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NO. 7

REPUBLIC OF THE PHILIPPINES
MINISTRY OF PUBLIC WORKS AND HIGHWAYS

THE PANAY RIVER BASIN WIDE FLOOD CONTROL STUDY

MAIN REPORT

NOVEMBER [illegible]

JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF THE PHILIPPINES
MINISTRY OF PUBLIC WORKS AND HIGHWAYS

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PREFACE

It is with great pleasure that I present to the Government of Republic of the Philippines this report entitled the Panay River Basin-wide Flood Control Study.

This report embodies the result of a survey which was carried out from August 1983 to November 1985 for the formulation of basin development plan placing emphasis on the flood control plan by a study team commissioned by the Japan International Cooperation Agency following the request of the Government of Philippines to the Government of Japan.

The study team, headed by Mr. Hirosuke Takahashi, had a series of discussions with the officials concerned of the Government of Philippines and conducted a wide scope of survey and data analyses.

I sincerely hope that this report will be useful as a basic reference for development of the Panay river basin as well as the country.

I wish to express my deep appreciation to the officials concerned of the Government of Philippines for their close cooperation extended to the study team.

November 1985

Keisuke Arita
President
Japan International
Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

November, 1985

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

Dear Sir,

We have the pleasure of submitting herewith the Final Report on the Panay River Basin-wide Flood Control Study.

For preparation of this report, field investigation and studies were made for about two years starting from August, 1983. The intermediate results of the studies were compiled into a series of reports and submitted to your Agency on schedule. During October 3 and October 12 of 1985, the survey team visited the Philippines again and had the meetings to discuss about the Draft Final Report with the officials of Philippine Government concerned. All the findings and comments obtained in the meetings have been fully incorporated in this Final Report.

The engineering and socio-economic studies of the Report on the level of Master Plan recommend some projects which are technically sound and economically feasible. It is our sincere hope that the projects will be proceeded to the next stage of study for the early realization of the project as soon as possible along the recommendations presented in this Report.

In submitting this report, we wish to express our sincere appreciation and gratitude to the personnel at your Agency, the Japanese Embassy in the Philippines, and the authorities concerned of the Government of Philippines represented by the Ministry of Public Works and Highways for the constant support and cooperation extended to us during our field survey as well as home office work.

Very truly yours,

H Takahashi

Hirosuke Takahashi
Team Leader
Panay River Basin-wide
Flood Control Study
(Nippon Koei Co., Ltd.)

Notes

1. The currency equivalents applicable to this report are :

   US$ 1 = Peso (₱) 18 = Yen (¥) 234.

2. Construction cost estimates in this Study are expressed in financial costs at mid-1984 price levels.

SUMMARY OF PROPOSED DEVELOPMENT PROJECTS

1. Outlines of Proposed Development Projects

The purpose and timing of implementation of the proposed development projects can be outlined as follows:

1.1 Flood Control Project

(1) 1st Stage work (Short-term provisional plan)

River improvement

River improvements for this stage would comprise the following:

(a) Cogon bypass floodway (9.5 km):
This plan would provide for a bypass floodway from 4 km downstream of Panitan to the mouth of the Hamulauon river. Flood flow exceeding the bankful capacity of the Pontevedra river of 500 m^3/sec would be diverted by this floodway.

(b) River improvement of the Pontevedra river (6.1 km):
This would provide partial improvement of the Pontevedra river from the entrance to the floodway to Pontevedra town. The channel section, where the carrying capacity is less than 500 m^3/sec, would be widened and eroded banks would be revetted.

(c) The stretch between Panitan and Cogon floodway entrance (6.5 km):
The low flow capacity of the river would be expanded by improvement of the existing river channel. Levees would be constructed on the both banks.

By this improvement work, the areas downstream of Panitan town (including the Panitan - Panay irrigation area) would be relieved of flood damages caused by floods of less than 10-year recurrence.

Polder dykes

Polder dykes would be embanked to alleviate flood damages at 4 towns/villages with high flood damage potentiality, i.e. Dao, Cuartero, Mambusao and Sigma.

Multipurpose dam

The Panay B dam would be constructed to reduce flood flows downstream of the dam. The dam is conceived as a multipurpose dam with a power station equipped with 7,100 kW generating facilities.

Non-structural measures

(a) Flood plain management

In areas upstream of Panitan (flood vulnerable area 220 km^2), where flood control projects by structural measures will not be carried out for the time being, development should be regulated to avoid any increase in the risks of future flood damage. For areas downstream of Panitan too (flood vulnerable area 118 km^2), appropriate guidelines for development will have to be set since the proposed Short-term Plan will only give protection against a 10-year flood.

(b) Relocation of housing

Relocation of housing is initially proposed for two sub-areas; (i) the lower reaches of the Maayon river (sub-area Y1) and (ii) the middle reaches of the Mambusao river (sub-area M3, but excluding Mambusao town). Actual implementation should however be subject to further detailed survey to be included in the feasibility investigations in which the practicality of the plan would be examined on the basis of each building.

Flood forecasting and warning system

Advance information on incipient floods will be indispensable for efficient operation of structural and non-structural measures proposed herein. Flood forecasting by a stage-correlation technique is proposed as a provisional step. This would be replaced later by telemetered facilities. (See Figure 5.6-1 of maintext for location of the proposed facilities.)

(2) 2nd Stage work

River improvement

At this stage, the bankful capacity of the river channels would be increased (design discharge: a 25-year flood) in the stretches downstream of Panitan which would have been already improved under the 1st Stage Project. 16.0 km would be so improved including the Cogon floodway.

Polder dykes

Polder dykes would also be constructed at 3 towns/villages, i.e. Maayon, Jamindan and Dumarao.

(3) 3rd Stage work

The 3rd Stage works would protect almost all the flood vulnerable areas and thus raise the protection level up to the 100-year flood. The protective work would include:

(a) Enlargement of bankful capacity of channels improved in 2nd Stage (16.0 km):
This would raise the bankful capacity to accommodate a 100-year flood for the stretches improved in the preceding 2nd Stage work.

(b) Improvement of upstream reaches of main and tributary rivers (93.4 km):
Improvement work would be initiated in this stage for the river stretches previously left unimproved, i.e. (i) middle and upstream reaches of the Panay, (ii) lower reaches of the Maayon and (iii) lower reaches of the Mambusao river.

1.2 Irrigation Development

Panitan - Panay Irrigation Project

This plan would bring a total area of 3,250 ha under irrigation, by integrating the existing sporadic PIS's into one. The target yield was set at 5.0 ton/ha (paddy). A constraint inherent in the proposed development area is that the itself area is prone to flooding. Therefore flood control project in (1) above should precede implementation of the irrigation project.

Mambusao Irrigation Project

This project would aim to rehabilitate existing irrigation facilities and to expand arable areas along the lower reaches of the Mambusao river. The project covers an area of 2,145 ha in total. Like the Panitan - Panay irrigation area, this irrigation project is also located in a flood-prone area. However, evaluation revealed that the project would be feasible without providing specific measure for flood protection.

1.3 Roxas City Water Supply Plan

The Roxas City municipal and industrial water supply project proposed herein, has the following two objectives:

(a) The existing water supply facility suffers from contamination by sea water. The primary objective of this project would therefore be to solve this problem, by diverting the streamflow of the main Panay river to provide a source of uncontaminated water.

(b) The second objective would be to increase the capacity of existing facilities. The required water supply capacity in 1995 is projected to be 11,650 m^3/day, while the present supply capacity is 4,200 m^3/day. The proposed intake and transmission facilities would make available an additional 7,450 m^3 of water a day.

Due to the urgency of item (a), the work should be given priority for its early implementation.

1.4 Hydropower Generation Plan

The Panay B dam, which would be proposed as part of the 1st Stage work of the flood control project, could be completed by 1994. The power supply and demand balance indicates that the Panay Grid will be faced with a shortage in supply capacity around 1995. This would justify the commissioning of the Panay B power station by that date. The electric power generated at the Panay B power station would be transmitted to the Panitan substation (138/69 kV) and thus feed the Panay Grid. The installed capacity of the Panay B power station would be 7,100 kW, and the annual energy production would amount to 31.4 GWh.

2. Implementation Schedule

Selective staged implementation has been proposed for the flood control project; initially a 1st stage project, followed by 2nd and 3rd stage projects. The two latter would be realized when future damage potentials increase and the projects become economically viable (EIRR of more than 8%). The proposed implementation schedules, including those of other projects, are presented in the attached table.

3. Construction Cost Estimate

The total construction cost of the above proposed projects was estimated to be ₱5,820 x 10^6 at 1984 prices. Breakdowns by project are presented in the attached table.

4. Economic Evaluation

The economic viability of the proposed projects was evaluated based on costs and benefits assessed for each project. All the proposed schemes are deemed to be economically favourable projects, as represented by favorable economic indices (EIRR ranges from 8.1% to 25.7%). The results of evaluation are shown in the attached table.

5. Summary of Recommendations

In view of the economic viability of the projects and increasing social needs in the basin, follow-up action should be taken to achieve early implementation of the proposed projects. The next-phase studies which should be started at the earliest opportunity are:

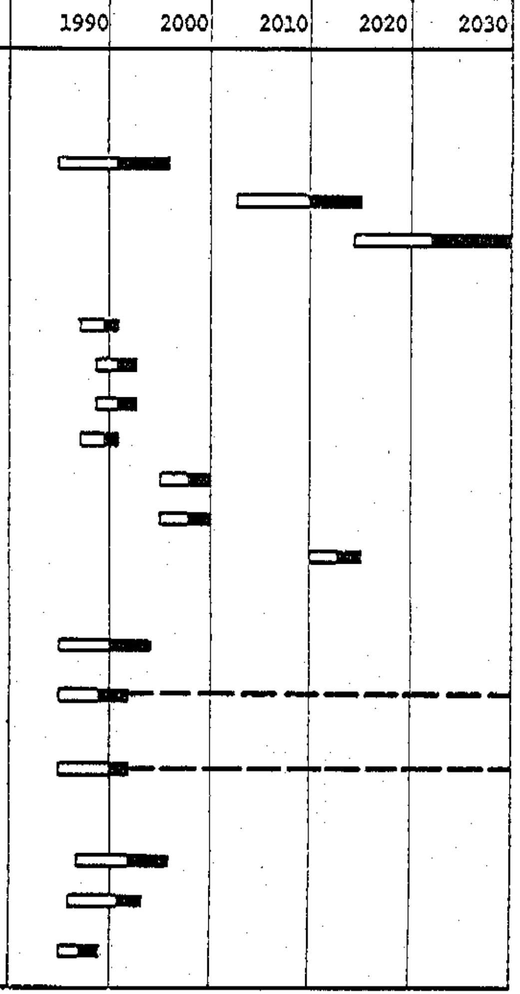
(a) A Feasibility Study of the 1st Stage Flood Control Project, including river improvement work, polders, Panay B dam, non-structural measures and flood forecasting/warning system.

