owner operator having 4 ha for sugarcane fields as mentioned before. The results of farm budget analyses are presented as below.

(Unit: ₱)

Description	Lessee for Rice Cultivation Farmer		Owner Operator for Sugarcane Planter
	Irrigated Area (1.3 ha)	Rainfed Area (1.3 ha)	(4.0 ha)
I) Gross Income	32,530	25,920	41,550
1) Farm Income	13,330	5,320	26,050
2) Off-farm Income	19,200	20,600	15,500
II) Gross Outgo	32,500	25,900	41,500
1) Production Cost	10,000	3,400	20,600
2) Living Expenses	22,500	22,500	20,900
III) Net Reserve/Capacity to Pay	30	20	50

The characteristics of the farm economy may be summarized as follows:

i) A considerable amount of income is derived from off-farm consisting of wage earned from work on other farm and non-farm activity, and remittances from families working in Metro Manila, abroad, etc.

ii) In spite of adequate family labor estimated at 4 persons/farm household, farming activities such as transplanting, harvesting and threshing, which requires intensive labor, is traditionally carried out by hired labors. This is reflected in the production costs.

iii) The food expenses amount for some 50% of total living expenses.

iv) The net reserve is negligibly small which indicates that the typical farmers in the study area have no reinvestment funds for improvement of their farming activities.

The study of farm budget makes clear that farm economy in the study area remains at the subsistence level.

In order to achieve an effective development plan, one must first identify the farmers' intentions. For this purpose, a farmers' intention survey was carried out in parallel with the farm economic survey of 120 sample farmers selected at random. The questions consist of the following two items:

i) Stress on the improvement of their present farm management

ii) Preferred cultivation crops after the implementation of the irrigation project

The results of this survey showed that about 90% of the sample farmers put stress on acquiring additional irrigation water, followed by prevention of pests and diseases. As for cultivation crops, more than 80% of the sample farmers want to cultivate paddy in both wet and dry seasons. An additional survey of sugarcane planters showed that the major constraints encountered in sugarcane production in the area were considered to be drought damage to rainfed cultivation.

It was concluded from the above that double cropping of rice under year round irrigation could be easily introduced in the irrigation development, and that irrigation of sugarcane coincides with the intention of sugarcane planters.

3.9 Agricultural Support System

3.9.1 Research and Extension

Agencies directly or indirectly responsible for research work are the following: International Rice Research Institute (IRRI), Maligaya Rice Research and Training Center (MRRTC), National Irrigation Administration (NIA), Bureau of Plant Industry (BPI), Bureau of Agricultural Extension (BAEx), Bureau of Animal Industry (BAI), Philippine Sugar Commission (PHILSUCOM), and Luzon Experimental Station (LES).

Only IRRI undertakes hybridization of rice that is both high yielding and resistent to diseases and pests. It also identifies unusual performance stability when grown in varying environments of hot and cold. MRRTC which is operated by BPI, conducts researches on rice varieties and improvement, crop production and processing, intensification of cultural and management practices, seed certification, etc. It also trains technicians and farmers who will directly apply the know-how to farm works.

NIA whose main function is to supply irrigation water, also undertakes water management, studies of land classification, irrigation extension and agro-economic research. BPI carries out research and field trials on rice and diversified crops such as legumes, vegetables, fiber, spices, etc. BAEx maintains extension works. In Pampanga and Bataan Provinces, there are 233 specialists for Masagana 99, and 12 specialists for Maisan 77 serving in extension work. Their workloads are estimated to be 244 ha per specialist for Masagana 99, and 92 ha per specialist for Maisan 77.

Aside from its main functions of research and development encompassing various aspects of the industry and regulating the distribution of sugar, PHILSUCOM provides technology transfer to both planters and millers. PHILSUCOM operates two major research centers, namely; the La Granja Sugarcane Experiment Station and the Luzon Experiment Station occupying 90 ha and 256 ha of experimental farm, respectively. As for government institutions related to the study area, there are the Luzon Experiment Station and the Pasumil Mill District Office having 11,300 ha of sugarcane fields to be processed by the NASUDECO sugar mill. In this district area, about 6,800 ha including 1,400 ha of the NASUDECO sugarcane fields are located within the study area. Total extension workers are 5 persons and their workloads are around 2,260 ha per one extension worker.

3.9.2 Credit Services

Credit services extended usually by banking institutions to farmers and cooperatives in the study area usually include:

i) Loans to farmers
   - Crop loans (in cash)
   - Commodity loans (in kind)

ii) Loans to cooperatives
   - Marketing loans
   - Facilities loans
   - Operating capital loans

Under the Masagana program, the Philippine National Bank (PNB) can release crop loans of ₱500 to ₱1,700 per hectare of crop land to farmers who are willing to participate in the program and adopt the rice or corn technology packages. The Agricultural Credit Administration (ACA) also assists in the financing crop and commodity loans to farmers as well as the marketing, facilities and operating capital loans to cooperatives.

Special financial assistance for purchase of processing and storage facilities and irrigation are granted in programs of the Development Bank of the Philippines (DBP), Land Bank of the Philippines (LBP), Farm Systems Development Corporation (FSDC) and National Irrigation Administration (NIA).

3.9.3 Agriculture and Food Programs

Recognizing the need for the development of agriculture and food production, the government has been extending assistance to the numerous agriculture and food programs such as Masagana 99 (national rice program), Maisan 77 (corn and feedgrains program), Guiayan Sa Kalusugan (vegetable production), Rice-Fish Culture, Barangay Irrigation Service Association (BISA), etc.

The Masagana 99 is a nationwide rice production program launched in May 1973 as a top national priority program and now in Phase XXI of operation. In six municipalities related to the study area, about 274 farmers took part in Masagana (with credit only) in Phase XX (November 1982 to April 1983), and 288 farmers in Phase XXI (May to October 1983). The total loan amounts reached ₱878 thousand in Phase XX and ₱653 thousand in Phase XXI. Repayments of loans are, however, relatively low being 66% on an average for Phases XX and XXI.

3.9.4 Farmers' Organizations

In the national development scheme, the government has been stepping up efforts to organize farmers into cooperatives or associations. As a result, some kinds of farmers' organizations were established in almost every province, municipality and barangay in the country.

In the six municipalities related to the study area, there are the following farmers' organizations:

Designation	No. of Unit	No. of Member	Characteristics (Promoter)
FIO	9	891	Farmer-irrigators' organization (NIA-PGRIS)
CIA	12	467	Communal irrigation association (NIA, FSDC)
KKK	5	39	National livelihood program (MHS)
Kilusang Bayan	4	1,194	Market and supply organization (BAEx)
Samahang Nayon	62	2,876	Barrio-based organization (BAEx)
ARBA	110	7,044	Group of agrarial reform beneficiaries (MAR)

In addition to the above farmers' organizations established by the government, there are two private cooperatives for sugarcane planters, the so called Del Carmen Sugar Producers' Cooperative Marketing Association Inc. (DCSPCMAI) and Porac Sugar Producers' Cooperative Marketing Association Inc. (PSPCMAI).

These farmers' organizations which number seven in and around the study area, do not compete with one another, even though they may seem to have similar legitimate objectives in the same area. These organizations were all set up to answer the needs of the farmers of various types and levels. However, farmers have pointed out that they experienced many inconveniences and problems.

Firstly, most programs lack an integrated approach in transferring modern technology as well as in extending financial assistance to the farmers. Traditional banking and credit facilities are readily available from the banks, while technology transfers are separately carried out by the government and private research institutions. Secondly, farmers are periodically faced with natural calamities, usually beyond their means of control; such as typhoon damage, prolonged drought or infestations of rats, pests and diseases. Thirdly, farmers complain of the weak farmers' organization as a result of which they have serious operational and financial troubles. Above all farmers want farm inputs, irrigation water, etc. to be delivered on schedule.

CHAPTER 4 PROJECT PLANNING

4.1 The Development Objective

The objectives of agricultural and irrigation development in the study area are to increase rice production by increasing the unit yield of paddy and to expand the irrigated area especially during the dry season. Also, as there are sugarcane fields in the study area, to increase sugar production through irrigation to raise the income of sugar planters.

For the above objectives, the development plan of the project is formulated as follows:

a) to provide year round irrigation by constructing a storage dam on the Gumain river,

b) to provide new conveyance facilities to supply irrigation water from the Gumain reservoir to the existing irrigation systems as well as to new irrigation areas including the sugarcane fields,

c) to rehabilitate and upgrade the existing irrigation systems,

d) to improve the drainage facilities and road networks including provision of new facilities where necessary,

e) to introduce improved irrigation farming practices,

f) to establish an operation and maintenance system for the irrigation and drainage facilities,

g) to improve the present agricultural support services, and

h) to examine possibility of hydroelectric power generation accompanying release of irrigation water from the Gumain reservoir.

4.2 Project Formulation

4.2.1 Assessment of Available Water Resources

The major water sources in the study area are the Gumain, Porac and Caulaman rivers. Although the available discharge records of these three rivers are quite long, the records of the Porac and Caulaman rivers are not considered to be reliable as mentioned in the previous chapter. Since the discharge records of the Gumain river correlate well with rainfall records at the Basa Air Base and it was, therefore, decided that the discharges of Porac and Caulaman rivers should be estimated from the discharge records of the Gumain river.

After examining the relationship between the discharges of the Gumain river and those of the Porac and Caulaman rivers by the double-mass curve method, the discharges of the Porac and Caulaman rivers can be estimated using the conversion factors for the discharges of Gumain river of 0.7 and 0.9, respectively as shown below:

$$Qp = 0.7 \times Q_G \times \frac{Ap}{A_G}$$

$$Qc = 0.9 \times Q_G \times \frac{Ac}{A_G}$$

where, Q_G: Runoff of Gumain river

Qp: Runoff of Porac river

Qc: Runoff of Caulaman river

A_G: Drainage area of proposed Gumain dam site, 114 km^2

Ap: Drainage area of existing Porac diversion dam site, 111 km^2

Ac: Drainage area of existing Caulaman diversion dam site, 72 km^2

The runoff of these three rivers was estimated on 10-day basis for the 26 years from 1958 to 1983. The average annual runoff is 248 MCM in the Gumain river, 169 MCM in the Porac river and 141 MCM in the Caulaman river, respectively. The mean monthly runoffs are summarized as follows:

(Unit: x10^3 m^3)

Month	Gumain R. (C.A = 114 km^2)	Porac R. (C.A = 111 km^2)	Caulaman R. (C.A = 72 km^2)
Jan.	4,838	3,298	2,750
Feb.	3,961	2,699	2,251
Mar.	4,153	2,830	2,360
Apr.	4,088	2,786	2,323
May	12,601	8,589	7,163
Jun.	23,582	16,073	13,404
Jul.	43,080	29,362	24,487
Aug.	60,129	40,983	34,179
Sep.	45,986	31,342	26,138
Oct.	25,705	17,520	14,611
Nov.	12,629	8,650	7,214
Dec.	6,715	4,577	3,871
Annual	247,527	168,709	140,699

4.2.2 Water Balance

(1) Methodology of the Water Balance Study

The essence of the Gumain River Irrigation Project is to supply irrigation water to the project area including the existing irrigation area, rainfed area and sugarcane field by providing a storage dam on the Gumain river.

To clarify the optimum scale of the dam and irrigation area, a water balance study was made on 10-day basis for 25 years from 1958/59 to 1982/83/1 based on the runoffs of Gumain, Porac and Caulaman rivers and the irrigation water demands estimated on the proposed cropping pattern, crop intensity and irrigable area.

The method and steps followed in the water balance study are summarized as follows (see Fig. 4):

1) Determination of cropping pattern by selecting the crops of paddy, vegetables and sugarcane.

/1: The calculation year was set to be from May to April based on the cropping calendar.

2) Calculation of crop water requirements using the meteorological data in and around the project area.

3) Calculation of effective rainfall based on the daily rainfall records at the Basa Air Base.

4) Estimation of irrigation diversion requirements.

5) Calculation of creek discharges at the existing checkgate structures for utilization of the return flow.

6) Water balance at the re-use points.

7) Water balance at the existing Porac and Caulaman diversion dam sites based on the unregulated flows of Porac and Caulaman rivers.

8) Reservoir operation study of the Gumain dam based on the inflows of Gumain river.

In the reservoir operation study, the following criteria concerning limitations for water shortages were used to determine the adequacy of project water supplies.

1) Maximum annual shortages should not be greater than 50 percent of the annual irrigation requirement,

2) Maximum combined shortages in any two consecutive years should not be greater than 75 percent of the irrigation water requirements, and

3) The average annual shortage over the 1958/59 - 1982/83 period should not be greater than 7 percent.

(2) Alternative Plans

1) Irrigable Area

Out of the gross area of 23,700 ha in the study area, the irrigable area was estimated to be as follows based on topographic maps with a scale of 1/4,000 taking into account the proposed irrigation canal alignment and topographic conditions.

Total irrigable areas (net) : 16,750 ha

Paddy fields (net) : 11,000 ha

Fields provided with irrigation facilities : 5,970 ha

Fields without irrigation facilities : 5,030 ha

Sugarcane fields (net) : 5,750 ha

In the water balance study, the following two alternative plans were taken into consideration for optimization of the irrigation area.

Alternative 1. To irrigate the existing paddy fields to the maximum extent during both the wet and dry seasons.

Alternative 2. To irrigate the existing paddy fields during the wet season and the sugarcane fields to the maximum extent, in this case to irrigate at least 5,970 ha of paddy fields provided with the existing irrigation facilities during the dry season.

2) Gumain Storage Dam

The proposed Gumain dam would be located on the Gumain river just downstream of the confluence of its two tributaries having a catchment area of 114 km^2. A fill type dam was adopted from the view point of the geological conditions of the foundations and abutments at the dam site.

Based on the analysis of geological conditions and availability of dam embankment materials around the dam site, the potential maximum dam scale was considered to be EL. 170.0 m of full water level. The water balance study was made for the following six cases of the dam scale to determine the optimum dam scale in relation to the above two alternative plans for the optimization of the irrigation area.

Description	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Dam Crest Elevation (m)	176.5	167.5	160.0	155.0	150.0	140.0
Full Water Level (m)	170.0	161.0	153.5	148.5	143.5	133.5
Gross Storage Capacity (MCM)	176.3	137.6	110.4	94.4	80.2	56.6
Active Storage Capacity (MCM)	164.9	126.2	99.0	83.0	68.8	45.2
Dam Height (m)	124.5	115.5	108.0	103.0	98.0	88.0
Embankment Volume (MCM)	11.15	7.97	5.58	4.79	4.35	3.26

(3) Result of the Water Balance Study

The relation between the dam scale and the irrigation area is summarized as shown below from the result of the water balance study.

Dam Scale		Irrigated Area (ha)				
Case	F.W.L. (m)	Paddy (Wet Season)	Paddy (Dry Season)	Vegetables (Dry Season)	Sugarcane	Total/1
Alternative 1						
1	170.0	11,000	9,200	1,800	5,100	16,100
2	161.0	11,000	9,200	1,800	3,000	14,000
3	153.5	11,000	9,200	1,800	400	11,400
4	148.5	11,000	8,300	1,800	0	11,000
5	143.5	11,000	7,200	1,800	0	11,000
6	133.5	11,000	5,970/2	1,100	0	11,000
Alternative 2						
1	170.0	11,000	8,800	1,800	5,750	16,750
2	161.0	11,000	7,500	1,800	5,750	16,750
3	153.5	11,000	6,000	1,800	5,750	16,750
4	148.5	11,000	5,970/2	1,800	4,100	15,100
5	143.5	11,000	5,970	1,800	2,400	13,400
6	133.5	11,000	5,970	1,100	0	11,000

Remarks: /1: Wet season paddy + Sugarcane

/2: Area provided with the existing irrigation facilities.

4.2.3 Optimum Scale of the Development Plan

Comparison of the alternatives mentioned above was made based on the Internal Rate of Return (IRR), Benefit Cost Ratio (B/C), and Net Present Value (B - C) with the following results:

Dam Scale	Alternative 1			Alternative 2		
	IRR (%)	B/C	B - C (₱10^6)	IRR (%)	B/C	B - C (₱10^6)
Case 1	9.8	0.97	-34	10.0	1.00	0
Case 2	10.5	1.07	61	11.4	1.19	207
Case 3	10.6	1.07	69	12.8	1.40	341
Case 4	10.3	1.04	32	12.2	1.30	246
Case 5	10.0	1.00	0	11.3	1.18	139
Case 6	8.8	0.85	-107	8.8	0.85	-107

Remarks: B/C and (B-C) were estimated at a discount rate of 10%.

From the above, Case 3 in Alternative 2 was selected as the best economic alternative showing the highest IRR of 12.8%. In determining the dam scale, Case 3 also appeared to be technically more sound than Cases 1 and 2, which would have required a saddle dam on the right bank and special attention to leakage.

Thus, the optimum scale of the project was determined as follows:

Gumain Storage Dam

Crest elevation	:	EL. 160.0 m
Full water level	:	EL. 153.5 m
Low water level	:	EL. 100.0 m
Gross storage capacity	:	110.4 MCM
Active storage capacity	:	99.0 MCM
Dam height	:	108.0 m
Crest length	:	435.0 m
Embankment volume	:	5.58 MCM

Irrigated Area

Paddy, wet season	:	11,000 ha
" , dry season	:	6,000 ha
Vegetables, dry season	:	1,800 ha
Sugarcane	:	5,750 ha

4.3 Agricultural Development Plan

4.3.1 Proposed Land Use

A net irrigated area of 16,750 ha was determined as the optimum project scale from both technical and economic considerations. Out of the total study area, about 91% or 21,600 ha were selected as the project area including the proposed irrigated area of the above. The land use in the project area under present and future with project conditions are delineated as below:

(Unit: ha)

Land Use Category	Present Land Use: Study Area	Present Land Use: Project Area	Proposed Land Use in the Project Area
1) Paddy Field	11,900	11,130	11,000
- Irrigated (Gravity)	5,970	5,970	11,000
(Pump)	1,270	1,100	-
- Rainfed	4,660	4,060	-
2) Upland	6,850	5,950	5,800
Sugarcane	6,800	5,900	5,750
- Irrigated (Gravity)	(-)	(-)	(5,750)
- Rainfed	(6,800)	(5,900)	(-)
Perennial Crop	50	50	50
3) Grass/Bush Land	300	270	270
4) Residential Area	1,300	1,200	1,200
5) Miscellaneous Area	3,350	3,050	3,330
Total	23,700	21,600	21,600

In the above table, the 770 ha of paddy field and 900 ha of sugarcane field in the study area were topographically excluded from the proposed project area. In the proposed project area, 5,030 ha of pump irrigated and rainfed paddy fields and 5,750 ha of sugarcane fields would be converted to gravity irrigation, and the remaining 130 ha and 150 ha would be converted into lands for rights of way on the newly installed irrigation facilities, respectively. The proposed irrigated area would consist of 11,000 ha for paddy fields and 5,750 ha for sugarcane fields. With regard to the land use under the future without project condition, no substantial change from present use would be expected, because land use in the project area is governed by water availability.

4.3.2 Proposed Cropping Pattern

In the formulation of the proposed cropping pattern, the following basic criteria were applied:

(1) The cropping pattern must make effective use of irrigation water to be provided by the project,

(2) The cropping pattern must provide the maximum benefit to the farmers as well as to the nation as a whole, and

(3) The cropping pattern must be acceptable to the farmers.

Rice, vegetables and sugarcane were taken to be the most suitable crops to be introduced in the project area, taking into account farmers' economy, profitability of crops, farmers' intentions, marketability, etc. As for vegetables, ampalaya and tomato are recommended. The commonest vegetable grown in the project area at present is ampalaya, and farmers have a superior ability in its cultivation. Tomatoes are also cultivated in farmers' home yards for home consumption, and this vegetable has high marketability at Metro Manila. Intercrops to be introduced to sugarcane cultivation are legumes such as mongo beans and peanuts as mentioned later.

The cropping pattern to be adopted into the project area is proposed as shown in Fig. 5 based on the climatic condition in the area. As for paddy cultivation, the plant physiological factor for attaining a high yield of this crop is how to increase the photosynthetic efficiency. Critical growth periods in terms of sunlight requirement for paddy are two weeks just before heading and three to four weeks after heading. Therefore, the framework of the cropping calendar for paddy is designed so as to get as much sunny weather during these periods as possible. Fruit vegetable cultivation is proposed in the dry season, because cultivation in the wet season suffers great damage from pests and diseases damage.

The cropping pattern for sugarcane proposed is for two ratoon cane cultivations after harvest of plant cane to reduce production costs. In the viewpoint of effective land use and improvement of soil fertility, intercropping system is recommended for introduction into sugarcane cultivation. Sugarcane is favorable to intercropping because of its initial slow growth particularly during the dry season, and its long crop cycle. Legumes such as mongo beans and peanuts are the best for intercropping with sugarcane, since they fit into the cultural practices in cane growing. Growth cycle peaks of legumes and sugarcane do not coincide, so competition is minimized.

The annual cropping area in the project are was determined as shown below:

Crops	Cropping Area (ha)	Physical Area (ha)	Multi-cropping Index
1) Paddy Field	18,800	11,000	1.71
- Wet Season Paddy	11,000		
- Dry Season Paddy	6,000		
- Diversified Crops (Fruit Vegetables)	1,800		
2) Sugarcane Field	5,750	5,750	1.00
- Sugarcane	5,750	5,750	1.00
- Intercrops	(5,750)		
Total/Average	24,550	16,750	1.47

As for the cropping area of fruit vegetables, this was estimated at 1,800 ha on the basis of the following assumptions:

1) A shortage of fruit vegetables estimated to be 19,560 tons in Pampanga and Bataan Provinces by 2000 would be supplied from the project area.

2) About nine percent of fruit vegetables consumed in Metro Manila have been supplied by Pampanga Province and this market share is expected to continue in the future.

4.3.3 Proposed Farming Practices

In regard to rice varieties, the IR series such as IR 36, 42, 46, 50, 52, etc. are recommended in order to ensure the anticipated high yields in future with project. The land preparation is recommended to be one plowing, two times of harrowing and one puddling. The nursery area is set to be 1/20 to 1/25 of the planting area. The spacing of transplanting is set to be 30 cm x 10 cm with three seedlings per hill. The fertilizer application for sustaining the target yield is estimated at 80 to 90 kg/ha of N and 30 kg/ha of P_2O_5 and K_2O. The proposed weeding consists of one application of herbicide during the period between puddling time and rooting stage, and two manual weedings depending on the state of weed growth after herbicide application. With regard to plant protection, the recommended dosage is 2 ℓ/ha for insecticides and 1 ℓ/ha of fungicides.

The recommended varieties of sugarcane are PHIL 58260, 5333, 56226, 62120, etc. The proposed land preparation consists of plowing, two times of harrowing and one furrowing, and deep plowing and harrowing at 45 - 60 cm are recommended. The amount of fertilizer is proposed to be 200 kg/ha of N, 100 kg/ha of P_2O_5 and 220 kg/ha of K_2O. The proposed cultivation method would consist of ridge busting, two times of off-barring and two times of hilling up. Weeding would be carried out in parallel with cultivation. For pest and disease control, spraying of pesticide estimating at 2 ℓ/ha for dosage is recommended. Harvesting would be carried out by manual labor. Harvested cane must be milled at the sugar mill factory as soon as possible because delayed cane causes sucrose deterioration.

With regard to the varieties of fruit vegetables, recommended varieties are Makiling and Sta. Rita for ampalaya and Improved Pope, Marikit, VF Rome, etc. for tomato. The land preparation consisting of one plowing, two times of harrowing and one furrowing is proposed for both ampalaya and tomato. The application amounts of fertilizers are estimated at 120 kg/ha each of N, P_2O_5 and K_2O for ampalaya, and 100 kg/ha of N, 190 kg/ha of P_2O_5 and 100 kg/ha of K_2O for tomato. The dosages for ampalaya are estimated to be 8 ℓ/ha for pesticides and 2 ℓ/ha for fungicides. For tomato, the dosages of pesticides and fungicides are estimated at 8 ℓ/ha and 4 ℓ/ha, respectively. A 10-day irrigation interval is proposed with cultivation, and weeding being carried out four times at intervals of three weeks after seeding of both ampalaya and tomato. Ampalaya and tomato would be harvested 10 to 12 times.

4.3.4 Anticipated Crop Yields and Production

The anticipated unit yields of crops under the future without and with project conditions were estimated as summarized below, based on the statistical analysis of past trends and the best judgement of the results of the yield survey, soil capability and experimental data in and around the project area.

(Unit: t/ha)

Crops	Present	Without Project	With Project
Irrigated paddy			
- Wet season paddy	2.70	2.97	4.50
- Dry season paddy	2.80	2.80	5.00
Rainfed paddy	1.96	1.96	-
Sugarcane	34.22	36.00	80.00
Diversified crops (fruit vegetables)			
- Ampalaya	10.90	10.90	14.00
- Tomato	9.85	9.85	25.00
Intercrops			
- Mongo beans	-	-	0.50
- Peanut	-	-	0.75

The production of crops under the future without and with project conditions were estimated by multiplying the anticipated unit yield with the future cropping area, and are summarized in the following table:

(Unit: t)

Crops	Present	Without Project	With Project
Paddy	42,060	43,970	70,500
Fruit vegetables	1,850	1,850	35,100
Sugarcane	201,900	212,400	460,000
Intercrops (Legumes)	-	-	3,600

4.3.5 Marketing and Price Prospects

The marketable surplus of crops produced in the project area and the market demand to be expected in 2000 were analyzed to assess the potential market for these crops. The marketable rice produced in the project area in 2000 is expected to be about 20,100 tons which would be equivalent to about 1.6% of the rice deficit of Region IV including Metro Manila. With completion of the project, sugar production would rapidly increase from 19,800 tons at present to 45,100 tons under full development, but this increment would only account for about 7.8% of the shortage of sugar estimated to be 580,000 tons for the whole country in 2000. In 2000, the scarcity of fruit vegetables in Pampanga Province will disappear with the increase in production in the project area, but the market share of this province in Metro Manila estimated at 9% will remain in the future. As for intercrops such as mongo beans and peanuts, no marketable surplus from Pamapanga and Bataan Provinces are forecasted, while the scarcity of legumes in these provinces will continue in the future. In short the marketable surplus of crops produced in the project area would be marketed in Metro Manila or the whole country with no marketing dislocation, because they are all so much in demand.

Economic and financial prices of farm outputs and inputs were forecasted in order to evaluate the expected monetary benefits and effects. Economic prices for trade goods such as rice, sugar and fertilizers were estimated on the basis of the projected world market prices of these commodities forecasted by the World Bank in the long term range for the period of 1983 to 1995. Non-trade goods such as fruit vegetables, animal power, etc. are valued at their financial price. Financial prices of farm outputs and inputs were estimated on the basis of current market of farm-gate prices prevailing in the project area as of March 1984.