(b) Detailed Design of Roxas City Water Supply Project

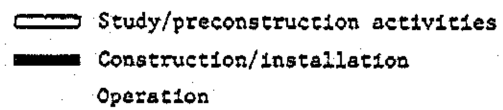
(c) Feasibility Studies of Panitan- Panay and Mambusao Irrigation Projects

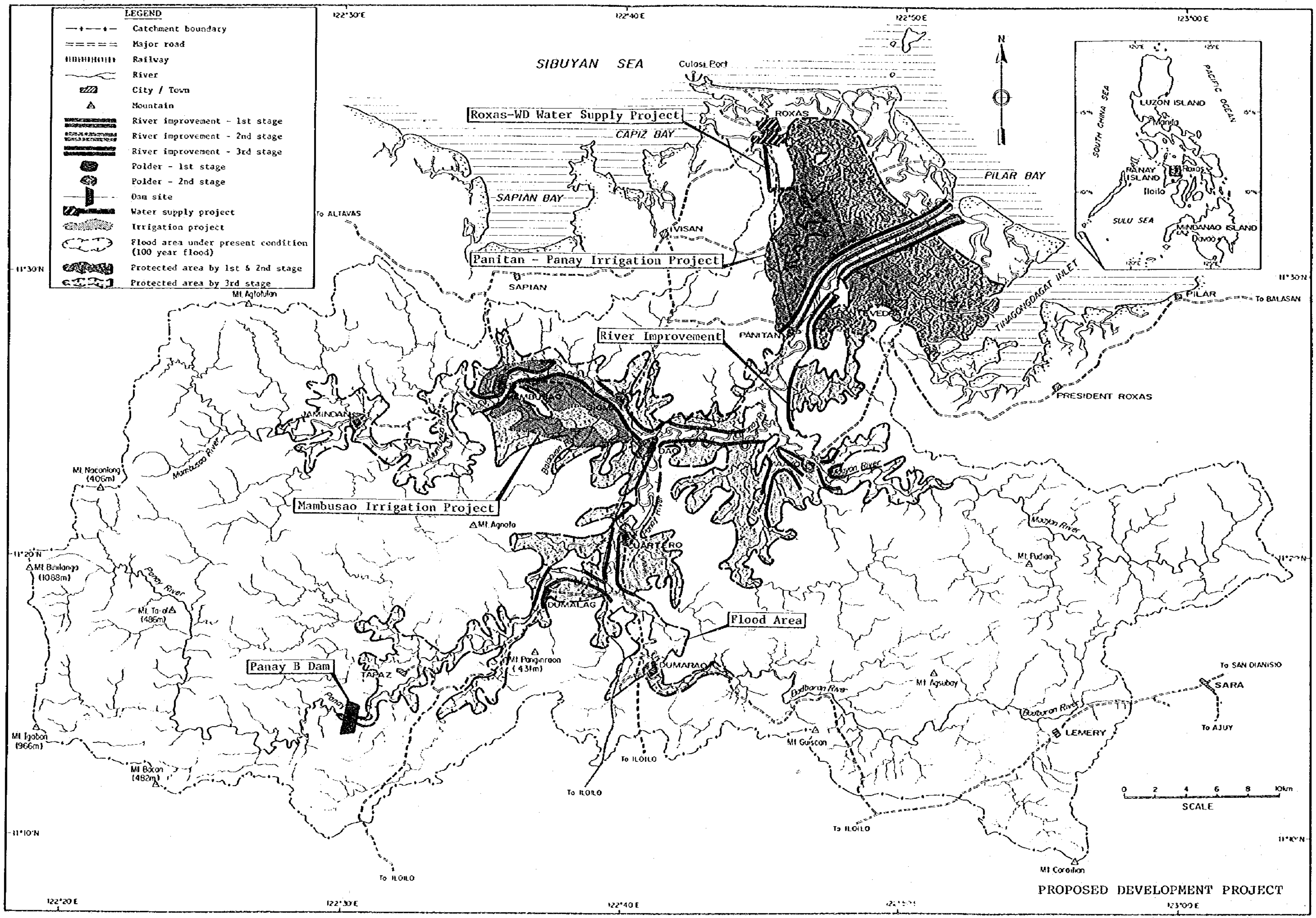
OUTLINE AND SCHEDULE OF PROPOSED DEVELOPMENT PROJECTS

Project	Description	Construction Cost (₱x10⁶ equiv) Total	FC	LC	EIRR (%)	Implementation Schedule (See Figure 10.2-1 for details) 1990 – 2030
Flood Control Project						
(1) River improvement work						
- 1st stage work	Improvement : 22.1 km	589	206	383	9.4	
- 2nd stage work	Enlargement : 16.0 km	440	154	286	9.8	
- 3rd stage work	Impr. & enlarge : 109.4 km	3,486	1,220	2,266	15.2 1/	
(2) Polder dykes						
- 1st stage Dao	Protection area : 1.17 km^2	55	27	28	12.7	
Cuartero	" : 0.49 km^2	57	29	28	25.7	
Sigma	" : 0.47 km^2	42	20	22	10.5	
Mambusao	" : 1.03 km^2	78	40	38	11.6	
- 2nd stage Maayon	" : 0.64 km^2	49	24	25	9.3	
Jamindan	" : 0.34 km^2	39	19	20	9.2	
Dumarao	" : 0.48 km^2	58	28	30	8.1	
(3) Multipurpose dam						
- Panay B dam	Hydropower : 7.1 MW, 31.4 GWh	471	277	194	11.2	
(4) Non-structural measures	Objective area : 328 km^2	51	-	51	9.6 2/	
(5) Flood forecast/warning system	Telemeter system : 1 lot	84	79	15	4.5 2/	
Irrigation Development						
- Panitan-Panay project	Irrigation area : 3,250 ha	183	108	75	11.7	
- Mambusao project	" : 2,145 ha	79	43	36	12.3	
Roxas city water supply project	Supply capacity : 7,450 m^3/day	56	38	18	16.9	



Notes : 1/ See para. 5.6 of Main Text for reason for high EIRR
2/ To be implemented irrespective their economic merits

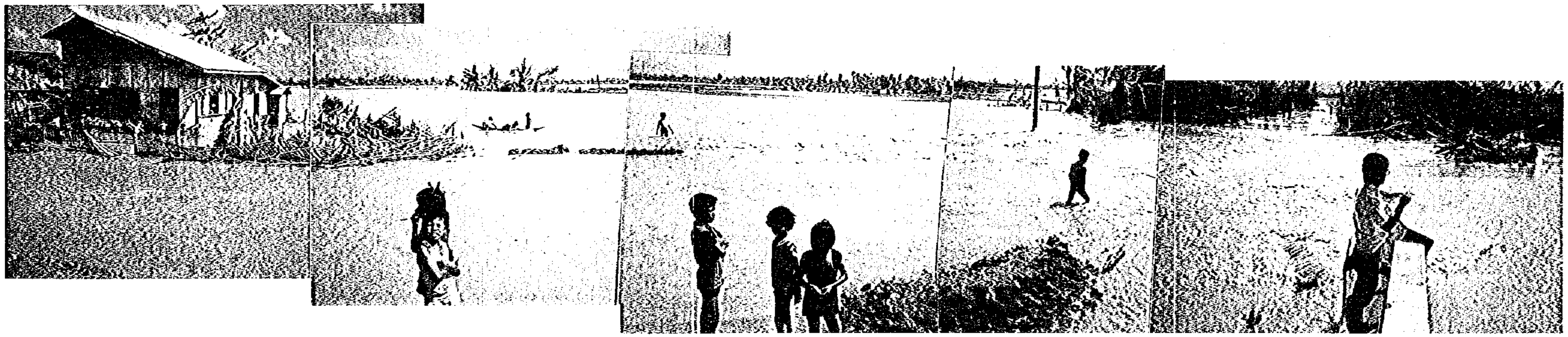




PROPOSED DEVELOPMENT PROJECT

1984 November Flood Photo No. 1 (taken on Nov. 6)

Typhoon "Undang" hit the Panay river basin on Nov. 5, 1984 and caused the flood with serious damage.
This picture shows the scene of submerged road connecting the two towns of Mambusao and Sigma and the surrounding paddy fields.
The water is flooded from the Mambusao river located on the left side of this picture.



1984 November Flood Photo No. 2 (taken on Nov. 8)

This picture shows a view of the submerged road connecting the two towns of Panay and Pontevedra and the surrounding paddy fields/ houses at Agbalo village. The water has overflowed from the Pontevedra river seen at the right side of this picture.

1984 November Flood Photo No. 3 (taken on Nov. 7)

This picture shows the scene of submerged road connecting the two towns of Panay and Pontevedra. The JICA jeep seen in the picture had to give up going to the Pontevedra town on the way due to the deeper water depth and high flow velocity.

1984 November Flood Photo No. 4 (taken on Nov. 9)

This picture shows the paddy fields along the Pontevedra river which are still submerged even 4 days after the typhoon attack.