Financial and economic prices of all outputs and inputs are summarized as below:

Farm Outputs and Inputs		Financial Prices as of March, 1984	Economic Prices in 1995 (1984 constant)
Paddy	(₱/t)	1,740	3,186
Sugarcane	(₱/t)	184	528
Ampalaya	(₱/t)	2,600	2,600
Tomato	(₱/t)	2,000	2,000
Mongo Beans	(₱/t)	5,000	5,000
Peanut	(₱/t)	4,000	4,000
Fertilizers			
- N	(₱/kg)	7.3	10.6
- P_2O_5	(₱/kg)	7.0	9.1
- K_2O	(₱/kg)	7.0	4.1
Agro-chemicals			
- Liquid	(₱/ℓ)	91	109
- Granular	(₱/kg)	14	17
Labor	(₱/day)	25	11
Animal power	(₱/day)	35	35
Machinery	(₱/ha)		
- 4-wheel tractor		400	400
- Hand tractor		175	175

Labor is valued at a shadow price of ₱11.0 per man day, on the basis of the conversion factor (0.44)/1 forecasted by the World Bank.

/1: Shadow Wage Rate x Consumption Factor = 0.52 x 0.84 = 0.44
Source: Philippines, Social Cost - Benefit Analysis, Estimates of Shadow Prices and Country Parameters, World Bank, December 1978.

4.3.6 Irrigation Benefit

Irrigation benefit to be expected is defined as the difference of the net return from crops between the future with project and the future without project conditions. The net return per ha for each crop was calculated as below, on the basis of estimated gross income and production cost.

(Unit: ₱/ha)

Crops	With Project	Without Project
Wet Season Paddy		
- Gravity Irrigation Area	10,050	5,876
- Pump Irrigation Area	-	5,131
- Rainfed Area	-	3,213
Dry Season Paddy		
- Gravity Irrigation Area	11,430	5,248
- Pump Irrigation Area	-	4,219
Diversified Crops (Fruit vegetables)		
- Ampalaya	29,003	18,216
- Tomato	41,222	-
Sugarcane	34,831	15,488
Intercrops	1,542	-

Applying the net return per ha for each crop estimated in the above table to the cropped areas, the total net return to accrue from the agricultural production was calculated on both the future with project and without project conditions. The irrigation benefit at full development stage was estimated at about ₱276 million. The benefit may be expected to increase linearly year by year, and to reach its full benefit about five years after completion of the project.

4.3.7 Farmers' Economy

After the implementation of the irrigation project, year round irrigation would be provided to all farmers in the project area, thereby making possible an increase in yield and production of crops. As a result, a significant increase in farm income would be expected in the future with project condition. On the other hand, no substantial increase in farm income will be incurred in the future without project condition.

The typical farm budgets for both future without and with project conditions are analyzed and summarized below:

Item	Farm Size (ha)	Net Farm Income/1 (₱)	Net Reserve/2 (₱)
I) Without Project			
Rice Cultivation Farmer (Lessee)			
- Irrigated Land	1.3	3,740	440
- Rainfed Land	1.3	1,920	20
Sugarcane Planter (Owner Operator)	4.0	6,470	1,070
II) With Project			
Rice Cultivation Farmer (Lessee)	1.3	11,720	9,120
Sugarcane Planter (Owner Operator)	4.0	16,770	11,370

Remarks: /1: Farm income - Production Cost
/2: Gross income - (Production Cost + Living Expenses)

The net farm income under the future with project condition is expected to increase 3 to 6 times as compared with the future without project condition, and the net reserve will also increase rapidly from ₱500 to ₱10,200 on an average. The increase in net reserve will offer incentives to the farmers and will enable them to pay the irrigation fee.

4.3.8 Agricultural Support System

The major objectives of this project are to increase agricultural production and to improve and stabilize the farmers' economy through irrigation development. For this purpose, the project will provide necessary infrastructures such as irrigation and drainage facilities. However, in order to realize the project objectives, there would remain some ancillary works which should be carried out by the governmental authorities concerned and the farmers themselves.

Such ancillary works include agronomic research, extension work, farmers cooperatives movement and credit services. Although most of the agricultural support systems for these services have already been established in and around the project area with Government Promotion, it is recommended that the following matters should be realized in order to accomplish the project objectives.

1) To strengthen agronomic research on irrigated crops, especially on vegetables and sugarcane, and to propagate improved farming practices to the farmers through existing extension channels,

2) To train field extension workers in improved practical techniques of irrigation farming,

3) To promote the establishment of water user's association comprising farmers in the benefited area, and

4) To strengthen the credit services not only for rice cultivation but also for vegetables and sugarcane cultivations.

4.4 Irrigation and Drainage Development Plan

4.4.1 General

The project area is well-endowed with land resources suitable for agricultural production but its present productivity is low because of various constraints. The major constraints relating to irrigation and drainage are:

1) Uneven seasonal distribution of rainfall,

2) Shortage of irrigation water especially during the dry season,

3) Inadequacy of the perennial irrigation system,

4) Lack of a drainage system, and

5) Improper water management.

To resolve these constraints, the optimum irrigation development plan was developed from assessment of the water resources, estimation of irrigation water requirements and a water balance study. The assessment of water resources was made through hydrological analysis of the three main rivers, Gumain, Porac and Caulaman, and effective use of return flow utilizing the existing checkgate structures. The irrigation water requirements were calculated for the proposed cropping pattern after selecting the most beneficial crops for the project. Based on the available irrigation water sources and irrigation water requirements, the water balance study was made to estimate the guaranteed irrigation area in relation with the scale of the proposed Gumain storage dam.

The proposed irrigation system was determined on the basis of the formulated development plan taking into consideration the best use of the existing irrigation systems in the project area. The drainage system is as important a components of the project works as the irrigation system. The drainage plan was made by means of improving the existing rivers and creeks, and providing new collector drains and farm drains at on-farm level.

4.4.2 Irrigation Water Requirement

Rice is the principal agricultural crop in the project area and sugarcane is the second. In addition to these two major crops, vegetables are also recommended as profitable crops for the project. Therefore, the study of irrigation water requirements was made for rice, sugarcane and vegetables.

The irrigation water requirements were calculated for the proposed cropping pattern on 10-day basis for 25 years from 1958/59 to 1982/83. The consumptive use of water by the crop was estimated as a product of potential evapotranspiration with crop coefficients relating to crop growth stages. The potential evapotranspiration was calculated by the empirical formula of the Modified Penman Method using meteorological data recorded in and around the project area. Effective rainfall was estimated by the daily water depth balance method based on the rainfall data at the Basa Air Base in the project area.

The diversion water requirement was defined as the farm water requirement plus allowances for farm waste, and operation and conveyance losses. The overall irrigation efficiencies were assumed to be 50% for wet season paddy, 55% for dry season paddy and 50% for sugarcane and vegetables.

The annual diversion water requirement by each crop for 25 years from 1958/59 to 1982/83 is shown in Table 8 and the averages are summarized below.

Paddy	wet season	:	4,980	m^3/ha/year
	dry season	:	16,200	"
Vegetables	dry season	:	12,020	"
Sugarcane		:	13,640	"

4.4.3 Effective Use of Return Flow

There are many checkgate structures on the drainage creeks to check local water including return flow from the paddy fields located at the upstream of the structures. Most of the re-use structures are not functioning normally due to improper operation and maintenance and lack of control gates. Through field investigation and study of their functions, it was found that only five of these structures could be utilized as project facilities with some rehabilitation works for the effective use of water.

The available discharge at the re-use structure was estimated on the basis of an equation which was obtained by analyzing the actual data for creek runoff in UPRIIS. In the dry season, where rainfall in the study area hardly occurs and the available discharge at the re-use structure depends on the return flow from the contributing paddy fields. The rate of return flow was judged to be 30% of the total irrigation supply to the contributing paddy fields from the results of the study, "Re-use of Drainage Water in the Vaca Creek Irrigation System" made by Drs. D. Cablayan, W. Ramos and S.I. Bhuiyan, of IRRI.

The total irrigable area covered by effective use of return flow was estimated to have been about 720 ha on average over the 25 years from 1958/59 to 1982/83, utilizing the five existing re-use structures as shown below.

Re-Use Point	Average Irrigable Area
1) Natividad Checkgate	240 ha
2) Sampang Checkgate	100
3) Patangue Checkgate	90
4) Calalabing Checkgate	130
5) Dam 84-A	160
Total	720 ha

4.4.4 Irrigable Area

In the study area, there are 11,900 ha of paddy fields and 6,800 ha of sugarcane fields at present. Out of these, the irrigable areas are estimated at 11,000 ha of paddy fields and 5,750 ha of sugarcane fields respectively, taking into account the proposed irrigation canal alignment and topographic conditions. The 11,000 ha of paddy fields comprise 5,970 ha with existing irrigation facilities and 5,030 ha without irrigation facilities.

The optimum irrigation areas were determined by the water balance study in relation to the scale of the Gumain storage dam, analysis of available runoff in the Gumain, Porac and Caulaman rivers, irrigation water requirements and effective use of return flow as discussed in the previous paragraphs. Based on the result of the water balance study and economic comparison, the proposed irrigation areas are proposed as follows:

Paddy	, wet season	:	11,000 ha
	, dry season	:	6,000
Vegetables	, dry season	:	1,800
Sugarcane		:	5,750

In determining the optimum irrigation areas, the following criteria were adopted to obtain the maximum benefit from the project.

1) to irrigate the whole 11,000 ha of existing paddy fields during the wet season,

2) to irrigate the existing sugarcane fields to the maximum extent,

3) to irrigate dry season paddy to at least include the 5,970 ha of areas provided with the existing irrigation facilities, and

4) to introduce vegetables as much as possible in the paddy fields during the dry season.

4.4.5 Proposed Irrigation System

In the project area, there are two National Irrigation Systems, namely Porac - Gumain RIS and Caulaman RIS. Therefore in the final layout of the definite plan for the irrigation system, these existing facilities were incorporated as much as possible.

The proposed irrigation works in the project area consist mainly of the following:

1) Construction of new facilities for diverting irrigation water from the Gumain reservoir to the existing Porac and Caulaman Irrigation systems

2) Rehabilitation of the existing irrigation facilities

3) Expansion of irrigation facilities to the existing rainfed paddy fields and sugarcane fields which are proposed to be newly irrigated in the project

For diverting irrigation water from the Gumain reservoir to the existing irrigation systems, a new Gumain diversion dam is proposed 2.6 km downstream of the Gumain dam site. From this diversion dam, the irrigation water would be diverted to the Porac river by the new 6.9 km Porac diversion canal and to the existing Caulaman main canal by the new 6.7 km Caulaman diversion canal.

Rehabilitation and improvement to the existing irrigation facilities would be made to meet the needs of the new irrigation system based on the results of the study of the present condition of facilities. New irrigation canals and related structures would be provided for the new irrigation areas, which at present are rainfed paddy fields and sugarcane fields.

The proposed irrigation system would be sub-divided into three systems, namely Porac River Irrigation System, Gumain River Irrigation System and Caulaman River Irrigation System. The irrigation systems would have the following irrigation areas:

Name of Irrigation System	Irrigation Area (ha) Paddy Field	Sugarcane Field	Total
Porac RIS	6,000	1,710	7,710
Gumain RIS	2,970	790	3,760
Caulaman RIS	2,030	3,250	5,280
Total	11,000	5,750	16,750

The general layout of the proposed irrigation system is shown in Fig. 6 and irrigation diagram is illustrated in Fig. 7.

4.4.6 Drainage Water Requirement

The drainage water requirement for the proposed drainage system was estimated separately for removing excess rainfall from the paddy fields and transporting the runoff from the hilly land on the basis of a 5-year return period and use of the daily rainfall records at the Basa Air Base.

The drainage requirement for removing the excess rainfall in the paddy field was estimated to be 11.7 ℓ/sec/ha on the basis of the maximum 3 days consecutive rainfall with 5-year return period and a drainage period of 3 days. Estimation of the drainage water requirement for transporting the runoff coming from hilly land in the catchment area was made by applying the McMatch's formula suggested in the Drainage Manual, USBR, and was estimated to be 22.5 ℓ/sec/ha.

4.4.7 Proposed Drainage System

The drainage plan in the project area was made by means of improving the existing rivers and creeks as main and secondary drains after checking present capacities so as to minimize construction costs and the land to be acquired. Further, new collector drains were proposed to collect excess water from tertiary drains and to transport flood water to main and secondary drains. The tertiary drains and drainage ditches were also provided for at on-farm level so as to remove excess water in the fields after heavy rainfall and to create adequate conditions of drawdown for the harvesting of crops.

In parallel with planning of the drainage canals, the appurtenant structures along these drainage canals were carefully studied with special attention to carrying capacities of the road crossing structures. All existing checkgates except for five structures which would be utilized for effective use of return flow, would be demolished to make smooth flow in the drainage creeks.

The proposed drainage system is illustrated in Fig. 8 and the general layout of the system is shown in Fig. 6 together with the proposed irrigation system.

CHAPTER 5 PROPOSED PROJECT WORKS

5.1 Dam and Reservoir

5.1.1 General

The proposed Gumain dam site is located in the gorge about 350 m downstream of the confluence of two tributaries of the Gumain river. At this point the river bed has an elevation of 60 m, a width of about 100 m, and a gradient of about 1 in 100. The left bank has a cliff to a height of about 100 m and then rises at a slope of about 45° of average slope towards a plateau of elevation 170 - 200 m. The right bank rises at about 30° towards a plateau of elevation 150 - 160 m. A width-to-height ratio of dam site is about 4, when a top elevation of dam is set at about 160 m.

Based on the optimization study of the project discussed in the previous Chapter, the salient features of the Gumain dam and reservoir are shown in Table 9.