MAIN REPORT

TABLE OF CONTENTS

Page

Page

Page

LIST OF TABLES

Table No.	Title	Page

LIST OF FIGURES

ABBREVIATIONS

ADB	Asian Development Bank
AKELCO	Aklan Electric Cooperative
AMC	Area Marketing Cooperative
ANTECO	Antique Electric Cooperative
BAEX	Bureau of Agricultural Extension
BCGS	Bureau of Coast and Geodetic Survey
BAECON	Bureau of Agricultural Economics
BPI	Bureau of Plant Industry
BS	Bureau of Soils
CAPELCO	Capiz Electric Cooperative
CAPLECS	The Law Enforcement Communication System
CIS	Communal Irrigation System
CY	Calendar year
DBP	Development Bank of the Philippines
EIRR	Economic Internal Rate of Return
EL	Elevation
F.C.	Foreign currency
EPA	Fertilizer and Pesticide Authority
F/S	Feasibility study
FSDC	Farm Systems Development Corporation
FWL	Flood Water Level
FY	Fiscal year
GDP	Gross Domestic Product
GNP	Gross National Product
GOP	Government of the Philippines
GRDP	Gross Regional Domestic Product
GVA	Gross Value-Added
HWL	High Water Level
HYV	High yielding variety
ILECO	Iloilo Electric Corporative
IRR	Internal Rate of Return
ISA	Irrigation Service Association
JICA	Japan International Cooperation Agency

KKK	National Livelihood Program
L.C.	Local currency
LBP	Land Bank of the Philippines
LRM	Local Resource Management
LWL	Low Water Level
LWUA	Local Water Utility Administration
MAR	Ministry of Agrarian Reform
MAF	Ministry of Agriculture and Food
MHS	Ministry of Human Settlement
MLG	Ministry of Local Government
MOH	Ministry of Health
MPW	Ministry of Public Works
MPWH	Ministry of Public Works and Highways
MWSS	Metropolitan Waterworks and Sewerage System
NASUTRA	National Sugar Trading 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 Agricultural Council
NIA	National Irrigation Administration
NIS	National irrigation system
NPC	National Power Corporation
NPCC	National Pollution Control Commission
NPV	Net Present Value
NSDW	National Standards for Drinking Water
NWRC	National Water Resources Council
OECF	Overseas Economic Cooperation Fund
O&M	Operation and maintenance
p.a.	Per annum
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PCARR	Philippine Council for Agriculture and Resources Research
PCIC	Philippines Crop Insurance Corporation
PECO	Panay Electric Company Inc.
PHILSUCOM	Philippine Sugar Commission

PIS	Pump irrigation system
RIS	River irrigation system
ROX-WD	Roxas City Water District
RWDC	Rural Waterworks and Sewerage Corporation
SCF	Standard Conversion Factor
SEAFDEC	Southeast Asia Fisheries Development Center
TWL	Tail Water Level

MEASUREMENTS

Length

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

Area

mm^2	=	square millimeter
m^2	=	square meter
km^2	=	square kilometer
ha	=	10^4 m^2 = hectare

Volume

lit	=	1,000 cm^3 = liter
kl	=	1 m^3 = kiloliter
m^3	=	cubic meter
lpcd	=	liter per capita per day

Time

sec	=	second
min	=	minute
h	=	hour
d	=	day
yr	=	year

Money

₱	=	Philippine Peso
US$	=	US dollar
¥	=	Japanese Yen

Electrical Measures

A	=	ampere
V	=	volt
kV	=	kilovolt
kVA	=	kilovoltampere
MVA	=	megavoltampere
W	=	Watt
kW	=	kilowatt
MW	=	megawatt
kWh	=	kilowatthour
MWh	=	megawatthour
GWh	=	gigawatthour
kWh/yr	=	kilowatthour per year
EHV	=	extra high voltage
Hz	=	Hertz (cycle)

Other Measures

%	=	per cent
0/00	=	per thousand
°	=	degree
'	=	minute
"	=	second
10^3	=	thousand
10^6	=	million
10^9	=	billion (milliard)
°C	=	degree centigrade
Kcal	=	kilocalorie
m^3/sec	=	cubic meter per second
pH	=	scale for acidity
ppm	=	parts per million (mg/lit)
PS	=	horse power
ton	=	metric ton
ton/ha	=	ton per hectare

LIST OF EXPERTS ASSIGNED FOR THE INVESTIGATION

ASSIGNMENT	NAME
Team Leader	H. Takahashi
Acting Team Leader	M. Kato
River Planning	T. Nishikawa
Hydrology & River Planning	H. Okada
Structural Design	T. Furukawa
Agriculture	M. Matsui
Agricultural Economy	K. Yamada
Irrigation Planning	H. Sekine
Irrigation Design	N. Nagano
Project Economy	T. Tashino*
Dam Planning	T. Tanaka
Geology & Groundwater	M. Yakou
Water Supply Planning	M. Kasuga**
Power Market Survey	Y. Tomiyama
Cost Estimation	E. Seki
Hydro Data Analyst	M. Ohuchi
Environment Assessment	M. Yanagibayashi***

Note; All the experts other than the following three experts are despatched from Nippon Koei Co., Ltd. (Consulting engineers).

* T. Tashino (Project Keizai Kenkyusho Co., Ltd.)

** M. Kasuaga (Chuo Fukken Co., Ltd.)

*** M. Yanagibayashi (Chiiki Kaihatsu Consultant Co., Ltd.)

CHAPTER I. INTRODUCTION

1.1 The Study

The Panay River basin is afflicted by floods almost every year. No effective countermeasures have been taken until today to alleviate damage from floods. The flood issue in the Panay River basin has long hampered the economic development of the basin area and hindered the livelihood of local residents.

With such a background, the Panay River basin was one of the river basins chosen for study in the "Nationwide Flood Control Plan" which was carried out from 1979 through 1982 to propose flood control plans for the twelve principal rivers of the Phillippines. As a result of this master plan study, the necessity for further study on flood control in the Panay River basin was confirmed.

The Government of the Philippines accordingly requested the Government of Japan to provide technical cooperation in undertaking the Panay River Basin-wide Flood Control Study (the Study), and the Government of Japan agreed.

The Scope of Work for the Study was agreed upon on December 17, 1982, between the Government of the Philippines and the Japan International Cooperation Agency (JICA), an executing agency to carry out the Study. The Study was completed by the end of July 1985.

The objective of the Study was to formulate an integrated water resources development plan for the Panay River basin. The Study covers various aspects related to basin water resources development, including investigation of socio-economy and hydrology, planning for flood control, agricultural development, groundwater development, multipurpose dam, water supply and land use. In the Study, particular emphasis was placed on the flood control aspect in view of its importance in the framework of the basin development plan.

Prior to this Study, another JICA project on the Panay river basin, completed in July 1984, has supervised topographic survey and had extended guidance in mapping. As its outcome, maps of 1 to 10,000 were produced covering all areas along the Panay river and its tributaries. These maps have greatly contributed to clarifying the extent of inundation areas and flood water levels, which constituted the basis of flood damage assessment and precise estimation of work quantities for protective measures. The intended level of accuracy of this Study would not have been realized if it could use only the previously available 1 to 50,000 maps. The topographic information contained in these maps was of importance not only for this Study but for subsequent planning stages for river channel improvement, irrigation development and road development, and for formulating other basin development plans in the future.

1.2 Reports

This report consists of the executive summary, the main report, thirteen appendices and two data books being contained in 8 volumes listed below.

- Executive Summary Report			
- Main Report			
- Supporting Report I	:	Appendix I	Meteorological and Hydrological Study
- Supporting Report II	:	Appendix II	Geology and Ground Water
		Appendix III	Flood Damage Study
		Appendix IV	Flood Control Plan
		Appendix V	Multipurpose Dam Plan
- Supporting Report III	:	Appendix VI	Agricultural Development Plan
		Appendix VII	Irrigation Development Plan
- Supporting Report IV	:	Appendix VIII	Water Supply Plan
		Appendix IX	Socio-economy
		Appendix X	Power Demand and Supply
		Appendix XI	Environmental Study
		Appendix XII	Construction Cost Study
		Appendix XIII	Additional Investigation on November 1984 Flood
- Data Book I			
- Data Book II			

The "Executive Summary Report" outlines the gist of the Team's investigations and recommendations. The "Main Report" presents the summarized results of all the studies. The "Supporting Reports" contain the details of respective sectoral studies including data, analyses and estimates. Aside from these reports, field data collected from meteo-hydrological and geological investigations are embodied separately in the "Data Books".

1.3 Acknowlegements

The Study Team wishes to express its heartfelt gratitude and sincere appreciation to all the concerned officials and staff of the government agencies for their substantial collaboration rendered during the course of the Study. In particular, the Team acknowledges invaluable assistance received from the Ministry of Public Works and Highways (MPWH) which was the counterpart executing agency in the Study.

Thanks are also extended for the cooperative responses accorded to the Team's activities in the field by MPWH regional directors and engineers as well by officials of other regional and provincial offices.

CHAPTER II. BACKGROUND

2.1 Need for Development

The Panay river mainstream is joined by its major tributaries (the Badbaran, Mambusao and Maayon rivers) in its middle reaches where an extensive flood plain is developed. These tributaries carry the runoff of occasional storms, causing inundation in the middle reach palin. The aggregated riverflow rushes downstream through meandering channels in the middle reach, until it drains into Pilar Bay. Due mainly to the meandering river channel and siltation near the estuary, the flow capacity of the lower Panay is not sufficient to accommodate the aggregated flood flow, and thus frequent inundation is caused in the downstream areas as well. Despite this flooding problem, the Panay river is still in its natural condition without any major river channel improvement works having been done or artificial dykes constructed, except for some revetment works provided in parts of eroded river banks.

Typhoons attack Panay island about once in every two years, causing heavy rainfall on the island. Most of the severe floods experienced in the Panay basin are concentrated in the typhoon period. These floodprone areas along the middle and lower reaches of the Panay are a centers of agricultural production and the major forms are concentration of economic activities. The flood issue in the Panay river basin has thus long been a constraint to the economic development in the area as well as to the stabilization of livelihood of local inhabitants. In preparing the basin development plan, it is therefore of primary importance to consider countermeasures against this flood problem.

Paddy fields are developed in widespread areas along the river but present paddy production remains at a low to moderate level (2.6 to 3.1 ton/ha). Productivity could be increased by providing systematic irrigation facilities. In this regard, irrigation development will be one of the aspects to be discussed in the basin development study.

Domestic and industrial water supply in the Panay river basin is still very limited. The largest existing supply system is the Roxas City Water District (ROX-WD). A problem of special importance is contamination due to intrusion of seawater into the intake site. Apart from this, new water sources will have to be explored to meet the increasing water demand. Improvement in terms of both quality and quantity of the water supply will be dealt with in this Study.

The ample streamflow of the Panay river, the result of abundant rainfall exceeding 3,500 mm in places, opens a good possibilities for hydropower development particularly in the western mountainous area along the upper Panay river. Development of hydropower will give impetus to stagnated electrical supply in the Panay island.

Taking into account the above development needs, the primary objective of this Study was to ameliorate the flood problems of the Panay river. A comprehensive flood control plan was therefore required for the core of the basin-wide development project, supported by and coordinated with considerations of other specific water resources development projects, such as irrigation development, water supply and hydropower generation.

2.2 Past Floods in the Basin

The Panay river basin has experienced 19 typhoons and 11 tropical storms during 36 years from 1948 to 1983, whereby flooding of varying extent has been caused. Notable flood events in the past decades occurred in November 1973, May 1976 and November 1984. The largest of these was in 1973 and caused by the Typhoon "Openg". This flood caused widespread inundation in the Panay river basin. The associated damage was reported to be ₱57.4 million at the 1973 price levels or ₱341 million at current (1984) price levels.

The flood in 1984, caused by the passing Typhoon "Undang", was another unforgettable flood event in the Panay river basin. The Undang flood caused extensive damage in the northern part of Panay Island. Inundation of the Panay river inflicted damage on 78,691 units of residential buildings in Capiz province. The total damage caused by the Undang flood was ₱247.6 million/1 at current price levels, more than half of which was afflicted on Capiz province.