5.1.2 Reservoir

The elevation-volume and -area curves of the reservoir were developed as given in Fig. 9. The full water level was determined from the results of the reservoir operation study. The low water level was determined on the basis of the deposited sediment in the reservoir. The high water level was defined as the water level which was equivalent to the full water level plus the overflow depth at the spillway for the design flood discharge. The dead storage capacity is equivalent to the deposited sediment volume of 100 years. The active storage capacity was estimated by deducting the dead storage capacity from the gross storage capacity. The proposed water level and storage capacity of the reservoir are shown below.

High Water Level	:	EL. 157.5 m
Full Water Level	:	EL. 153.5 m
Low Water Level	:	EL. 100.0 m
Effective Storage Depth	:	53.5 m
Gross Storage Capacity	:	110.4 MCM
Active Storage Capacity	:	99.0 MCM
Dead Storage Capacity	:	11.4 MCM

Based on the long term measurement data of suspended load on the Gumain river, the annual yield of suspended load at the proposed dam site was estimated to be about 104,300 m^3/year which is equivalent to 915 m^3/km^2/year. Allowing for some adjustment for factors such as river bed load, trap efficiency of the reservoir, etc., the design sediment load was determined to be 1,000 m^3/km^2/year. The useful life of the reservoir was assumed to be 100 years and therefore, the total sediment volume was estimated to be 11,400,000 m^3.

5.1.3 Dam and Appurtenant Structures

(1) Type of Dam

The proposed dam site has massive rock foundations beneath shallow overburden and a relatively narrow gorge with a steep slope at left abutment. A width-to-height ratio is about 4. From the above appearances, both a fill dam and a concrete gravity dam were conceived, but since the dam site has some weak points for founding a concrete gravity dam, a fill dam was adopted because it would have an inherent plastic characteristic to adapt itself smoothly to settlement and deformation of the foundation.

Considering the proposed dam scale, availability of materials for dam embankment nearby the dam site, influence of earthquake, etc., a zone type of rockfill dam with center core was selected as the optimum dam type.

(2) Typical Section of Dam

The crest width of dam was determined to be 12.0 m taking into account the roadway requirement and practicability of construction. Freeboard for dam must be sufficient to prevent overtopping of embankment and was estimated at 6.5 m including the overflow depth of 4.0 m at the spillway above the full water level of 153.5 m, resulting in 160.0 m of the dam crest elevation.

A width of core proposed would be more than 50% of the water head to ensure the safety of dam since the settlement of foundation was estimated to be relatively large. The rock materials around the dam site are mostly lappili tuff and agglomerate. Lappili tuff is weaker but more abundant than agglomerate. To save dam construction costs, lapilli tuff would be utilized as much as possible and is proposed for the inner shell and protected by hard agglomerate. Selected gravels and boulders in the river deposits are recommended for use as riprap for protection of the upstream slope.

The embankment slopes were designed to be 1 : 2.9 and 1 : 2.3 for upstream and downstream respectively, based on stability analysis of the dam by means of the slip circle method. The stability of the dam was also examined in relation to the results of laboratory tests on the embankment materials. A design seismic coefficient of 0.12 was adopted after analysis of data on occurrence, location, depth of epicenter and magnitude for earthquakes in and around the Philippines. Three critical cases were examined in the analysis: for full water level; intermediate water level; and rapid drawdown of water level The results of the analysis show that the safety factor of the critical slip circle for each case exceeds 1.2 which is the minimum allowable safety factor.

The tpyical section of the proposed dam is shown in Fig. 10.

(3) Foundation Treatment of Dam

To maintain a stable support against shearing and deformation, stripping would be performed for top soil layers, weathered layers with N value less than 50, talus layers, alluvium clayey deposits, sharply projecting rocks, etc. Sand and gravel layers formed in the river bed are fairly firm and could be used as the dam foundation except for the core zone. Excavation of the core trench would be continued until sound rock having the seismic velocity of about 2.0 km/s to ensure a reliable contact between the impervious core and the rock foundation. The bottom elevation of the core trench would be about EL. 52.0 m.

. The foundations of the dam site generally have comparatively low permeability, but partially have a high permeability zone with a Lugeon value of more than 10. The groundwater also appears to be very deep in the both abutments. Therefore, foundation treatment by grouting is necessary to protect the dam from excessive leakage and hydraulic failure. The success of grouting should be confirmed by Lugeon values in the range of 1 - 3 Lugeon.

(4) Spillway

The spillway was designed for a design flood discharge of 2,650 m^3/s and was also examined for safety of the dam for the Probable Maximum Flood (PMF) of 2,850 m^3/s. The location of spillway was selected on the right abutment from a topographic viewpoint. Ungated side channel type spillway is proposed and a crest length of an overflow weir was determined to be 155.0 m with an overflow depth of 4.0 m based on the comparative study. The spillway would be composed of a side channel weir, transition, chute and an energy dissipator with the following hydraulic dimensions:

(Unit: m)

Structure	Width	Depth	Elevation of Sill
Side Channel	15.0 - 30.0	16.7 - 24.7	143.5 - 135.5
Transition	30.0	24.7 - 19.0	135.5
Chute	30.0 - 45.0	6.5	138.05 - 43.0
Energy Dissipator	45.0	23.0	43.0

(5) Outlet Works

Outlet works would consist of an intake structure and outlet conduit. The intake structure would be constructed of reinforced concrete with the design discharge of 15.31 m^3/s. The water taken at the intake would outlet through the diversion tunnel up to the point of plug concrete and then through the outlet conduit of iron pipe with a diameter of 2.0 m installed within the diversion tunnel. The hydraulic energy would be dissipated at the downstream end of the outlet conduit by using a jet flow gate having a diameter of 1.0 m.

(6) Diversion Tunnel

The diversion tunnel would be provided under the right abutment to divert the 10-year flood discharge of 1,290 m^3/s during dam construction. The length of tunnel would be 660.0 m and the radius of tunnel was estimated to be 6.0 m on the assumption that the water depth in tunnel would be 90% maximum for the tunnel section. The crest elevation of the upstream cofferdam was designed to be 90.0 m for the 25-year flood discharge of 1,550 m^3/s.

5.2 Irrigation and Drainage Facilities

5.2.1 General

The main objective of the project is to supply irrigation water to the proposed irrigation areas consisting of the Porac RIS, Gumain RIS and Caulaman RIS from the Gumain dam. The facilities required for the project include the diversion dams, diversion canals, irrigation and drainage canals, and their relevant structures.

The facilities should be designed to fulfill their functions in the most effective and economical manner compatibly with the other farming operations. Based on the above requirements, the following works are proposed for irrigation and drainage. The general features of irrigation and drainage facilities are given in Tables 10 and 11, respectively.

5.2.2 Diversion Dams

In addition to three existing diversion dams, i.e. Porac, Gumain and Caulaman diversion dams, one new diversion dam, the Upper Gumain Diversion Dam, is proposed on the Gumain river and located about 2.6 km downstream of the Gumain dam site. The improvement works at existing diversion dams are mainly to replace intake gates. The main features of four diversion dams are summarized as follows:

Description	Name of Diversion Dam			
	Upper Gumain (New)	Porac (Existing)	Gumain (Existing)	Caulaman (Existing)
1. Dam				
Type	Ogee Type	Ogee with Flap Gate	Ogee Type	Ogee Type
Crest Elevation	EL. 45.0 m	EL. 22.6 m	EL. 17.4 m	EL. 21.4 m
Crest Length	80.0 m	43.3 m	224.0 m	72.0 m
Height of Dam	4.0 m	2.8 m	2.0 m	1.8 m
Gate Height	—	1.4 m	—	—
2. Scouring Sluice				
(Right)				
Gate Type	Roller Gate	Roller Gate	Roller Gate	—
Number of Gate	1 no.	1 no.	1 no.	—
Size of Gate	3.0m x 4.0m	2.4m x 3.5m	4.6m x 2.2m	—
(Left)				
Gate Type	Roller Gate	Roller Gate	Roller Gate	Roller Gate
Number of Gate	1 no.	1 no.	1 no.	1 no.
Size of Gate	4.0m x 4.0m	3.0m x 3.5m	1.8m x 2.2m	4.3m x 1.9m
3. Intake				
(Right)				
Design Discharge	5.3 m^3/s	1.1 m^3/s	3.9 m^3/s	—
Intake Water Level	EL. 45.0 m	EL. 24.0 m	EL. 17.4 m	—
Gate Type	Sluice Gate	Sluice Gate	Sluice Gate	—
Number of Gate	2 nos.	1 no.	4 nos.	—
Size of Gate	2.0m x 2.0m	1.5m x 1.5m	1.4m x 1.3m	—
(Left)				
Design Discharge	7.2 m^3/s	6.1 m^3/s	—	5.2 m^3/s
Intake Water Level	EL. 45.0 m	EL. 24.0 m	—	EL. 21.4 m
Gate Type	Sluice Gate	Sluice Gate	—	Sluice Gate
Number of Gate	3 nos.	3 nos.	—	2 nos.
Size of Gate	2.0m x 2.0m	1.5m x 1.5m	—	2.0m x 1.0m

5.2.3 Diversion Canals

Two new diversion canals would be constructed to divert irrigation water from the upper Gumain diversion dam to the existing irrigation systems. One is the Porac diversion canal to the Porac river and the other is the Caulaman diversion canal to the Caulaman main canal. Both of canals would be lined with 10 cm thick plain concrete to check seepage from canal and to protect the inside slope of canal against erosion, taking account of soil conditions along canals. The main features of two diversion canals are shown below.

Description	Porac Diversion Canal	Caulaman Diversion Canal
Design Discharge	6.0 - 7.2 m^3/s	5.3 m^3/s
Length of Canal	6.9 km	6.7 km
Height of Canal	1.9 & 2.4 m	1.4 m
Bottom Width of Canal	2.0 m	2.0 m
Inside Slope of Canal	1:1.5	1:1.5

5.2.4 Irrigation Canals and Related Structures

The major irrigation canal system would consist of 4 main canals and 38 laterals. The total lengths of the main canals and laterals would be 28.8 km and 169.6 km, respectively. All main canals of the existing systems would be utilized as the proposed main canals with some rehabilitation works. Out of the total length of laterals, 103.8 km would be newly constructed to supply irrigation water to the proposed irrigation areas. The existing laterals would be rehabilitated as necessary based on the results of the study of present conditions.

A large number of structures are essential for effective functioning of the above canal system. The following structures are proposed:

1) structures for distribution of irrigation water such as head gates and turnouts,

2) structures for regulation of water levels such as checkgates and drops,

3) structures for conveyance of water over or under roads, rivers, streams, etc. such as siphons, aqueducts, culverts and bridges, and

4) structures for protection of canals such as spillways and cross drains.

A total of 776 structures would be required of which 553 would be newly provided as shown in Table 10.

At the on-farm level, which would have each rotation area of approximately 50 ha served by one turnout, main farm ditches and supplementary farm ditches would also be constructed at a density of about 16 m/ha and 40 m/ha, respectively.

5.2.5 Drainage Canals and Related Structures

The existing rivers and creeks totalling 131.4 km are proposed for use as the main and secondary drains with some rehabilitation works after checking their present carrying capacities. To collect excess water from the farms and to transport flood water to main and secondary drains, new collector drains having 64.8 km in length are proposed. Further, catch drains of 9.3 km in length would be provided along the Porac and Caulaman diversion canals. At the on-farm level, tertiary drains and drainage ditches would be constructed with the total length of 58.0 km and 321.0 km, respectively.

In relation to the above drainage canals, 26 bridges and 196 culverts would have to be provided to convey drainage water under roads, and out of these 17 bridges and 182 culverts would be newly constructed.

CHAPTER 6 CONSTRUCTION PLAN AND COST ESTIMATE

6.1 Construction Plan

6.1.1 General

The project comprises new construction of the Gumain dam, upper Gumain diversion dam, Porac and Caulaman diversion canals, irrigation and drainage canal systems, and improvement of the existing facilities. As these construction works are mainly concerned with earth works, due attention must be paid to the characteristics of earth materials which directly after earth moving plan, selection of construction equipment, specification of dam embankment and so forth.

Major construction works having a large amount of earth volume must be executed by heavy construction equipment but the remaining minor works can be implemented by manpower to increase employment opportunities for the local people in and around the project area. Earth work is mostly governed by rainfall. Workable days for embankments of impervious materials would be strictly controlled by the amount of rainfall. The monthly workable days were estimated at 25 days in the dry season and 22 days in the wet season based on the daily rainfall intensity record at the Basa Air Base.

6.1.2 Dam Construction

From the results of the soils and geological investigations, the dam embankment materials would be obtained from the following places:

Zone 1 : Borrow Area I (normal soil), Spillway (normal soil)

Zone 2 : Quarry Site I (weathered rock, rock), Spillway (rock), Dam Foundation (weathered rock, rock)

Zone 3 : Quarry Site I (rock), Dam Foundation (rock)

Filter : River Deposit (sand)

Riprap : River Deposit (gravel)

The diversion tunnel and river diversion would have to be completed prior to excavation of the dam foundation. Excavation of dam foundation would be started from both abutments because of having steep slopes, and continuously excavation of the river bed would be conducted. Foundation treatment should be started from the river bed in order to facilitate an early start on the dam embankment works. Treatment works for both abutments would follow gradually prior to the dam embankment.

Embankment materials would be spread by bull-dozer in the specified thicknesses and compacted by suitable compacting machines as shown below.