The Undang flood was of special importance to the Study. The meteo-hydrological data concerning the Undang flood are by far better than for any other floods including the Openg. Analysis of flood hydrology would have been best achieved by the use of the Undang flood records but, because it took place near the end of the field investigation period, the draft final report of the Study could only make limited use of its data. Additional investigations, conducted in June 1985, assembled the data for flood hydrology and damage, such as rainfall, runoff, flood marks and inundation conditions, and the revised analysis of the Undang flood are reflected fully in this final report of the Study.

2.3 Recommendations in Previous Studies

2.3.1 Previous Studies

In connection with the development of the Panay river basin, there have been two previous studies, which provided valuable information for the present study. The were:

(a) Nationwide Flood Control Plan and River Dredging Program River Dredging Project (November 1982)

(b) Framework Plan of Western Visayas Region Panay River Basin (January 1977 by NWRC)

The two reports will be referred to as the "Nationwide Flood Control Plan" and "Framework Plan" respectively. Brief explanations of these reports are given hereinbelow.

/1 Based on flood damage estimation detailed in Appendix XIII.

Nationwide Flood Control Plan

The Study was made by Nippon Koei Co., Ltd. in association with Nikken Consultants Inc. and Basic Technology and Management Corporation commissioned by the Ministry of Public Works and Highways (MPWH).

One of the objectives of the Study was to formulate a nationwide flood control plan at master plan level for 12 selected major rivers in the whole country. The Panay river was one of these.

The study was made to a considerable depth in regard to flood control, but aspects such as water resources development such as irrigation, water supply and hydropower generation were out of the scope of the Study.

Framework Plan

This report was prepared by the National Water Resources Council (NWRC) to provide a broad framework for analysis of water and land resource problems in the Panay river basin and to establish guidelines for planners in developing a comprehensive river basin plan for the Panay river basin.

The report included basic information such as precipitation, streamflow, population, water requirement, land use, soil distribution and existing development plans. The information was quite helpful in this Study.

2.3.2 Outline of Plan Proposed in Nationwide Flood Control Study

In the report of the "Nationwide Flood Control Plan", the flood control plans for the Panay river were formulated as follows:

Basic Plan

The basic master plan proposed in the report assumed a design flood of a 100-year return period. The proposed plan was to protect the flood plain by embanking levees, improving river channels and constructing a flood control dam on the Badbaran river, a tributary of the Panay river.

In this plan, river improvement work was proposed along the channels of the Panay river except in the lower Panay, Badbaran Mambusao and the Pontevedra rivers.

First Phase Plan

The report recommended a stage-wise development of the above basic plan, in which the first phase plan assumed a reduced design flood of 25-year recurrence. The first phase plan was basically the same as the basic plan in regard to the proposed structures and the scope of improvement.

Of the proposed works, the report further recommended the early protection of downstream-most reaches (the Pontevedra river), which is the most frequently flooded area, as the first step of the First Phase Plan. The channel improvement of upper stretches and the construction of the Badbaran dam were proposed as second storage works.

These recommendations in the previous study were duly taken into account in preparing the present study.

CHAPTER III. PROJECT AREA

3.1 The Panay River Basin

The Panay river basin drains an area of approximately 2,181 km^2. It has a length of about 152 km along its mainstream. The basin is located on the northeastern part of the Island in the Western Visayas Region and encompasses almost the entire province of Capiz, with small parts lying within the provinces of Iloilo and Aklan. The basin is bounded on the south by the province of Iloilo and on the west by the Panay highlands which separate it from the province of Antique. The northwestern boundary is the Aklan province and in the north is Sapian Bay.

The upstream part of the Panay river basin is composed of the Upper Panay river mainstream basin and three major tributary basins, the Badbaran, Mambusao, and Maayon river basins:

The Upper Panay river rises in the high mountain range which constitutes the western water divide of the Panay river basin. The Panay river flows southward first, then changes its direction eastward and again northeastward.

The Mambusao river rises also in northern part of the high mountain range of the western water-divide of the Panay river basin, and flows eastward joining the Panay River near the town of Dao.

The Badbaran river rises in the eastern watershed, which is formed by low ranges of mountains with the highest elevation at about 500 m. The Badbaran river basin is very gentle generally in the southern part as opposed to the steep slope in the northern part. The Badbaran river flows westward, forming considerable meanderings in the low gentle plain.

The Maayon river, which flows westward joining the Panay river near Maayon, originates in mountain ranges elevated several hundred meters, which constitutes the eastern water-divide of the Panay river basin.

The middle reach of the Panay runs in a slightly dissected, meandering river channel. Along the stretches between the confluence with the Maayon and with the Mambusao in particular, the meandering river course has left numerous oxbows. The sub-basins along the middle and lower reaches of the Panay river are mostly a flat alluvial plain, devoted primarily to rice production. Natural levees are barely formed along the Panay river.

Near the estuary, the Panay river bifurcates into the Lower Panay and the Pontevedra rivers, about 5 km downstream of the town of Panitan. The river drains mainly into the Pontevedra, with only a small portion of the streamflow diverted into the Lower Panay. The lower-most stretch of the Pontevedra passes through artificial dykes in the fishpond area and branches off to the Hamulaoun river, before it flushes out into the sea.

Figure 3.1-1 presents the general location map of the Panay river basin.

3.2 Natural Conditions

3.2.1 Meteo-hydrology

The climate of the basin is classified as type III by PAGASA, which is characterized by a moderate deviation of the climatic condition through the year though the actual climate in the basin is somewhat different. The air temperature and relative humidity in the basin averages 27°C and 81% respectively, both with only small monthly deviations. Seen in detail, the three months from February to April are generally drier than the rest of the year, with a monthly rainfall of less than 100 mm, whereas the six months from June to November are wet, with a monthly rainfall often exceeding 200 mm. The three months in-between are transition periods. The annual rainfall in the Panay river basin is estimated to be 2,550 mm on a basin average, though it widely deviates from as high as 3,500 mm in the mountainous area near the western watershed to 2,000 mm in the southeastern area as shown in Figure 3.2-1. There are 16 rainfall gages in operation at present, dispersed quite evenly in the basin except in mountainous areas near the western and eastern water-divides.

The streamflow of the Panay river has been measured at 11 stream gauging stations, of which, 8 are in operation at present. At the bifurcation point to the Pontevedra river (catchment area 1,976 km^2), for example, the annual discharge is estimated to be $2,920 \times 10^6$ m^3, which corresponds to 92.6 m^3/sec of mean discharge. The dependable discharge (of 95% of firmness) at the same point is 16.2 m^3/sec. The location of the stream gauges are given in Figure 3.2-2.

Intensive rainfalls in the basin are mostly caused by passing typhoons. According to the past records, 19 typhoons visited the Panay Island during the 37-year period from 1948 to 1984, or in other words, once in every two years. Noteworthy typhoons, which caused remarkable floods in the Panay river basin, were the Openg typhoon in November 1973 and the Undang typhoon in November 1984. The Openg flood was probably the largest in the post-war period, with the estimated return period of 25 years. In the event of the Openg typhoon, 3-day rainfall was observed as 269.6 mm at Roxas city, 384.8 mm at President Roxas, 519.1 mm at Libacao (Aklan), and 665.5 mm at Culasi (Antique). The instantaneous peak discharge inducea by the flood was 1,420 m^3/sec at Cuartero.

The flood caused by the Undang typhoon in 1984 was slightly less intensive than the Openg flood. The flood event was assessed to correspond to 10-year recurrence. The importance of the Undang flood was that the outburst of the flood, including the heavy downfall of rain, was quite readily recorded in the meteo-hydrological observation network newly established in the Panay river basin. The observed 3-day rainfall was 104.0 mm at Roxas city, 163.6 mm at President Roxas, 138.0 mm at Libacao (Aklan), and 167.7 mm at Culasi (Antique). The instantaneous peak discharge of the flood was 1,080 m^3/sec at Cuartero and 1,450 m^3/sec at Panitan, and the above estimation of discharge is supported by the actual discharge measurement performed by the study team at the time of the flood. Concerning the inundation from streamflow, flood marks were collected throughout the river basin by hearings with local residents as part of the additional field investigations. The flood flow analysis and simulation of inundation in this report has been reconstructed based on the collected records of the Undang flood.

3.2.2 Geology

The Upper Panay and Mambusao basin areas are composed of moderately hard consolidated conglomerate, sandstone and siltstone of Oligocene - Miocene age. By contrast, the areas of the Badbaran and Maayon rivers are composed of andesitic volcanic breccia of Upper Miocene - Pliocene age and andesite of Oligocene age.

The middle part of the river basin is hilly with a low gentle topography. These hills are composed of moderately soft consolidated siltstone, claystone, sandstone and conglomerate of upper Miocene - Pliocene age.

In further downstream area, wide and flat cultivated lands are developed along the main Panay river channel. The area is composed of Quarternary alluvial and diluvial deposits.

In addition to the lithologic units stated above, several other types of rocks are also observed in the river basin. These rock units are limestone of Pliocene - Pleistocene age, moderately hard consolidated sandstone of upper Miocene - Pliocene age, and hard sandstone of Oligocene age.

Most of lithologic units in the Panay basin belong to the relatively young geological age. Rocks are generally moderately soft except for andesitic volcanic breccia, hard sandstone, hard conglomerate, and limestone.

The geological map of the Panay river basin is shown in Figure 3.2-3.

3.2.3 Groundwater Potential

In the Framework Plan by NWRC, the average annual precipitation over the Panay river basin is estimated to be 88 ltr/sec per square km. The calculated groundwater contribution on the Panay river and its tributaries is 25 ltr/sec per square km.

The balance of 63 ltr/sec is estimated to be evapotranspiration and surface and subsurface runoffs.

Along the main river channels, there develops a wide flat cultivated plain formed by alluvial deposits. As the alluvial deposits have been derived from weathered clayey materials, coarse deposits rarely exists in the area. The depth of alluvial deposits is about 10 m to 20 m in the middle reaches and about 30 m or more in the lower reaches.

The alluvial aquifers of the alluvial deposits develop over several kilometers in width in the middle reaches of the Panay river and in the lower reaches of the Mambusao and the Maayon rivers. A wide extending alluvial aquifer occurs in the areas of the lower Panay river and the Pontevedra river. However, the lower reaches of these areas are close to the coastal swamp area, where seawater intrusion is commonly observed.

Based on surveys of existing wells in the basin, the average static water level (groundwater level) is in the range of -0.3 m to -17.5 m below ground surface, mostly within a shallow depth of -5.0 m. The shallowest average static water level is -1.7 m below ground surface in the Panay town and the deepest average static water level is -5.6 m below ground surface in Dumarao. The groundwater level of the basin averages -3.0 m below the ground surface. In general, static water levels are at relatively shallow depths.