Zone	Thickness of Spreading (cm)	Number of Compaction (nos.)	Compacting Machine
Zone 1	20	6	Tamping Roller
Zone 2	40	4	Vibration Roller
Zone 3	60	4	Vibration Roller
Filter	30	4	Compactor
Riprap	30	4	Compactor

The moisture contents of impervious materials would be checked throughout the construction period and whenever necessary water would be added to the materials by tank lorry so as to approximate the optimum moisture content.

Excavation of the spillway would be executed in parallel with the dam embankment, because the excavated materials could be hauled directly to the dam. Concrete for appurtenant structures would be mixed by a batching plant installed at the dam site.

6.1.3 Irrigation and Drainage Facilities Construction

The construction work on the upper Gumain diversion dam would be mainly executed during the dry season. Excavation works at the site would mainly be by back-hoe shovel and excess excavated materials would be hauled to a spoil area by dump-truck.

Most of the canal excavation and embankment would be executed mainly by rather small construction equipment, however for earth works of Porac diversion canal about 2 km in length running near the northern boundary of the Basa Air Base, normal earthmoving equipment would be used due to the deep excavation and a large amount of earth volume. Concrete work for structures related to the canals would mainly be executed by manpower using transportable concrete mixers.

Construction works for on-farm development such as farm ditches, farm drains, small diversion boxes, etc., would be done by hand.

6.1.4 Implementation Schedule

The implementation period of the project was assumed to be 7 years from 1986 to 1992 as shown in Fig. 11.

The whole of 1986 would be required for detailed design and mobilization. Actual construction works would be commenced in 1987. Dam construction including the diversion tunnel, foundation treatment, excavation, embankment, appurtenant structures, etc., needs 6 years in all. The dam embankment would be commenced in 1989 and be completed by the end of 1982.

Improvement works of existing facilities would be planned to be completed by the end of 1989 so that irrigation benefits should be enjoyed as soon as possible. This would also facilitate an early start to implementing improvements of the agricultural and administrative infrastructure. New construction works of upper Gumain diversion dam, and Porac and Caulaman diversion canals would be completed in 3 years from 1990 to 1992.

6.2 Cost Estimate

6.2.1 General

The project cost comprises the direct construction cost, land acquisition cost, procurement cost of O&M equipment, administration cost, engineering services, physical contingency and price contingency.

The following considerations were taken into account for the cost estimate of the Project.

(a) The exchange rate used in the estimate is:

US$1.0 = ₱14 = ¥240

(b) The construction works would be executed on a contract basis. The construction machinery and equipment required for the construction works would be provided by the contractors themselves. Therefore, depreciation cost of machinery and equipment were included in estimates of the construction unit costs.

(c) The construction cost comprises foreign currency and local currency portions. The local currency portion was estimated on the basis of the current prices in Manila in March 1984 and the foreign currency portion was estimated on the CIF prices at Manila.

(d) The physical contingency related to the construction quantities was allowed for at 15% of the direct cost. The price contingency was assumed as follows:

(Unit: %)

Year	Foreign Currency	Local Currency
1985	8.0	45.6
1986	9.0	12.0
1987	9.0	12.0
1988	9.0	12.0
1989	7.5	12.0
1990	6.0	12.0
1991	6.0	12.0
1992	6.0	12.0

6.2.2 Project Cost

The project cost was estimated at ₱2,768 million, comprising ₱1,635 million of foreign currency and ₱1,133 million of local currency. The summary of the cost estimate is given in Table 12.

6.2.3 Annual Disbursement Schedule

The annual disbursement schedule was based on the construction time schedule and is summarized as follows:

(Unit: ₱10^6)

Financial Years	Total	Foreign Currency	Local Currency
1986	60.6	47.4	13.2
1987	362.9	233.8	129.1
1988	395.0	247.5	147.5
1989	346.8	209.8	137.0
1990	586.2	324.2	262.0
1991	520.0	286.6	233.4
1992	496.5	285.3	211.2
Total	2,768.0	1,634.6	1,133.4

6.2.4 Operation and Maintenance Cost

Annual operation and maintenance cost covers the salaries of administrative and water control staff, the material and labour costs for repair and maintenance of project facilities, the costs for operation, repair and maintenance of O&M equipment. The operation and maintenance cost annually required for the project was estimated at ₱4.7 million.

6.2.5 Replacement Cost

Some of the facilities installed or constructed in the Project will have a shorter useful life than the Project life and will require replacement within the project useful life.

The replacement costs and the useful lives of gates and O&M equipment were assumed to be as follows:

Items	Useful Life	Replacement Cost
Gate	25 years	₱23.8 million
O&M Equipment	10 years	₱9.6 million

CHAPTER 7 ORGANIZATION AND MANAGEMENT

7.1 Organization for the Project Execution

The proposed Gumain River Irrigation Project would integrate the new irrigation areas with in the existing irrigation systems by construction of a storage dam on the Gumain river and irrigation and drainage facilities. During construction of the project works, operation and maintenance of the existing national irrigation systems would have to be carried out uninterruptedly.

The project executing office during the construction would be established in the existing Porac - Gumain River Irrigation System Office and operation and maintenance works for the existing irrigation system would be carried out in parallel with the construction works. For this purpose, the Porac - Gumain River Irrigation System Office would be reorganized.

The existing Caulaman River Irrigation System Office would also be integrated with the new office in order to ensure integration of the construction of the new works and operation of the existing irrigation systems.

The proposed organization structure is shown in Fig. 12.

7.2 Organization for Operation and Maintenance

As mentioned in the previous chapter, there are two national irrigation systems and seven communal irrigation systems in the project area. Details of present condition for operation and maintenance of the existing PGRIS and CRIS are presented in Appendix IX.

After completion of the project construction, these national and communal irrigation systems would be integrated with the new national irrigation system, namely Gumain River Irrigation System. The project executing office would be reorganized into the operation and maintenance office (O&M office) of the new project which would be responsible for operation and maintenance of dam, reservoir, and irrigation and drainage systems. The main functions of the O&M office may be summarized as follows:

1) Operation and maintenance of the irrigation and drainage facilities except for such facilities at the farm level,

2) Collection of the irrigation service fee, and

3) Other services such as training and extension on irrigation techniques, etc.

It is recommended that these works should be carried out for areas greater than 200 ha which would be controlled by a sub-lateral. As for operation and maintenance for areas less than 200 ha, these would be transferred to the farmer's organizations to be instituted in the project area. Engineering support would be given by the staff of the O&M office.

The proposed organizational structure of the O&M office is composed of the following six sections. The detailed organization chart is illustrated in Fig. 13.

1) Administrative Section
2) Repair and Maintenance Section
3) Operation Section
4) Billing and Collection Section
5) Farmer's Assistance Section
6) Dam and Reservoir Section

The operation manager would be responsible for management of the irrigation and drainage system through the above mentioned sections. The staff necessary for the O&M office were estimated at 235 persons including Irrigation Engineers, Assistance Water Management Technicians, Ditchtenders, etc.

In order to ensure close cooperation between the O&M office and irrigated farmer's organizations to be established in the project area, institution of a Coordination Committee is recommended.

The purpose of the Coordination Committee would not only be to ensure proper operation of the irrigation water supply but also to coordinate the crop rotation schedule and harvesting schedule of sugarcane.

7.3 Farmers' Organization

In order to ensure the benefits of irrigation development, NIA has promoted establishment of Farmer-Irrigators' Groups (FIG) and Farmer-Irrigators' Associations (FIA). FIGs and FIAs would also be instituted in the proposed Gumain River Irrigation Project area.

There are two types of agriculture in the project area, rice cultivation and sugarcane planting, and water consumption patterns are quite different for rice and sugarcane.

Separate farmers' organizations would therefore be established for rice farmers and sugarcane planters.

1) Organization of Rice Farmers

FIGs for rice farmers are established on the basis of one for each rotational area of about 50 ha and would comprise about 20 farm households. These FIGs are federated into FIAs. In the project area, the size of a FIA is expected to be about 200 ha which would be controlled by a sub-lateral. There would be about 220 FIGs and about 55 FIAs for the rice farmers.

2) Organization of Sugarcane Planters

Sugarcane planters in the project area vary widely in farm size from 4 ha to 150 ha. Therefore, it is proposed that FIG would be established for a unit of 20 sugarcane planters. About five or so FIGs would be federated into one FIA. There would be about 10 FIGs and two FIAs for the sugarcane planters.

As indicated above, about 57 FIAs would be established in the project area. In order to coordinate these efficiently, it is recommended that these FIAs should be further federated into one representative farmers' organization, namely the Federal Farmer-Irrigators' Association (FFIA).

The proposed activities of the farmers' organizations are described in detail in the APPENDIX IX.

CHAPTER 8 PROJECT EVALUATION

8.1 General

The object of project evaluation is to ascertain the economic and financial feasibility of the project. For the economic analysis, the internal rate of return (IRR), benefit-cost ratio (B/C) and benefit minus cost (B - C) were examined, and a sensitivity analysis in terms of IRR was made to evaluate the economic viability of the project against possible changes in estimates of the project cost and benefits. For the financial analysis the repayment capability of the project and the capacity to pay of benefited farmers were analyzed. The indirect benefits and socio-economic impacts of the project were also studied briefly.

The project costs and benefits to be used for these economic and financial evaluations were estimated on the basis of price levels and exchange rates as of March 1984, but the sensitivity analysis was also made on the price levels forecast in December 1984 since the costs of wages, construction materials, etc. rose remarkably after the decree floating the peso on June 6, 1984.

8.2 Economic Evaluation

8.2.1 Project Benefit

The project benefits will accrue primarily from increased crop production due to stable irrigation water supplies. The benefit is estimated from the difference of the annual net production values under future with and without project conditions. The irrigation benefit amounts to ₱276 million per annum at full development as shown in Table 13. This benefit would start to accrue from 1990, and would gradually increase up to the full benefit in 1997.

As for agricultural production within the reservoir area which would be affected by implementation of the project, it was estimated that this would be negligibly small because the reservoir area is mostly occupied by non-farm land such as forest land, bush/grass land, etc. Therefore, the negative benefit for agricultural production within the reservoir area was disregarded in the study.

8.2.2 Economic Cost

The economic cost of the project would consist of the construction cost, replacement cost and operation and maintenance cost (O&M cost), and is obtained by deducting transfer payments such as direct/indirect taxes, levies, etc. from the financial cost. The transfer payment was estimated at 17.3% of the financial cost on the basis of the conversion factor /1 for shadow prices as analyzed by the World Bank. The economic construction cost would amount to ₱1,252 million as shown in Table 14. Steel gates installed in the proposed irrigation and drainage systems would be replaced once during the entire period of the project life, and the O&M equipment would be replaced every 10 years. The O&M cost of the project would be initially disbursed in 1990 when partial operation would commence, and would reach the full amount of ₱3.9 million in 1992. Land acquisition costs and price contingencies are excluded from the economic evaluation.

8.2.3 Evaluation

(1) IRR, B/C and B-C

In order to compute the IRR, the annual economic cost and benefit streams were prepared as shown in Table 15. From this table, the IRR was estimated to be 12.8%. In addition, the B/C and B-C were also estimated at the discount rate of 10% as follows:

1) IRR : 12.8%
2) B/C : 1.40
3) B-C : ₱341 million

These results indicate that the feasibility of the project is highly sensitive.

(2) Sensitivity Analysis

Project sensitivity was analyzed in respect of changes in project benefit and cost. The results are summarized as below:

/1: Philippines, Social Cost-Benefit Analysis, Estimates of Shadow Prices and Country Parameters, IBRD, 1978.

(IRR: %)

Construction Cost Increased	Benefit Decreased 0%	Benefit Decreased -10%	Build-up Period Delay in One Year
0%	12.8	11.9	11.8
+10%	12.0	11.1	11.1
+20%	11.2	10.4	10.5

The above sensitivity analysis was made on the basis of the price levels and the exchange rate as of March, 1984. In view of the recent economic dislocation in the Philippines, moreover, the project sensitivity was also analyzed in order to ascertain the feasibility of this project realistically for; i) the price levels forecast in December 1984, and ii) an exchange rate of ₱18.0 equivalent to US$1.0.

For the price levels in December 1984, it was forecasted that the foreign currency portion of project costs and benefits will increase in proportion to the decline in the peso rate, and the local currency portion will increase by at least 30%. On this basis, the IRR was estimated to be 12.8% which indicates the same value as with the price levels as March 1984. As a result, the feasibility of the project at the price levels of December 1984, is still highly sensitive.

8.3 Financial Evaluation

8.3.1 Repayment Capability

In order to analyze the repayment capability of the project, a cash flow statement was prepared as shown in Table 16, based on the annual disbursement schedule of the project financial cost and the anticipated project revenue. In the analysis of repayment capability, it was assumed that the capital required for project implementation would be arranged in terms of the following financial conditions:

Foreign Currency Portion

The capital would be financed by bilateral or international organizations with an interest rate of 3.5% per annum and a repayment period of 30 years including 10 years of grace period.

Local Currency Portion

The capital would be financed by budget allocation of the Government with no interest and no repayment.

According to the above assumptions, the total fund requirement for bilateral or international organizations were estimated at about ₱1,635 million and the capital to be financed by the Government amounting to about ₱1,133 million. As for the anticipated project revenue, this would only consist of the irrigation service fee which was estimated at about ₱6.6 million per annum under full payment conditions.

As a result of this analysis, the project revenue of irrigation service fee could not cover the annual repayment of the fund, except for O&M cost. Therefore, the repayment of capital will have to be made by subsidies from the Government, which were estimated to be ₱88 million per annum on an average during the repayment period from 1987 to 2015.

8.3.2 Capacity to Pay of Farmers

In order to assess the capacity to pay of farmers, a farm budget analysis was made for the typical farmer under the future with project and the future without project conditions. The results are summarized below:

Description	Farm Size (ha)	Gross Income (₱10³)	Gross Outgo (₱10³)	Net Reserve (₱10³)
Present Condition				
1) Rice Cultivation Farmer				
- Irrigated	1.3	32.5	32.5	-
- Rainfed	1.3	25.9	25.9	-
2) Sugarcane Planter	4.0	41.6	41.5	0.1
Without Project				
1) Rice Cultivation Farmer				
- Irrigated	1.3	33.1	32.7 /1	0.4
- Rainfed	1.3	25.9	25.9	-
2) Sugarcane Planter	4.0	42.9	41.8	1.1
With Project				
1) Rice Cultivation Farmer	1.3	46.2	37.1 /1	9.1
2) Sugarcane Planter	4.0	86.3	74.9 /1	11.4

Remarks: /1: Including irrigation fee

The annual net reserve or capacity to pay under the future with project condition would increase remarkably as compared with the future without project condition. The increase in net reserve would enable the farmers to pay the fixed irrigation fee and would also offer to them incentives for further development.

8.4 Indirect Benefit and Socio-Economic Impact

Various indirect benefits and socio-economic impacts are expected from the implementation of the project as mentioned below:

(1) Food Supply to Metro Manila

Since demand for rice and vegetables in Metro Manila will continue to increase with population growth, Region III including the project area will have to be a supply base to Metro Manila for these products. The project would produce a substantial marketable surplus estimated at 20,100 tons of rice and 13,700 tons of vegetables.

(2) Employment Opportunity

The project would create a demand for farm labor due to increased farming activity, more intensive use of land, and higher productivity. The incremental farm labor requirement was estimated to be 1.39 million man-days per annum. In addition, construction of the project would increase the employment opportunities of the area. During the construction stage, the majority of workers would be un-skilled laborers most of whom would come from landless workers and farmers in and around the project area.

(3) Farmers' Income

After the implementation of the project, income of farmers estimated to be 5,040 households is expected to increase considerably as a direct result of the increase in crop production. Such increase in income would contribute to improving living standards. Moreover, it is expected that farmers' purchasing power would increase along with improvement of their living standards, and this increased purchasing power would benefit development of regional economy.

(4) Marketing of Farm Inputs and Outputs

Market facilities in the project area may be expected to be improved as compared with the present condition. With anticipated higher agricultural production, farm products could be marketed by the farmers more effectively and the proportion of sales would increase relative to consumption. The merchants would have a larger turnover which should improve their services.

Marketing functions would not only be influenced by agricultural outputs. It is assumed that when agricultural production develops as a result of the project, the project area would be the good market for farm supplies such as tools, fertilizers, agro-chemicals, sacks and related agricultural supplies. Both ends of the marketing channels could therefore expect substantial beneficial impacts from the project.

(5) Productivity of Sugar

The increased production of sugar would be a major objective of agricultural development. The productivity of land for sugarcane was evaluated as below:

	Productivity of Land (₱/ha)
Without Project	1,311
With Project	2,493

As shown in the above table, the productivity of sugarcane would increase remarkably as compared with the future without project condition, and this increased productivity would have a benefitial impact in price competition for sugar export.

(6) Operational Improvement of Sugar Mill

Owing to the shortage of raw sugarcane, the existing sugar mill (NASUDECO) operates at only 41% of its milling capacity which is uneconomical. After implementation of the project, capacity utilization of NASUDECO would reach a level of around 80% with the increase in sugarcane production. At this level of capacity utilization, it may be expected that management of NASUDECO would be improved.

(7) Contribution to National Economy

With completion of the project, sugar production would increase from 19,800 tons at present to 45,100 tons under full development, and increase in sugar export would be estimated to be about 14,200 tons/1.

For the annual net contribution to the national economy, it would be expected that export earnings from sugar would be about ₱49.7 million/2.

/1: (45,100 tons - 19,800 tons) x 56%* = 14,200 tons

* Allocation rate for export by NASUTRA.

/2: 14,200 tons x US$250/ton** x ₱14 = ₱49,700,000

** World market price in 1984 forecasted by the World Bank.

CHAPTER 9 ENVIRONMENTAL IMPACT ASSESSMENT

9.1 General

The Gumain River Irrigation Project comprises construction of a 108 m high storage dam on the Gumain river, and construction/rehabilitation of 16,750 ha of irrigation and drainage systems. The construction of the dam and reservoir may effect the environmental resources of the area, and the environmental impact assessment is carried out preliminary for the project.

The environment defined by the Philippine Environmental Impact Assessment System (EIAS) covers all facets of the human environment-physical, ecological, aesthetic, cultural, economic, historic, institutional and social. Such a wide definition of the environment results in some inevitable overlap between the EIAS and other sectors of the feasibility study.

In this chapter, therefore, the principal environmental impacts of the project are considered, and an assessment of the potential impacts is given on the basis of information collected from existing sources.

The construction of Gumain dam and reservoir would have major positive impacts on the area in terms of environmental resources such as on hydrologic regime and ecological systems. Some relatively minor adverse effects would be mitigated by measures which would be undertaken as part of the project.

9.2 Physical Environment

9.2.1 Water

At present, water from the Gumain river is taken for existing irrigation systems at the Gumain diversion dam constructed in 1957. In the dry season almost all of the natural flow of the river is taken for the irrigation systems, and there is no water in the river immediately downstream of the diversion dam.

The proposed Gumain reservoir would store water in the rainy season and release it in the dry season in accordance with the water requirements of the service area. Flood control has not been considered as a project function as floods cannot be controlled within the capacity limits of the proposed reservoir. However, the reservoir would reduce flood peaks by temporarily impounding inflow peaks in reservoir surcharge storage for later discharge through the spillway.

Under present conditions, even in the dry season, there is no serious salt water intrusion problem at the downstream boundary of the project area and it is very important to maintain the present fresh-saline water equilibrium in the downstream area. After the project, the groundwater table in the downstream area is expected to rise in the dry season by increasing recharge of the aquifer due to the increase in irrigation water supply and expansion of the irrigation area. These changes will result in positive impacts to the present equilibrium.

9.2.2 Mining

At present, there are no actual mining operations or mining rights registered with the Bureau of Mines and Geo-Sciences (Ministry of Natural Resources) within the proposed reservoir area and the watershed of Gumain dam. Nevertheless some mineral prospecting has been carried out within the watershed area by a private mining company as mentioned below.

Name of Project	:	Dizon-type Cu-Au exploration project
Organization	:	Benguet Corporation
Location	:	In the catchment area of left tributary of Gumain River (Upstream of reservoir area with the elevation of more than 450 m)
Control of Mineralization	:	Lithologic (Older volcanic)
Primary Mineral	:	Copper
By-Product Mineral	:	Gold

Water pollution resulting from the mining operations would be expected unless suitable measures are taken such as provision of a proper tailings pond. Problems may arise from mining activities if they produce large volumes of mine wastes and tailings in the process of extracting minerals. Sedimentation and siltation would result when uncontrolled tailings are let loose during floods, and also toxic mine tailings would be discharged directly into water courses.

9.3 Ecological Environment

9.3.1 Fauna and Flora

It is difficult to assess the impact on fauna and flora because so little data and information is available at present.

The development of dams and reservoirs usually cause some alteration to hydrologic regimes, but in this case the impact on the area is likely to be small because the flooded area of the dam would only be about five percent of the catchment area, and no rare species have been reported in the area.

9.3.2 Soil Conservation

The 114 km^2 drainage area of the Gumain dam has been deforested by "slash and burn" cultivation, and most of the area is now grass land with clumps of secondary forest growth.

There are some trails in the watershed, and new access routes upstream of the dam are likely to follow completion of the dam and reservoir. This usually results in some impact on watershed.

Watershed management including reforestation should be carried out to reduce siltation and soil erosion which would reduce the useful life of Gumain dam.

9.3.3 Fishery

At present, there are few riverine fishes in the Gumain river, and there are no migrant fishes due to the existing Gumain diversion dam which has no fish ladder. Main fishery activity in the area is fish pond culture around Pampanga bay. No effects on fisheries are therefore expected.

9.4 Aesthetic, Cultural and Recreational Environment

From limited field observations in the reservoir area of the Gumain dam, it would appear that there are no geological, historical, archeological or scenic sites to be submerged by the reservoir.

The Summer Place located about 1.5 km downstream of the proposed dam site, constructed and operated by the municipal government of Floridablanca as a local recreational center, would be the approach point for the downstream construction road as presently planned. The present facilities comprising five huts of the Summer Place would have to be relocated further downstream.

During the dam construction, turbidity of the river water downstream will increase, but in order to mitigate nuisance, a holding basin of some kind would be provided.

9.5 Resettlement

The reservoir basin consists of steep walled gorges some of which are covered by grass tussocks. In the watershed area, there are very few families inhabiting in this rugged terrain, and they are cultivating land by the "slash and burn" method.

The proposed Gumain dam and reservoir area are located on lands in the public domain where there are no existing settlements or cropped farm lands which would be submerged by the construction of the Gumain dam.

There are no constructed facilities such as roads or bridges within the area of reservoir which would require relocation.

CHAPTER 10 HYDROPOWER POTENTIAL

10.1 General

The Gumain River Irrigation Project is primarily formulated for irrigation but would include construction of a dam of about 108 m high and a reservoir with gross storage capacity of 110 x 10^6 m^3.

The hydropower scheme would aim to generating power by harnessing the head produced by dam construction and water released for irrigation. In this Chapter, the viability of such a hydropower scheme was examined. The hydropower scheme must not in any way hinder proposed irrigation scheme and the study was made only for the proposed optimum irrigation development plan.

10.2 Basic Layout of Facilities

According to the preliminary design for the main dam and appurtenant structures, one large diversion tunnel would be constructed on the right bank of the river and this would also be used as an irrigation water release facility.

Power generation facilities would be arranged to be compatible with this design and to minimize the construction cost. The power station would be sited at outlet of diversion tunnel on the right bank of the river to use the tunnel as a waterway, as well as topographic and geological conditions, and the penstock would be provided within the diversion tunnel.

Power generated by the Gumain power station would be conveyed to the existing Basa substation to connect with NPC's Luzon grid. For this purpose the Basa substation would have to be extended.

10.3 Selection of Optimum Installed Capacity

10.3.1 Methodoloty

The Gumain Project would be developed primarily for irrigation and therefore water use in the power scheme would be strictly constrained by the irrigation water requirement. Only water released for irrigation and/ or spilled would be available for power generation and no special releases for power would be made.

The optimum installed capacity was selected to give the maximum net benefit. However, the unit construction cost per kWh is also important index for selection of optimum scale for a power scheme such as the Gumain Project which cannot provide a firm power output due to preferential water use for irrigation and of which the power benefit can only be assessed in terms of energy output. Such optimum installed capacity is found through comparative study.

10.3.2 Criteria

(1) Reservoir Water Level

Applying the proposed irrigation plan, reservoir water level conditions were set as below:

F.W.L.	El. 153.5 m
L.W.L.	El. 100.0 m

Tail water level for power was set at El. 60 m taking into account the elevation of river bed.

In view of the range of available head and discharge, a horizontal shaft Francis turbine would be the most appropriate. This would have the following operating constraints to avoid unfavourable behavior of turbine in operation such as cavitation.

a) Allowable range of head, 65% to 125% of design head

b) Allowable minimum turbine discharge, 40% of rated turbine discharge

To meet the above requirements, minimum reservoir water level, which is defined as the water level below which operation of the power station should be stopped, was set at El. 108.6 m. From this, the rated water level was set at El. 131.1 m, which was the mid-point of drawdown for power generation.

(2) Operation Mode

Since there is no regulating capacity for daily operation at the proposed Gumain diversion dam site, peaking operation is not possible and firm operation following irrigation water release was adopted. From consideration of water levels, the following operation mode was applied.

For reservoir water level above rated water level, the rated power output (= installed capacity) would be secured whenever irrigation water requirements exceed the required turbine discharge. Conversely whenever the reservoir water level is below the rated water level, the rated power output would no longer be secured.

The number of units to be installed was taken to be two, in view of the wide variation in turbine discharge, economics, and risk dispersion.

(3) Available Water for Power Generation

As mentioned before, the available water for power generation would be irrigation water released and water spilled out from reservoir. No extra water release for power would be allowed.

(4) Cost Estimate

The direct construction cost of the power generation facilities was estimated from the estimated work quantities and unit construction cost investigated as of March 1984.

Engineering costs and administration costs were assumed to be 10% of direct construction cost. Physical contingency was taken as 10% of the sum of direct construction cost plus engineering costs and administration costs. Also, operation and maintenance cost was assumed to be 2.5% of direct construction cost. For computation of annual costs, a discount rate of 10% and life time of 40 years are applied.

(5) Power Benefit

The installed capacity of Gumain power station would be less than 10 MW and as such would be implemented by NEA according to the governmental regulations. In case of NEA's developments, power supply is usually made by construction of diesel power plants or energy purchases from NPC. The service area of Gumain power station already receives a power supply through NPC's Luzon grid. Also as Gumain power station has no firm output to be evaluated due to the reasons mentioned before and as only energy produces benefit, the power value to assess power benefit is represented by cheaper cost as between the fuel cost of diesel plant and the energy purchase cost from PELCO II and MANSONS. The said purchase cost was estimated to be 0.6 ₱/kWh at the price level of early 1984 based on the sales records, while, the fuel cost of diesel plant was estimated as follows:

Diesel oil price	:	4.48 ₱/ℓ
Fuel consumption rate	:	0.28 ℓ/kWh
Fuel cost	:	1.254 ₱/kWh

Fuel cost of diesel plant is more expensive than NPC's sales price, so a power value of 0.6 ₱/kWh was adopted for the present study.