The existing wells are located mostly in the populated areas along the main tributaries of the Panay river, such as the towns of Tapaz, Dumalag, Dumarao, Cuartero, Dao, Sigma, Panitan, Mambusao, Jamindan, Maayon, Pontevedra, Panay and the Roxas city.

According to the summary of the inventory survey on the existing wells only about 50 wells out of 108 inventoried wells supply water are acceptable for drinking purpose. The remaining wells yield water of low quality, such as salty taste, foul smell, or coloured, etc. The chief reasons for the low water quality are malfunctioning aquifers containing silt materials, pollution by sewage water, insufficient natural filtration and so on. Seawater intrusion is one of the causes of salty taste of water. During the survey, this was confirmed in 15 wells, especially in the area of the lower Panay and the lower Pontevedra.

Judging from the result of surveys stated above, the potential of grounwater exploitation is concluded to be poor due mainly to its quality. A large scale development of groundwater will not be prospective, although minor exploitation will still be possible as water sources for local or private uses.

3.3 Land Use

3.3.1 Present Land Use in the Panay River Basin

The present conditions of land use in the Panay river basin were clarified by use of aerial photographs at a scale of 1/20,000 taken in 1983. The areas and proportions of each land use item are summarized below. Table 3.3-1 gives the details of land use categories by province, city and municipality concerned in the Panay river basin. The schematic land use map of the basin area is presented in Figure 3.3-1.

Land Use in Panay River Basin

Land Use Category	Area (ha)	Proportion (%)
Paddy	40,960	19
Sugarcane Upland crops	48,530	21
Orchards (Coconut)	7,740	4
Pasture/Grassland	8,410	4
Scrub	86,730	40
Forest	11,880	5
Marshes/Swamps	1,850	1
Fishponds	10,560	5
Builtup area/Village yards	1,540	1
Total	218,200	100

As seen in the table above, agricultural land uses account for 48% of the total basin area, while 45% of the area is covered with shrub and forest, without any intensive use. Industrial or commercial land uses are only negligible in terms of the area.

The alluvial plain is principally cultivated for production of rice. The uplands and rolling areas are adapted to diversified farming, particularly of sugarcane and upland rice, or to grazing. The mountainous areas are covered with secondary forests of scrub, resulted from slash and burn agriculture. Almost all the fishponds constructed on the low-lying land along the seashores were exploited on original marshes or swamps, parts of which still exist in a limited scale.

(1) Agricultural land use

Rice is the main crop in the basin. Paddy fields occupy an aggregated area of 40,960 ha or 19% of the basin total, which are mainly distributed on the alluvial plain along the middle and lower reaches of the Panay. In the municipalities of Dao, Dumarao, Mambusao and Panay, paddy cultivation forms the staple land use. Double or triple cropping is widely practiced.

The area developed for cultivation of sugarcane and upland crops is estimated at about 48,530 ha or 21% of the basin total. The planting of sugarcane is concentrated in the municipalities of Dumarao, Maayon and Tapaz. Small scattered plantings that cannot be indicated separately on a small-scale map are also found widely in the basin.

The areas covered with coconut are 7,740 ha or 4% of the basin total. They are situated mostly along the shores and in home yards.

(2) Other land use

Fishponds occupy an aggregated area of 10,560 ha or 5% of the basin total, 30% of which is for prawn and 70% for milkfish. Fish culture is conducted more intensively than in other regions in the Philippines.

Scrub extends widely over the elevated slopes, and is the largest constituent in terms of its proportion. Most of the scrub land demarcated here is not suitable for future agricultural development mainly because of erodability of soil. However, scrub plays an important role in soil and water conservation.

The built-up areas are still very small in proportion to the total area of the basin, accounting only for 1% of the area: Commercial and industrial land uses are negligible. The land uses for residential, commercial and industrial purposes will certainly expand in the future, as the population of the basin grows and the regional economy develops.

3.3.2 Present Land Use in the Flood Vulnerable Area

The areas along the middle and lower reaches of the Panay river are prone to inundation, due mainly to the inadequate capacity of the present river channel, as stated in preceding Chapter II. The areas that would be inundated by 5- and 100-year floods are shown in Figure 3.3-2.

The flood vulnerable area is defined in this Study by the areas that would be inundated by the 100-year probable flood, under the present conditions of the river. The flood vulnerable area covers the lowlands along the coast, the alluvial plains along middle and lower reaches of the Panay river and the areas along the lower reaches of the Mambusao and Maayon rivers. The flood vulnerable area encompasses a total area of 338 km^2, which accounts for 15% of the basin area or about a quarter of the usable area, and is inhabited by 121,300 of residents, or 27% of the basin population. The population and land use of the flood vulnerable area are shown in the table below:

Population and Land Use of Flood Vulnerable Area

Item	Basin Total	Flood Vulnerable area	Percentage (%)
Population	447,800	121,300	27.1
Area (ha)			
- Paddy field	40,960	18,944	46.3
- Sugarcane	48,530	3,849	7.9
- Fishpond	10,560	1,137	10.8
- Others	114,760	9,886	8.6
Total	218,200	33,816	15.5

The flood vulnerable area includes 18,944 ha of paddy fields, which are widely distributed on the alluvial plains along the river. The paddy fields in the flood vulnerable areas above account for 46% of all the paddy fields in the river basin. Since rice production in this basin is the primary economic activity that sustain the regional economy, the protection of farmland, particularly paddy fields, from flood damage should be given a special importance.

The sugarcane in this basin is cultivated at high elevations, and, therefore, the area of sugarcane fields that falls in the flood vulnerable area is only 3,849 ha or about 8% of the basin total.

Some 1,137 ha, or 11% of the basin total of the fishponds, are included in the flood vulnerable area, which are exploited almost exclusively near the estuary. The fishponds are dyked, and extensive inundation is unlikely to take place, unless the seawater should extraordinarily rise due to a storm surge.

In order to clarify the regional distribution of the land use pattern in the areas that would be inundated by floods, a more detailed study was made by using a systematic mesh map. Table 3.3-2 presents the land use of areas inundated by 100-year floods, by 23 river stretches or sub-areas which are established to clarify the regional distribution of flood damage. The divisions of the sub-areas are shown in Figure 3.3-3. As seen from the table, paddy fields would be the largest land use category in all the upper, middle and lower basins. Inundation of paddy fields is particularly significant in lower and middle reaches of the Panay river (Sub-area P1, P5 and P8) and in the Balacuan sub-basin area (Sub-area M7). A large proportion of the sugarcane occurs in the middle to upper areas along the Panay river. Fishponds are almost exclusively found in the downstream-most Pontevedra area (Sub-area P1). The land use pattern in the flood vulnerable area is shown in detail in Figure 3.3-4.

3.4 Socio-Economy

3.4.1 General

Approximately 90% of the Panay river basin, 2,181 km^2 in total area, belongs to the province of Capiz and the remaining 10% belongs to the provinces of Iloilo and Aklan. The Capiz province consists of the city of Roxas and 14 municipalities among which 12 municipalities are situated wholly or partly in the river basin. Capiz, Iloilo and Aklan belong to Region VI (Western Visayas), administratively.

Region VI, comprising two principal islands, Panay and Negros, covers an area of 20,223 km^2. It is made up of five (5) provinces; Aklan with an area of 1,818 km^2, Antique with 2,522 km^2, Capiz with 2,633 km^2, Iloilo with 5,324 km^2 and Negros Occidential with 7,926 km^2. The former four (4) provinces are located on the Panay Island and the last on the Negros Island.

3.4.2 Population

According to the 1980 census by NCSO, the population within the Panay river basin was 447,844, while the population in the same census of the Capiz province was 492,231. The majority of the population within the basin are Capiznons and the remainder Ilongos. Among 73 provinces of the Philippines, Capiz ranks 34th in terms of population.

The average annual growth rate of the population in the province of Capiz during 1970 - 1980 was calculated to be 2.37%, compared with 2.25% for Region VI and 2.75% for the whole country. The growth rate of the basin population is lower than that of the whole country, but slightly higher than that of Region VI.

In the river basin, the population of productive ages, namely those in 15- to 64-year age group, was 52.2% of the total population in 1980. As for the whole country and Region VI, it was 54.6% and 53.6% respectively. Although the population of the productive age group in Capiz is increasing year by year, the percentage to the total population is still lower than those of the country and in Region VI.

In the Philippines, agriculture and its related industries provide more job opportunities for the labor population than other industrial sections. The sector absorbed 67.2% of gainful workers in Capiz in 1980, while the sector of the country and Region VI absorbed 51.4% and 60.5% of the gainful workers in the same year respectively. Therefore it is said that the basin economy depends more on agricultural activities than in other areas in the country.

The population density was 186.9 persons per km^2 in 1980. This was larger than 160.3 persons per km^2 for the whole country and was smaller than 223.8 persons per km^2 for Region VI. In Capiz, the population in the urban areas was 13.5% of the total population. As for the urban population, Capiz ranks 66th among 73 provinces. The average number per family in the basin was 5.7 persons in 1980, compared with 5.6 persons for the whole country and 5.8 persons for Region VI, in the same year.

The future population in the basin is projected to be 573,000 in 1990, 699,000 in 2000 and 825,000 in 2020 as shown in Table 3.4-1. Average growth rates during 1980 - 2000 and 2000 - 2020 are calculated as 2.1% and 1.0% respectively. Future family size is projected to decrease from 5.7 persons in 1980 to 5.1 in 2020.

3.4.3 Gross Regional Domestic Product

GRDP (Gross Regional Domestic Product) of Region VI amounted to ₱8,288 million in 1983 at the 1972 constant prices. This accounted for 8.3% of GDP of ₱100,125 million for the nation. Among the GRDP of Region VI, ₱3,171 million (38.3%) was contributed by the agricultural sector, ₱2,380 million (28.7%) by the industrial sector and ₱2,737 million (33.0%) by the services sector.

The per capita GRDP of Region VI in 1983 ammounted to ₱1,691 at the 1972 constant prices, which corresponded to 87.8% of the per capita GDP of ₱1,927. On the other hand, the per capita GRDP in 1983 at current prices was ₱5,952, which corresponded to 81.2% of the per capita GDP of ₱7,330. This implies that development in Region VI is slightly sluggish, compared with that in the nation.

NEDA prepared a projection of GRDP in Region VI in June 1984, although it covered only a 5-year period from 1983 to 1987. Since there is no pertinent long-term economic projection, future GRDP was estimated in this Study by assuming that it would grow in proportion to GDP. In the Study, the functional relationship between GDP and GRDP was assumed to be linear, based on past data. GRDP in Capiz was also assumed to change in proportion to GRDP in Region VI. Results of the projection are given in Table 3.4-2.