10.3.3 Optimum Installed Capacity

Based on the methodology and criteria mentioned above, a comparative study was made for the following 6 cases of installed capacity:

Case No.	Installed Capacity (kW)	Annual Energy Output (GWh)	Annual Net Benefit ($₱10^3$)	Unit Construction Cost (₱/kWh)
1	8,000	30.9	1,386	4.27
2	7,000	29.5	2,002	4.09
3	6,000	27.3	2,156	4.00
4	5,000	24.3	1,946	3.99
5	4,000	20.7	1,442	4.07
6	3,000	16.5	784	4.26

As seen in the above table, Case 3 gives the maximum net benefit and also its unit construction cost is almost same as the lowest one of Case 4. Therefore, an installed capacity of 6,000 kW (3,000 kW x 2) was selected as an optimum one, and in this case, the annual energy output was estimated to be 27.3 GWh. The internal rate of return (IRR) for this case of development was calculated at 10.6%.

10.4 Further Considerations

10.4.1 Water Use Mode

As explained above, the water use mode in the study was completely governed by irrigation water requirement and no unconstrained water use was allowed for power scheme. However, modification of the water use mode by introducing the power scheme should be taken into consideration if the variation of irrigation water deficit rate is negligible and also if any firm power output can be secured or if energy output increase can be expected.

Accordingly, additional computation was made for the condition that at least one of the two units would be operated regardless of irrigation water requirement when reservoir water level is above rated water level. The result is summarized hereunder.

Water Use Mode	Energy Output (GWh)	Deficit Rate (%)
Original Mode	27.3	6.82
Modified	28.0	10.65

As seen in the above table, the increase in energy output is small compared with the variation of irrigation water deficit rate which cannot be ignored. Consequently it was concluded that the modification of the water use mode would not be necessarily contributable to the project.

To secure firm power is not practicable because the drawdown of reservoir exceeds the allowable range of head for the turbine. The only possibility would be to change a runner depending on the reservoir water level, but this also would not be practicable due to difficulty of operation and maintenance.

10.4.2 Power Benefit

In this study the power benefit was assessed from the purchase power rate of PELCO II and MANSONS after comparison with the fuel cost of diesel plant for the reason that Gumain power development would be implemented by NEA. However, if the power supply for the project area is assumed to be carried out by NPC, the power benefit of Gumain power station should be assessed by saving in the fuel cost of thermal plant in the Luzon Grid. In that case, power value may be estimated as follows:

Type of plant	:	Coal-fired thermal
Fuel cost	:	868 ₱/t
Heat value	:	11,540 BTU/Lb
Thermal efficiency	:	37%
Adjustment factor	:	1.084
kWh-value	:	0.34 ₱/kWh

The above kWh-value is much lower than power value of 0.60 ₱/kWh applied to the study. If 0.34 ₱/kWh is applied to power benefit estimation, the proposed power scheme becomes unfeasible unless some countermeasures to secure firm power is taken to increase the power value.

TABLES

Table 1 MEMBER LIST OF ADVISORY COMMITTEE, STUDY TEAM AND COUNTERPART GROUP

Name	Title/Speciality
Advisory Committee	
1. Mr. Minoru TSUKADA	Chairman of the Committee
2. Mr. Kanezo TAKEUCHI	Advisor on Irrigation and Drainage
3. Mr. Tadatsugu TANAKA	Advisor on Dam
4. Mr. Masahiko KAMEDA	Advisor on Dam
5. Mr. Masanao HAYASHIDA	Advisor on Soil and Agriculture
6. Mr. Junichi HASEGAWA	Advisor on Economic Analysis
7. Mr. Kazuo SUDO	Coordinator
JICA Study Team	
1. Mr. Kensaku TAKEDA	Team Leader
2. Mr. Takeshi KAWAGUCHI	Co-Leader/Irrigation and Drainage Planner
3. Mr. Yutaka NAKANO	Irrigation and Drainage Engineer
4. Mr. Yukihiro KAWAHARA	Irrigation and Drainage Engineer
5. Mr. Michimasa MENJO	Dam Planner
6. Mr. Tsuguo MURAKAMI	Dam Engineer
7. Mr. Hirofumi SADAMURA	Hydropower Engineer
8. Mr. Hakuro SUZUKI	Hydrologist
9. Mr. Masao OKAMOTO	Geologist
10. Mr. Mikihiro HASHIMOTO	Soil Mechanical Engineer
11. Mr. Yutaka MATSUMOTO	Pedologist
12. Mr. Tadaharu MURONO	Agronomist/Agro-Economist
13. Mr. Yoshimitsu YUKAWA	Construction Planner
14. Mr. Shozo SHIMODA	Survey Engineer
Counterpart Group	
1. Mr. R.F. POTENCIANO	Chief Counterpart
2. Mr. E.B. PUNZAL	Head, Irrigation Works Section
3. Mr. R.L. LLAMOSO	Irrigation Engineer
4. Mr. C.T. ALANANO	Head, Dams & Reservoirs Section
5. Mr. R. GONZALVO	Dam Engineer
6. Mr. R. BARWELO	Hydropower Engineer
7. Miss A.S. VILLALUNA	Hydrologist
8. Mr. O.M. BUENO	Hydrographic Engineer
9. Mr. D. FAJARDO	Geologist
10. Mr. M. ABAD	Soil Mechanical Engineer
11. Mr. E. ANCHETA	Soil Mechanical Engineer
12. Mr. C.Q. TINGZON	Head, Land Classification Section
13. Mr. L. COSTA	Agronomist
14. Mr. D. SUELEN	Agro-Economist
15. Mr. D. FULO	Construction Planner
16. Mr. F.M. GALIT	Head, Surveys & Mapping Section

Table 2 BASIC DATA FOR SOCIO-ECONOMIC INDICATORS

Item		1979	1980	1981	1982	1983
1) Population	(10^6)	46.8	48.1	49.4	50.7	52.0
2) Labor Force						
- Total Labor Force	(10^6)	18.4	18.5	19.0	20.0	20.5
- Employed	(10^6)	17.8	17.7	18.0	19.1	19.5
Agriculture		9.0	9.4	9.5	9.9	10.2
Manufacturing and Others		8.8	8.3	8.5	9.2	9.3
3) Gross National Product (GNP)						
- GNP at Current Market Prices	$(₱10^9)$	221	265	304	336	377
- GNP at 1972 Constant Prices	$(₱10^9)$	69	93	96	99	100
- Growth Rate	(%)	6.6	4.4	3.7	2.8	1.3
- Per Capita GNP/1	$(₱10^3)$	4.7	5.5	6.1	6.6	7.3
4) GDP (1972 Constant) by Industry	(%)	100.0	100.0	100.0	100.0	100.0
- Agricultural Sector		25.6	25.6	25.6	25.6	24.8
- Industrial Sector		36.4	36.1	36.3	36.2	36.0
- Services Sector		38.0	38.3	38.1	38.2	39.2
5) Production Indexes						
- Agriculture (1969 - 1971 = 100)		116.0	123.0	128.0	131.0	129.0
- Manufacturing (1975 = 100)		120.0	129.0	134.6	141.9	*/3
- Electricity (1978 = 100)		124.6	131.9	139.3	142.0	*
6) Price Indexes						
- Wholesale (1978 = 100)/2		119.0	140.8	159.2	176.3	189.0
- Consumer (1978 = 100)/2		118.8	140.0	158.7	176.2	195.3
7) Balance of Payments	$(US\$10^9)$					
- Export (f.o.b.)		4.60	5.79	5.72	5.02	4.83
- Import (f.o.b.)		-6.14	-7.73	-7.94	-7.67	-7.20
Trade Balance		-1.54	-1.94	-2.22	-2.65	-2.37
- Services (net)		-0.39	-0.54	-0.54	-1.16	-1.27
- Transfer (net)		0.35	0.43	0.47	0.49	0.39
Current Balance		-1.58	-2.05	-2.29	-3.32	-3.25
- Capital Flows						
Direct Investment		0.09	0.04	0.40	0.29	0.45
Portfolio Investment		0.01	-	-	-	-
Other Long-Term Capital		1.15	1.03	1.33	1.47	1.24
Other Short-Term Capital		-0.05	0.78	0.16	0.57	-0.91
- Net Errors & Omissions		-0.26	-0.34	-0.59	-0.39	-0.44
Monetization of Gold		0.04	0.13	0.40	0.27	0.18
Allocation of SDRs		0.03	0.03	0.03	-	-
- Overall Balance		-0.57	-0.38	-0.56	-1.11	-2.73
8) Gross Regional Domestic Product (1972 Constant Price)	(%)	*	100.0	100.0	100.0	*
- NCR		*	32.3	32.6	32.9	*
- Region I		*	3.6	3.6	3.5	*
II		*	2.6	2.5	2.5	*
III		*	8.1	8.1	8.1	*
IV		*	14.0	13.9	13.8	*
V		*	3.5	3.5	3.6	*
VI		*	7.9	7.8	7.8	*
VII		*	7.3	7.3	7.2	*
VIII		*	2.5	2.4	2.4	*
IX		*	3.5	3.5	3.5	*
X		*	4.6	4.7	4.7	*
XI		*	6.8	6.8	6.7	*
XII		*	3.3	3.3	3.3	*
9) GDP (1972 Constant) - Region III	(%)	*	*	*	*	100.0
- Agricultural Sector		*	*	*	*	28.5
- Industrial Sector		*	*	*	*	24.0
- Services Sector		*	*	*	*	37.5

Remarks: /1: Current market price
/2: Metro Manila
/3: *: No data

Source: (1) 1983 Philippine Statistical Yearbook, NEDA.
(2) The Philippine Economy - Past Trend and Outlook 1984, Central Bank of the Philippines.
(3) Regional Development Investment Program, NEDA Region III Office.

Table 3 CROP PRODUCTION IN THE PHILIPPINES

(Unit: 10^3t)

Crops	1978	1979	1980	1981	1982
Palay (Rough Rice)/1	6,895	7,198	7,836	7,723	8,108
Corn (Shelled)	2,855	3,167	3,123	3,110	3,290
Peanut (Unshelled)	38	49	50	30	49
Beans and Peas	41	42	47	49	50
Rootcrops	3,004	3,567	3,470	3,407	3,173
Vegetables	524	467	505	502	523
Mango	335	363	377	367	597
Banana	3,156	4,179	3,977	4,073	4,077
Pineapple	465	605	1,281	1,293	1,242
Coconut/2	4,195	4,295	4,570	4,312	3,786
Sugar/3	3,282	3,199	3,121	3,193	3,403
Abaca	130	148	157	128	120
Tobacco	57	51	42	39	46
Rubber	54	59	68	72	79
Coffee	119	116	125	147	171

Remarks: /1: Paddy
/2: Includes nuts used for making copra, dessicated coconut, etc.
/3: Includes centrifugal sugar, molasses, Muscovado and panocha.

Source: 1983 Philippine Statistical Yearbook, NEDA

Table 4 PHILIPPINE EXPORTS BY MAJOR COMMODITY GROUP

(Unit: US$$10^6$)

Commodities	1980 Value	1980 (%)	1981 Value	1981 (%)	1982 Value	1982 (%)
Commercial Crops	1,893	32.7	1,812	37.7	1,484	29.6
- Coconut Products/1	(811)	(14.0)	(750)	(13.1)	(590)	(11.8)
- Sugar & Products/2	(657)	(11.4)	(609)	(10.7)	(445)	(8.9)
- Fruits	(365)	(6.3)	(378)	(6.6)	(374)	(7.4)
- Abaca & Products	(31)	(0.5)	(25)	(0.4)	(26)	(0.5)
- Tobacco & Products	(30)	(0.5)	(50)	(0.9)	(49)	(1.0)
Forest Products	468	8.1	469	8.2	362	7.2
Mineral	1,031	17.8	758	13.2	532	10.6
Mineral Fuel & Lubricants	38	0.7	42	0.7	33	0.7
Chemicals	89	1.5	107	1.9	96	1.9
Textiles	33	0.6	69	1.2	56	1.1
Manufactures and Others	2,198	38.0	2,455	42.9	2,449	48.7
Re-exports	37	0.6	10	0.2	9	0.2
Total	5,788	100.0	5,722	100.0	5,021	100.0

Remarks: /1: Includes copra, coconut oil, copra meal, dessicated coconut, etc.
/2: Includes centrifugal sugar, refined sugar, molasses, etc.

Source: 1983 Philippine Statistical Yearbook, NEDA.