It is assumed that after 1992, GDP of the Philippines will grow at a rate of 6.5% per annum on an average. Based on Table 3.4-2, however, GRDP in Region VI will grow at a somewhat smaller rate than GDP. Although per capita GRDP in Capiz is relatively high compared with that of other provinces in Region VI as shown in the table, it is still low compared with the per capita GDP in the country.

3.4.4 Industries in the basin

(1) Agriculture, fishery and forestry

Paddy

Paddy is a staple product of Capiz. In 1981, the paddy production in Capiz was approximately 275,000 tons, corresponding to 21% of the regional production (1,273,000 tons) and 3.5% of the national production (7,723,000 tons). This shows that Capiz is an important rice producer in Region VI and in the country.

Sugarcane

Sugarcane, one of the major products for foreign currency earnings, is a principal product of Region VI. Sugarcane production in the Region in 1981 corresponded to about 27% of the total production in the country. Capiz also produces sugarcane as one of the principal crops in the province. However, the percentage of sugarcane production in Capiz to that of the Region is only 4%, and therefore, the role of Capiz in sugarcane production is relatively small.

Corn

Corn is an important crop, second to rice among cereals, especially during the lean months of the year. Although corn production in the

Region in 1981 was only 2% of that in the whole country, about 16% of its production comes from Capiz.

Other crops

The share of banana and other fruits produced in the Region is about 10% of the national production. The fruit production in Capiz, however, is only 5% of the regional production. The production of other crops except banana is relatively small, and most of them are for self-consumption.

Livestock and poultry

Livestock and poultry raisings are important industries in the economy of Capiz. However, most of the production is carried out on a small scale. Among the livestock, carabao is used not only for meat but also for farm labor.

Fishery

Fishery is also a significant industry for the Region. In 1981 its production amounted to 277 million tons, corresponding to 17% of the national production. In the same year, the production in Capiz was 16 million tons, corresponding to 6% of the regional production. Most of the production in Capiz depends on inland fishery, and Capiz produces 29% of the regional production on inland fishery.

Forestry

In the region, the production of logs and lumber has decreased year by year due mainly to shortage of exploitable stock, and in addition, the world recession has brought decrease in the export demand. Capiz hardly produces logs and lumber, and is not likely to produce them in future.

(2) Industry

The development of manufacturing industries in Capiz has been very slow. There are only two manufacturing industries with more than 100 employees in Capiz in 1978, which consist of two (2) sugar refineries; one at President Roxas and the other at Dumalag. Enterprises other than the above are small scale industries with 5 to 99 employees or cottage industries employing 1 to 4 people. They are food processing, wood products, furniture, shoemaking, shellcraft, bamboocraft, metalcraft, garment sewing and the like.

Future development in Capiz would involve agricultural diversification to stabilize the regional economy. The diversification would encourage agri-business industries, which depends basically on two crops; rice and sugarcane. The future development should also promote small and medium-scale industries that would generate labor intensive employment.

3.4.5 Transportation

As of 1982, the total length of roads in Capiz are 2,469 km under the following distribution; 11% or 285 km of national road, 19% or 467 km of provincial road, 33% or 819 km of municipal road and 36% of 898 km of barangay road. The road density is 0.46 km per ha.

Capiz has only one port, the Culasi port. It has a 55.5 m x 12.0 m pier with a 9.0 m warf and the depth of water is 7.5 m. Capiz has only one airport, which is regularly servicing one flight a day between Roxas city and Manila, and some other local flights. Panay Railways has a main-trunk of 116.6 km running through the provinces of Capiz and Iloilo.

3.5 Flood Problem and Flood Damage Estimate

3.5.1 Present River Condition and River Characteristic

The Panay river is a natural river without any major river channel improvement work or artificial dykes, except for some revetment works provided in parts of eroded river banks. The river in the middle reaches runs in a channel slightly dissected from the ground surface, but natural levees are rarely formed along the Panay river.

In the stretch between the confluences of the Panay with the Badbaran and Maayon rivers, numerous meanderings have been formed that constrain the carrying capacity of the stretch below 500 m^3/sec. By contrast, between the confluence with the Maayon and the town of Panitan, the bed slope is very gentle (about 1/19,000), but meanderings are relatively few as compared with the above stretch. The Panay river bifurcates into the

Lower Panay and Pontevedra rivers at the branch point near the village of Paslang. With the Lower Panay river considerably silted and incapable of carrying a large streamflow, the Panay river mainly drains into the Pontevedra river. The Pontevedra river has an almost elevated riverbed, with its river mouth built up with sediment and clogged. The capacity of the river is estimated to be less than 500 m^3/sec.

The chief features of the Panay river such as the flow capacity, channel width and depth, and bed slope are shown in Figure 3.5-1. It is clearly seen in the figure that the flow capacity of the river is less than a 2-year flood discharge in most of the reaches.

3.5.2 Flood Characteristic

The principal flood characteristics inherent to the Panay river basin are the widespread area and prolonged duration of induced inundation. As discussed in Subsection 3.3.2, the area inundated by a 100-year flood (flood vulnerable area) would account for 15% of the basin area of 338 km^2 in total area. The people residing in the area numbers 121,300, or 27% of the basin population. Even in the event of minor floods, the inundated area and affected population would not be significantly decreased.

Furthermore, the inundated water stays in the basin for a prolonged duration. In the case of the Undang flood, for instance, the duration of the resulted inundation was one week and in places even as long as two weeks. One of the reasons for the prolonged inundation in the Panay river basin is that the topography near the Panitan town makes a natural drainage bottleneck of inundated water. The river section near the Panitan town is bounded by hills on both banks with about 300 m width, and the backwater extends from this point upstream in the event of large floods. The inundated water in the areas upstream of this reach forms a very gentle and affluent flow. Bottleneck sections also exist near towns of Dao and Cuartero

The flooded water that has passed through the bottleneck section of Panitan is once again dispersed to the lowlying plain below, and causes inundation in the lowlying Panay - Panitan area. The inundated water in this area is gradually drained into the estuary inlets.

The prolonged submergence of areas under the inundated water, due to the bottleneck and maldrainage in the downstream-most plain described above, inflicts considerable losses of properties in the inundated areas.

3.5.3 Existing Flood Records

Among the past floods, the largest flood experienced in the Panay river basin was the Openg flood, which occurred in November 1973, and the second largest the Undang flood in November 1984. The records of flood hydrology and damage, particularly of the Undang flood, were sufficient and practicable for use in flood runoff analysis and its verification.

(1) Inundation area of Openg and Undang floods

The flood peak discharges of the 1973 (Openg) and 1984 (Undang) floods were respectively estimated at 1,420 m^3/sec and 1,080 m^3/sec at Cuartero. Probability analysis revealed that the Openg flood corresponded to a 25-year flood, and the Undang flood a 10-year flood. The inundation area in the event of the Undang flood, which was estimated on the basis of hearing of flood marks during the additional investigation, is shown in Figure 3.5-2. The total area of the inundation was some 250 km^2.

(2) Flood damage

The flood damage caused by the Openg flood was estimated in the Nation-wide Flood Control Plan, based on the results of questionnaires. The estimated flood damage was ₱57.4 x 10^6 at the price level of 1973, or ₱341 x 10^6 at the current (1984) price level.

Information on flood damage afflicted by the Undang flood was collected during additional investigation performed in June 1985. The estimated flood damage was ₱247.6 x 10^6/1 at the current (1984) price level. Of the assessed flood damage, ₱115.9 x 10^6 was inflicted on crops, about 86% of which was on paddy. Building and infrastructure damages contributed ₱90.1 x 10^6 and ₱31.9 x 10^6 respectively.

/1 The figure was derived from flood damage statistics prepared by the government agencies, with minor corrections and adjustment by the study team.

3.5.4 Preparatory Investigations

At the time of the previous study, "Nationwide Flood Control Plan", topographic information available for the analysis consisted only of 1 : 50,000 maps with contours at 20 m intervals and river cross sections at about 6 km intervals on an average. This insufficiency of topographic information was the main constraint for making flood damage estimation with proper accuracy.

Another JICA project, aiming to produce the topographic maps of 1 to 10,000 scale, was duly completed in July 1984. The topographic information contained in these maps was of great importance in the assessment of flood damage potential, estimation of construction costs and planning of facilities in this Study, and will continue to be of importance in the further planning stages. The project conducted:

1) Aerial photography

   Aerial photographs were taken at a scale of 1 : 20,000, covering the whole Panay river basin (area; 2,300 km^2).

2) Preparation of topographic maps

   Topographic maps of the flood plain area (area; 700 km^2) were prepared at a scale of 1 : 10,000 with contour intervals of 2 m from the above photographs.

3) River profile and cross section survey

   The topographic surveys covered the Lower Panay river, the Pontevedra river, the Panay mainstream up to the point about 10 km upstream from Badbaran junction, downstream portion of Maayon and Badbaran and Mambusao up to the point about 25 km upstream of Panay junctions. The interval of the cross sections are about 3 to 5 km and the surveyed width are about 1 km.

3.5.5 Flood Flow Analysis

(1) Method of flood flow analysis

A flood flow analysis was made to estimate probable flood runoffs with different return periods from past rainfall records, and to estimate the flood water level and possible inundation conditions in the river basin. In the Study, a river system model was built and used for flood runoff calculation with the aid of an electronic computer. The major steps of the analysis are shown below.

a. Construction of a river system model,

b. Estimation of probable basin rainfalls with different return periods,

c. Estimation of probable flood runoff from each sub-basin with different return periods,

d. Flood routing along the river course, and

e. Estimation of flood water levels and duration.

The river system model is schematically shown in Figure 3.5-4. The river system model was calibrated by rainfall, flood flow and flood mark data of the Undang flood in November 1984, with supplementary use of the Openg flood in November 1973.

(2) Records used for flood flow analysis

The Openg flood which took palce in 1973, was the largest flood event in the post-war period, and on this account, it would have been the most suitable flood on which to base the flood flow analysis. Unfortunately, most of rainfall stations in the Panay river basin were only installed in or after 1976, and there is only very limited rainfall data for the floods prior to this period.

Typhoon Undang caused extensive inundation in the Panay river basin in November 1984. This flood is considered to have been the second largest flood event in living memory, and caused severe flood damage comparable to that of the Openg flood. Since the flood took place while the Study team was still based in the Philippines, first hand information concerning the flood hydrology was collected. Additional field investigations in June 1985 provided further information, including flood marks in widespread inundation area and records of damage, through field visits and hearings.