Table 5 SUMMARY OF CLIMATIC CONDITIONS

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average Total
Mean Temperature (°C)													
Basa Air Base (1958-1981)	25.6	26.0	27.1	28.6	28.7	27.8	27.3	26.8	27.1	27.0	26.7	26.2	27.1
Mean Maximum Temperature (°C)													
Basa Air Base (1963-1981)	30.6	31.4	32.8	34.3	33.8	32.2	31.3	30.5	31.5	31.7	31.3	30.6	31.8
Hacienda Luisita (1963-1980)	31.4	32.1	34.0	35.3	34.9	33.2	32.5	32.7	32.2	33.0	32.2	31.8	32.9
Mean Minimum Temperature (°C)													
Basa Air Base (1963-1981)	20.6	20.6	21.5	23.0	23.8	23.4	23.3	23.1	22.8	22.8	22.3	21.8	22.4
Hacienda Luisita (1968-1980)	19.2	19.8	20.5	22.0	23.0	23.3	22.6	22.5	22.6	21.6	20.8	19.3	21.4
Mean Relative Humidity (%)													
Basa Air Base (1970-1974)	67.1	67.9	67.9	66.7	70.9	78.8	82.9	82.5	79.0	78.8	73.0	72.5	74.0
Hacienda Luisita (1968-1980)	66.5	61.9	58.6	57.5	68.7	75.9	79.4	82.3	79.7	74.3	68.8	67.2	70.1
Mean Sunshine Duration (%)													
Hacienda Luisita (1969-1983)	63.4	71.2	67.4	75.6	64.1	46.2	41.9	31.7	41.3	50.5	58.9	57.6	55.8
Mean Wind Speed (m/sec)													
Basa Air Base (1958-1981)	3.3	3.5	3.3	3.4	3.0	3.3	3.1	3.2	2.8	2.5	3.2	3.2	3.2
Hacienda Luisita (1968-1980)	3.3	3.1	3.4	3.1	2.5	2.4	2.3	2.2	2.0	2.4	3.3	3.5	2.8
Mean Evaporation (mm)													
Hacienda Luisita (1958-1983)	154.0	169.4	213.0	221.0	182.5	129.5	115.7	102.3	104.7	122.7	128.3	141.5	1,784.6

Table 6 MEAN MONTHLY RAINFALL

No.	Station Name	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1.	Basa Air Base	6.5	6.7	9.8	26.9	145.9	344.7	519.2	632.1	376.4	151.0	59.0	22.7	2,300.9
2.	Pasumil	31.3	25.9	35.7	51.1	147.6	320.7	430.1	571.9	416.3	250.8	130.0	86.4	2,497.8
3.	Santa Cruz Porac	7.1	11.1	14.9	32.9	165.5	211.2	483.6	442.9	293.1	202.9	101.4	43.7	1,878.7
4.	Santa Rita	6.3	3.1	27.3	13.3	207.0	246.1	305.9	542.2	310.9	171.9	74.6	34.9	1,533.4
5.	Cabanbagan Bacolor	6.3	7.9	16.3	29.0	124.8	266.4	460.3	480.7	256.9	194.8	85.6	36.5	1,960.1
6.	Lubao	6.2	2.9	25.3	1.1	274.2	238.4	505.9	807.4	378.0	253.4	106.0	75.7	2,329.7
7.	Armeria Dam Tarlac	7.8	0.7	14.6	34.1	84.5	208.1	407.2	360.7	247.0	160.6	90.8	9.3	1,625.4
8.	Carangian, Tar.	14.1	4.8	13.5	40.2	319.8	285.9	269.3	478.8	292.4	245.2	85.3	26.3	2,075.6
9.	Hashienda Luisita	10.3	0.9	13.7	53.4	143.5	226.4	370.9	340.8	297.8	153.4	80.4	21.9	1,656.8
10.	Amucao Tarac	10.7	4.8	6.4	16.3	178.5	287.4	268.3	421.1	335.3	122.9	65.5	19.1	1,736.3
11.	La Paz	10.2	1.6	8.9	25.0	200.7	182.0	286.5	334.5	329.5	171.2	32.9	16.8	1,429.8
12.	Dolores Capas	17.5	0.8	3.5	29.2	232.1	219.0	322.3	373.3	348.0	163.7	67.3	19.3	1,796.0
13.	Clark Air Base	11.8	10.3	24.9	42.7	169.6	245.9	369.3	444.5	313.8	166.0	97.6	55.2	1,951.6
14.	San Agustin Arayat	15.3	3.6	21.7	31.4	165.2	225.7	379.5	409.4	268.8	170.2	118.5	53.3	1,811.6
15.	San Fernando	7.2	6.3	18.9	22.1	145.2	230.5	423.1	455.3	270.2	188.9	82.5	38.2	1,743.2
16.	San Matias	2.8	0.0	21.6	14.5	323.4	431.2	148.2	310.2	189.3	167.9	61.2	77.7	1,122.4
17.	Cansinara Apalit	3.1	1.4	10.9	10.0	106.1	161.7	360.4	399.5	164.8	153.6	91.5	36.7	1,386.4
18.	Masantol	11.2	3.3	20.3	18.8	113.9	212.7	356.6	513.4	270.3	210.4	88.1	41.8	1,815.9
19.	Talisai Balanga	14.6	7.9	16.6	25.0	218.4	270.6	643.3	840.5	332.8	257.6	120.7	50.0	2,797.8
20.	Iba	3.2	3.0	12.5	18.9	277.4	542.5	798.7	1,061.6	608.2	218.8	84.1	23.7	3,652.6
21.	San Marcelino	4.4	6.4	26.8	35.1	239.2	498.7	592.4	993.6	522.6	291.9	96.4	37.1	3,344.6
22.	Cabanatuan	6.5	5.3	13.7	31.0	171.8	256.4	319.5	397.9	313.5	173.7	138.7	40.1	1,850.3
23.	Pasbol	-	-	-	-	-	-	-	-	-	-	-	-	-
24.	Nabuclud	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 7 BASIC SOCIO DATA IN THE STUDY AREA

Municipality	No. of Garangay	Population 1975	Population 1980	Annual Population Growth Rate (%)	Area (km2)	Population Density (person/km2)	Total Household in 1980 (No.)	Family Size	No. of Farm Household in 1980	Percentage of Farm Household (%)
A) Municipalities related to the Study Area										
Floridablance	32		51,648	2.60	125	413	8,219	6.3	2,000	24.4
Guagua	30	65,336	72,609	2.13	62	1,171	12,444	5.8	1,260	10.1
Lubao	43	69,903	77,502	2.09	156	497	12,637	6.1	2,730	21.6
Sta. Rita	10	22,167	24,995	2.43	33	757	3,898	6.4	960	7.6
Dinalupihan	39	36,302	41,415	2.67	45	920	6,590	6.3	1,760	26.7
Hermosa	21	23,246	25,672	2.01	157	164	4,140	6.2	1,480	35.7
Total:	175	262,373	293,841	2.29	578	508	47,919	6.1	10,190	21.3
B) Study Area	92	140,900	157,400	2.24	237	664	25,400	6.2	5,400	21.3
(Estimated in 1983)			(168,200)	(2.24)	(237)	(710)	(27,100)	(6.2)	(5,480)	(20.2)

Source: (1) 1980 Census of Population by Province, Municipality and Barangay, NCSO
(2) Socio-economic Profile (1982), Provincial Development Staff Office, Pampanga
(3) Socio-economic Profile (1982), Provincial Development Staff Office, Bataan
(4) 1975 Integrated Census of the Population and Its Economic Activities, Bataan and Pampanga, NCSO

Table 8 ANNUAL DIVERSION WATER REQUIREMENT

(Unit: mm)

Year/1	Paddy Wet	Paddy Dry	Paddy Total	Sugar-cane	Diversified Crop
1958/59	653	1,770	2,423	1,216	1,490
59/60	640	1,523	2,163	975	1,175
1960/61	319	1,668	1,987	1,268	1,326
61/62	535	1,787	2,322	1,214	1,420
62/63	565	1,623	2,188	1,218	1,408
63/64	253	1,658	1,911	1,049	1,425
64/65	455	1,475	1,930	778	1,257
65/66	285	1,527	1,812	1,047	1,250
66/67	473	1,494	1,967	1,133	1,368
67/68	167	1,728	1,895	1,125	1,459
68/69	358	1,785	2,143	1,100	1,393
69/70	387	1,721	2,108	931	1,377
1970/71	247	1,464	1,711	901	1,284
71/72	451	1,353	1,804	1,157	1,184
72/73	242	1,733	1,975	1,240	1,412
73/74	357	1,557	1,914	1,107	1,316
74/75	677	1,207	1,884	1,282	1,128
75/76	850	1,498	2,348	1,252	1,297
76/77	551	1,656	2,207	1,319	1,326
77/78	539	1,678	2,217	1,251	1,498
78/79	380	1,719	2,099	1,439	1,473
79/80	852	1,763	2,615	1,443	1,473
1980/81	792	1,644	2,436	1,368	1,464
81/82	650	1,664	2,314	1,679	1,420
82/83	765	1,805	2,570	1,558	1,473
Average	498	1,620	2,118	1,202	1,364
(C.W.R.)/2	890	1,018	1,908	1,230	817

Remarks: /1 : May to April based on the cropping calender.
/2 : Crop Water Requirement

Table 9 SALIENT FEATURES OF GUMAIN DAM AND RESERVOIR

1.	**Reservoir**	
	(1) Drainage Area	: 114 km^2
	(2) Gross Storage Capacity	: 110.4 x 10^6 m^3
	(3) Dead Storage Capacity	: 11.4 x 10^6 m^3
	(4) Active Storage Capacity	: 99.0 x 10^6 m^3
	(5) High Water Level	: EL. 157.5 m
	(6) Full Water Level	: EL. 153.5 m
	(7) Low Water Level	: EL. 100.0 m
	(8) Effective Storage Depth	: 53.5 m
	(9) Reservoir Area at Full Water Level	: 3.36 x 10^6 m^2
2.	**Dam**	
	(1) Dam Type	: Zone Type Rockfill Dam
	(2) Dam Crest Elevation	: EL. 160.0 m
	(3) Freeboard	: 6.5 m
	(4) Dam Height	: 108.0 m
	(5) Dam Crest Length	: 435.0 m
	(6) Dam Crest Width	: 12.0 m
	(7) Embankment Slope, Upstream	: 1 : 2.9
	Downstream	: 1 : 2.3
	(8) Embankment Volume	: 5.58 x 10^6 m^3
3.	**Spillway**	
	(1) Design Discharge	: 2,650 m^3/sec
	(2) Type	: Side Channel
	(3) Crest Length	: 155.0 m
	(4) Overflow Depth	: 4.0 m
4.	**Outlet**	
	(1) Design Discharge	: 15.31 m^3/sec
	(2) Type	: Sub-merged Orifice
	(3) Intake Section	: 9.0 m x 7.0 m
	(4) Outlet Conduit	: ø2.0 m
	(5) Energy Dissipator	: Jet Flow Gate, ø1,000 m
5.	**Diversion Tunnel**	
	(1) Desing Discharge	: 1,290 m^3/sec
	(2) Tunnel Section	: R = 6.0 m
	(3) Tunnel Length	: 660.0 m

Table 10 GENERAL FEATURES OF IRRIGATION FACILITIES

I. Diversion Dams

Diversion Dam	Irrigation System	Dam Type	Crest Length(m)	Dam Height(m)
1. Upper Gumain (New)	PRIS, CRIS	Ogee	80.0	4.0/1
2. Porac (Existing)	PRIS	Ogee with flap gate	43.3	4.2/1
3. Caulaman (Existing)	CRIS	Ogee	72.0	1.8
4. Gumain (Existing)	GRIS	Ogee	224.0	2.0

Remarks: /1: Height of dam plus gate

II. Irrigation Canals

(Unit: km)

Canals	PRIS	CRIS	GRIS	Total
1. Diversion Canal	6.9(0)	6.7(0)	-	13.6(0)
2. Main Canal	12.0(12.0)	12.8(12.8)	4.0(4.0)	28.8(28.8)
3. Lateral & Sub-Lateral	88.4(31.3)	40.4(12.5)	40.8(22.0)	169.6(65.8)
4. Main Farm Ditch	101.9(-)	84.4(-)	60.0(-)	246.3(-)
5. Supplementary Farm Ditch	254.8(-)	210.6(-)	150.0(-)	615.4(-)

III. Related Structures

(Unit: Nos.)

Structures	PRIS	CRIS	GRIS	Total
1. Head Gate	19(8)	7(4)	9(2)	25(14)
2. Turnout	136(22)	106(37)	70(17)	312(76)
3. Check Gate	77(10)	57(0)	36(0)	170(10)
4. Culvert	87(37)	68(39)	36(25)	191(101)
5. Bridge	7(2)	12(3)	-	19(5)
6. Syphon	9(7)	2(2)	1(1)	12(10)
7. Drop	6(1)	12(0)	-	18(1)
8. Waste Way & Spillway	6(0)	3(0)	4(0)	13(0)
9. Cross Drain	10(6)	4(0)	-	14(6)
10. Aqueduct	2(0)	-	-	2(0)

Remarks:
1) PRIS: Porac River Irrigation System (include new area commanded by Porac Diversion Canal)
2) CRIS: Caulaman River Irrigation System (include new area commanded by Caulaman Diversion Canal)
3) GRIS: Gumain River Irrigation System
4) Figures in ( ) indicate the length of existing canal or the number of existing structure

Table 11 GENERAL FEATURES OF DRAINAGE FACILITIES

I. Drainage Canals

(Unit: km)

Canals	PRIS	CRIS	GRIS	Total
1. River and Creek	64.8(64.8)	38.6(38.6)	28.0(28.0)	131.4(131.4)
2. Collector Drain	31.0(-)	14.6(-)	19.2(-)	64.8(-)
3. Catch Drain	4.3(-)	5.0(-)	-	9.3(-)
4. Tertiary Drain	25.0(-)	18.0(-)	15.0(-)	58.0(-)
5. Drainage Ditch	141.0(-)	105.0(-)	75.0(-)	321.0(-)

II. Related Structures

(Unit: km)

Structures	PRIS	CRIS	GRIS	Total
1. Bridge	12(4)	5(2)	9(3)	26(9)
2. Culvert	87(6)	58(3)	51(5)	196(14)

Remarks: 1) PRIS: Porac River Irrigation System (include new area commanded by Porac Diversion Canal)

2) CRIS: Caulaman River Irrigation System (include new area commanded by Caulaman Diversion Canal)

3) GRIS: Gumain River Irrigation System

4) Figures in ( ) indicate the length of existing canal or the number of existing structure