The data assembled for flood flow analysis was thus as follows:

- Daily (inclusive partly of 6-hourly) rainfall records at ten stations in the Panay river basin,
- Water level records at six stream gauging stations on the Panay river,
- Flood marks at 30 location along the Panay river and its tributaries,
- Hearing results of highest water level and duration of inundation at 250 locations,
- Discharge measurements at the Panitan station, based on which the stage-discharge rating curve applicable to floods could be constructed,
- Course of Typhoon Undang, with velocity and air pressure recorded at the Roxas city, and
- Records of each damage item.

On account of availability of precise and detailed data on flood hydrology, the Undang flood was employed chiefly for calibration of flood flow analysis. The data of the Openg flood in 1973 were used to verify and supplement the simulation results.

(3) Estimate of probable floods

Consequently, the distribution of flood flow for varying probable recurrences was estimated as shown in Figure 3.5-5. Based on the water level estimates at each base point, the inundation condition for 5-, 25- and 100-year floods were assessed, as shown in Figures 3.5-6 to 3.5-8.

Table 3.5-1 summarizes the estimated area and number of housings susceptible to flooding by varying probable floods.

3.5.6 Estimation of Flood Damage

Flood damages were estimated in this Study for the following 6 major categories, i.e. 1) crop, 2) livestock, 3) building, 4) fishpond, 5) infrastructure and 6) indirect damage. The two major categories, crop damage and building damage, were further subdivided into the following sub-categories:

Crop damage

- Irrigated paddy
- Rainfed paddy
- Vegetables
- Sugarcane

Building damage

- Residential buildings
- Household effects
- Non-residential buildings
- Inventory stocks

Each item of flood damage was assumed to increase in future in accordance with the population increase, enlarged economic activities and improved agricultural production due to advanced technology. The detailed procedure for estimating each item of flood damage is shown in Appendix III.

The flood plain was divided into 100 m squares. Flood damages were assessed square by square and consolidated by sub-river basins shown in Figure 3.3-3. The inundation condition of each square was estimated by relating the elevation of specific squares to water levels calculated from the flood flow analysis.

First, flood damages were assessed in each damage category for different probable floods, and for several years in the future. After this the average annual flood damage was assessed for 1984 and in future years.

The estimated damage values in 1984, 2009 and 2029 are shown in Tables 3.5-2 to 3.5-4.

3.5.7 Analysis of Flood Damage under Present River Condition

The results of the estimated flood damage may be summarized as follows:

(i) Even a small flood (5-year flood) will cause deep inundation in the areas along the middle reaches of the main river downstream of Dumalag to the confluence with the tributary Maayon and in the paddy field area south of the downstream reaches of the tributary Mambusao. In other words, crop damage in the above areas would be large even in the face of a small flood (5-year flood).

(ii) Larger floods will extend the above deep inundation areas downstream as far as the Pontevedra town. In this case the associated crop damage in the Panitan-Panay area would increase conspicuously.

(iii) Damage to buildings is the most prevalent damage item followed by crop damage. Damage to buildings increases sharply as the size of inflow flood increases.

(iv) Damage to buildings is concentrated in a limited number of towns along the mainstream and major tributaries such as Dumarao, Dumalag, Cuartero, Maayon, Mambusao, Sigma, Panitan and Pontevedra. Most of the above are located in the middle reach area.

3.6 Agriculture and Irrigation Development

3.6.1 Present Land Use

The main crops grown in the Panay river basin are rice, followed by sugarcane. Paddy fields occupy a total area of 40,960 ha or 19% of the basin area. Upland crops presently cultivated are maize cassava, sweet potato, etc. Other crops grown as adjuncts to paddy farming are leafy vegetables and beans.

3.6.2 Paddy Yield and Production

Paddy yield and production under the present conditions were estimated on the basis of production data at municipality level obtained from the Bureau of Agricultural Economics and the Ministry of Agricultural Economics, both in Roxas. These data were confirmed and adjusted through crop yield surveys at the farmer's field level conducted by the Study Team. Based on these data, average yields of paddy are about 3.2 tons per ha for irrigated paddy and 2.8 tons per ha for rainfed paddy with some deviations from year to year due to natural calamities such as drought and flood.

3.6.3 Existing Irrigation Development

There are at present ten National Irrigation Systems (NIS) on the Panay Island but only one NIS in the river basin, located at Mambusao, with an irrigation service area of 1,440 ha. Apart from the Mambusao River Irrigation System (RIS), there are many Communal Irrigation Systems (CIS), Pump Irrigation Systems (PIS) and other private irrigation systems covering about 8,580 ha out of the total paddy field of 40,960 ha in the river basin.

Construction of irrigation and drainage facilities on the NIS is carried out by NIA. Operation and maintenance works of the system are also carried out by NIA. CIS have an irrigation service areas totalling less than 1,000 ha. Irrigation and drainage facilities are constructed by NIA, but operation and maintenance works are carried out by the farmers themselves.

The Mambusao RIS was initially established in 1975 to irrigate about 780 ha during the dry season in crop year 1977 - 78. The system was expanded in 1979 to supply irrigation water to 1,440 ha and 780 ha during the wet and dry seasons respectively.

There are 23 CISs in the river basin which irrigate approximately 2,200 ha of paddy field.

54 PISs have been constructed in the river basin and are operated under the Farmer's System Development Corporation (FSDC); and 169 PISs have been constructed by NIA and operated by private owners. The potential service areas of PIS under FSDC is 3,460 ha and that of PIS operated by private owners is 1,490 ha.

The locations of the Mambusao RIS and CIS are shown in Figure 3.6-1. The location of PIS under FSDC is illustrated in Figure 3.6-2.

3.7 Public Water Supply

Based on the 1980 Census of Population and Housing in Capiz, only 8,230 households or 9.5% of the total households were served by public water systems as shown below.

Public Water Supply in Basin
(1980)

(households)

Service Level		Total		Urban		Rural	
Public Water Systems	Level I	3,130	(3.6%)	368	(3.2%)	2,762	(3.7%)
	Level II	2,331	(2.7%)	1,360	(12.1%)	971	(1.3%)
	Level III	2,769	(3.3%)	2,064	(18.4%)	707	(0.9%)
	Sub-total	8,230	(9.5%)	3,790	(33.8%)	4,440	(5.9%)
Other Systems	Community Water System	665	(0.8%)	290	(2.6%)	375	(0.5%)
	Others	77,545	(89.7%)	7,128	(63.6%)	70,417	(93.6%)
	Sub-total	78,210	(90.5%)	7,418	(66.2%)	70,792	(94.1%)
Total		86,440	(100.0%)	11,208	(100.0%)	75,232	(100.0%)

Notes: Level I - A point source, usually a protected well or a spring with an outlet, with no distribution system.

Level II - Level I plus a communal faucet system.

Level III - A piped system with individual house connections.

Others were served either by private water systems or by other individual sources such as wells, springs, rivers, etc.

Of the households served by the public systems, 3,130 households or 3.6% of the basin households are covered by Level I facilities built by MPWH. The Capiz Engineering District of MPWH has constructed 450 systems of Level I facilities such as shallow wells and deep wells in the past three years. Therefore more than 15,000 households are presumably served by the public water systems of Level I by the end of 1984, provided each Level I system is expected to cover around 30 households.

There are 37 water supply systems of Level II, which were constructed by MPWH during the last three years. Although only 2,331 households were covered by Level II in 1980, more than 7,000 households are presumably served by Level II systems at the end of 1984, on condition that each Level II system would cover an average of 200 households.

The municipalities in the Panay basin have public water-works systems of Level III in urban areas. Of the 17 municipalities, however, only the following 6 water-works systems were functioning at the end of 1984 as shown in Table 3.7-1, Roxas City Water District, Pilar Water District, Dumalag Water-works, Ivisan Water-works and Sigma Water-works. The other 6 systems are not operated because most of the pumping systems did not have some parts of the systems repaired, which had been damaged by the typhoon "Undang" in November 1984. The rest of Level III systems are still under construction, so only small portions of the town population are covered by these systems. In any case, these water-works are located only in the urban areas of the municipalities.

Only around 2,300 households might be covered by the public water-works of Level III as of the end of 1984, despite 2,064 households or 18.4% of urban households were already served by Level III water-work systems in 1980.

3.8 Power Supply

3.8.1 Power Supply System

The island of Panay is subdivided into four provinces, i.e., Iloilo, Capiz, Antique and Aklan. The whole island is covered by the electricity service area of NPC (National Power Corporation).

The electricity service in the individual provinces is provided by the electric service cooperatives that distribute power and sell it to consumers, while NPC is responsible for the power generation and transmission of electric power.

In the Panay Island, there are six (6) electric service cooperatives as follows:

Electric Service Cooperatives in Panay Island

	Name	Service Area
(1)	Panay Electric Company Inc. (PECO)	Iloilo City
(2)	Iloilo Electric Cooperative I (ILECO I)	Southern part of Iloilo province
(3)	Iloilo Electric Cooperative II (ILECO II)	Nothern part of Iloilo province
(4)	Capiz Electric Cooperative (CAPELCO)	Capiz province
(5)	Aklan Electric Cooperative (AKELCO)	Aklan province
(6)	Antique Electric Cooperative (ANTECO)	Antique province

Figure 3.8-1 presents the electric service area of each cooperative. The Panay river basin is composed mostly of Capiz province. The electricity service in the Capiz province has been undertaken by CAPELCO (Capiz Electric Cooperative) which was established in 1971 by its members.

3.8.2 Power Supply Facilities

Figure 3.8-2 presents the existing power systems, power systems under construction in 1984 and proposed power system.

In addition to the power generating facilities owned by NPC, PECO has its own generating facilities. But they are decrepit and in uneconomical conditions. The generation capabilities of the Panay Island system are summarized overleaf:

Existing Power Facilities - Panay System

Power Station		Station Capability (kW)	Installed (W)
PDPP I	(NPC Dingle)	24,820	4 x 7,300
PBP-2	(NPC Power Barge)	27,200	4 x 8,000
PDPP II	(NPC Panitan)	7,600	2 x 5,500
PECO		12,500	19,750 in total

Presently, the major distribution networks are owned by PECO, CAPELCO, ILECO I and II, and two other electric service cooperatives in the remaining provinces. The areas covering 80 percent of the island are considered to be electricity supply areas and the electrification ratio is estimated at 37 - 38 percent in the whole of the island.

3.8.3 Historical Power Demand

Tables 3.8-1 and 3.8-2 show historical records of power generation and consumption in the whole Panay Grid and in the Capiz province respectively.

In 1983, the total energy sales by CAPELCO amounted to 15,473 MHh. The peak load was 7.8 MW. The annual growth rate of energy consumption in Capiz province during the past 8 years was 32 percent.

The existing loads in Capiz province are predominantly residential and commercial areas, while the load of industrial customers occupies a minor portion of the total load. Consumers dominant in terms of numbers are residential, representing 93 percent of the total consumption; others are commercial in the 5 percent and street light, 2 percent. Industrial consumers are negligible in numbers. Consumers dominant in power sales are residential with 47 percent, others are commercial with 18 percent, industrial with 19 percent and others with 16 percent.

The maximum power demand of the whole Panay Grid was 42 MW in 1983

(See Table 3.8-1). According to NPC, electric power demand has long been suppressed by the shortage of power generating capability (especially before commissioning of 32 MW Power Barge Plant-2 in July 1984). NPC assumes that the demand will amount to 48 MW by additional connection to waiting consumers when such restriction in lifted. The major loads are rice mills, rice plants, fishing port, etc.

Another noteworthy aspect is that there is latent energy consumption which is presently categorized as "losses". Energy supply in Capiz province in 1983 was 27,100 MWh of which 6,324 MWh were generated by CAPELCO and 20,776 MWh was purchased from NPC (See Table 3.8-1). Out of the total energy, the plant use amounted to 652 MWh and the losses to 10,975 MWh. The annual load factor at the supply end is 41 percent. This means that the plant's own consumption and distribution losses account for more than 50 percent.

3.9 Water Budget

River water is presently used for irrigation in Mambusao and Panitan-Panay areas and for municipal/industrial (M&I) water supply to major towns located along the river. The quantity of water use will increase in future, especially once the projects proposed under this Study are implemented.

A water budget analysis was attempted in this Study to evaluate the water demand/supply balance under both present and future conditions. Figure 3.9-1 shows a schematic diagram indicating the locations of water demand, based on which the water budget was analyzed.

The results of the analysis indicate that water demand up to the year 2030 could be met with natural river water sources (80% dependable discharge for irrigation and 95% dependable discharge for M & I water supply) without specific flow regulation by a reservoir. In this respect, the Panay river is deemed to have plenty of water compared with the present water demand as well as with future demand.

CHAPTER IV. BASIC CONCEPTS OF BASIN-WIDE DEVELOPMENT PROGRAM

4.1 General

Repeated damage from floods constitutes the most important issue in the Panay river basin as discussed in Chapter III. Planning for flood control, therefore, was of primary concern in this Study. Apart from this issue, consideration was given to possibilities for irrigation development, municipal and industrial water supply and hydropower generation, for the purpose of formulating a comprehensive basin-wide development program.

The following basic concepts were adopted in plan formulation for flood control, irrigation development, municipal and industrial water supply and hydropower generation.

4.2 Flood Control Plan

4.2.1 Basic Concepts for Plan Formulation

A flood control project would be implemented through both structural and non-structural measures. This Study will chiefly contemplate protection by structural measures, in which non-structural measures will be discussed in combination with and as substitute of the structural measures.

In principle, if a flood control project is to be carried out by structural measures, a high target level of protection, say against a 100-year flood, would be desirable for the safety of facility and the long-term stability and livelihood of the people concerned. However, a plan formulated on such a basis would not necessarily be viable from economic standpoints, because the target protection level must be appropriate to the economic conditions of the study area. If a plan with a high protection level is not justifiable economically, an alternative plan needs to be formulated, which would comply with a provisional target aimed at a slightly lower target level of protection in the first stage, followed by an ultimate plan with a higher target level which would protect increasing future potential damages in the area.

In the Panay river basin, a provisional plan (short- to medium-term) will be proposed on these lines as the core of the flood control plan, since flood control measures with the high level of protection could not be justified economically. Flood control measures are therefore proposed as a result of this Study that would best fit present conditions and requirements in the Panay river basin.

4.2.2 Plan Formulation Criteria

(1) Definition of the development plans

LP: Long-term plan

- A flood control measure of a high protection level was assumed to be enacted for the purpose of protecting most of the flood vulnerable area (refer to Subsection 3.3.2 for its definition)

- The target flood control effects of this plan would be:

  (a) to relieve more than 90% of residents in the flood vulnerable area from flood damage (through both structural and non-structural measures).

  (b) to protect the farmland from flooding to a practically achievable maximum degree (through structural measures) since the staple industry in the Panay river basin is paddy-based agriculture and the common feeling among the residents is for protection of farmland.

MP: Mid-term plan

- A mid-term plan was assumed to be introduced, if the long-term plan was not economically justified under present conditions. The protection level of this plan was defined by a flood of practically conceivable size, say, the recorded maximum flood.

- The target effect of this plan would be to ameliorate flood damage to 70 to 80% of the population in the flood vulnerable area.

SP: Short-term provisional plan

- A short-term provisional plan would be introduced, if the mid-term plan above was found not to be justifiable in terms of economic viability.
- The protection level would have to be low, as the plan would aim at accommodating minor floods with repeated occurrences. Provisions would have to be made, however, so that the plan would reduce the expected damage even in the face of floods larger than the design flood. The areas to be protected would be priority areas where even minor floods cause considerable damage in terms of intensity and of population affected.
- The target effect of the plan would be to reduce damage in any form for more than 50% of the population in the flood vulnerable area.

(2) Definition of design flood

For each of the protective plan given above, the design floods were defined as below:

LP: Design flood for the long-term plan

- A 100-year probable flood was taken as the design flood, taking into account the size of the Panay river and the land use potential in the basin. This design flood level accords with the recommendations of the Nationwide Flood Control Study.

MP: Design flood for the mid-term plan

- The recorded maximum flood in the recent years in the basin was the Openg flood caused in November 1973 (corresponding to a 25-year recurrence period). This flood was taken as the design flood of this plan, as it accords with the criterion of the flood of practically conceivable size. The design flood coincides with the objective flood in the First Phase Work proposed in the "Nation-wide Flood Control Study".
- The 1973 flood has a special significance to local residents, as this flood is still fresh in mind as the largest flood in recent years.

SP: Design flood for the short-term provisional plan

In the short-term provisional plan, it is difficult to establish comprehensive criteria. Therefore the design flood was determined through an economic comparison of the following two cases:

(a) Minimum compound section channel plan:

The minimum of a 10-year flood should be safely accommodated, if dykes, although low, are to be constructed. In this case, a 10-year flood was taken as the design flood.

An example of such flood is the 1984 flood, which was one of the major floods in the decade, and this criterion has a special significance similar to that of the MP plan.

(b) Single section channel plan:

This plan intends to realize the minimum size of protective countermeasures, by improving the river channel with a single section channel. As it would have no dykes present inundation conditions would by no means be aggravated.

This plan would accomodate a 2- to 3-year flood by straightening the river course and improving its section from the natural bankful capacity of a 1- to 1.5-year flood. The single section channel provided in this plan would ultimately constitute the low flow section of the compound section in the future.

(3) Selection of implementation timing

The relative merits of the above Long-, Mid- and Short-term Plans would be compared though economic evaluations, in which the discount rate was selected to be 8% p.a. as a rate applicable to evaluation of standard flood control projects. The Study set forth a criterion that the projects having the EIRR value of more than 8% would be worthy of implementation. Projects which fall outside of this criterion should be deferred until a future date, when the enlarged benefits justify the implementation. In selecting the short range plans, the implementation in the order of EIRR merits would be recommended.

4.2.3 Definition of Flood Control Priority Areas

(1) Preliminary selection of priority protection areas

The inundation area maps under present river conditions, corresponding to 5- and 100-year probable floods, are given in Figure 3.3-2. As seen in the figure, the inundation areas would not significantly change with the size of inflow floods. This indicates that reduction of the flood discharge would not directly result in relief of widespread areas from inundation damage, and, therefore, delineation of priority areas on the basis of topography is hardly practicable. However, reduction in flood discharge would bring about mitigation of inundation damage due to decreased inundation depths, as typically shown in a 3.7 m decrease in the inundation depths at the base point of Panitan, in the event of a flood reduced from a 100-year to a 5-year flood.

The intensities of potential flood damage caused by 5- and 100-year floods are respectively shown in Figures 4.2-1 and 4.2-2. As depicted in the figures, flood damage would be inflicted throughout the river course, but the potential flood damage would be largest in the areas along the stretch downstream of the Panitan town, while the intensity of flood damage would be higher in the major towns dispersed in the areas. Table 4.2-1 presents the damage potential (assessed in annual average damage) and the affected population, according to the river stretches in the sub-areas shown in Figure 3.3-3 and according to the major towns.

A preliminary selection of priority protection areas is given in Table 4.2-1 on the basis of the criteria cited below:

Selection Criteria for Priority Areas

Proposed Structure	Area/Place to be Selected	Selection Criteria
River improvement	River stretch (inundated area)	Priorities given by the damage potential per km of stretch (₱/km). Damage on towns excluded, assuming they would be eliminated by polder dykes
Polders (dyked enclosures)	Major town/ villages	Priorities given by the damage potential (₱)

The river stretches and towns given "Level-1" assessment in the table are respectively the priority areas for river improvement and polder dyking, and subsequently the priority follows those assessed as "Level-2" and "Level-3".

(2) Selection of alternative protection areas

The following views were taken into consideration in selecting the flood protection areas:

(a) Protective works should be carried out in the order of the area's damage potential shown in Table 4.2-1.

(b) Excessive protective works (especially by river improvement) would result in considerable increase of flood discharge in the downstream reaches, and thereby inflate the total construction cost. To avoid this, the areas with a relatively low damage potential should be intentionally left unimproved for the purpose of positively retaining the present retarding effect. The areas retained as retardation basins are as shown in Table 4.2-2.

From the above viewpoints, six plans of alternative protection areas were formulated for mutual comparison, as shown in Table 4.2-3. The basic concepts underlying each of the plans are as summarized below:

Alternative-1 would only improve the river stretches downstream of the Panitan town (River Stretch P1 and P2), where the damage potential is the highest, and leave the other areas in the present inundation condition.

Alternative-2 would extend the improvement stretches up to the confluence with the Mambusao river. Nonetheless, the areas to be retained as retardation areas, as shown in Table 4.2-2, would be set aside.

Alternative-3 would expand the planned protection up to the confluence with the Badbaran river, and up to Mambusao town. Retardation areas shown in Table 4.2-2 would be set aside.

Alternative-4 would have improvement stretches extended up to Dumalag town along the Panay river, and along the Maayon and Balacuan rivers.

Alternative-5 would further enlarge the improvement stretches to the upper Panay and upper Mambusao rivers and thus wholly cover all the "Level-2" areas under protection.

Alternative-6 would provide protective work along all the river stretches, including the "Level-3" areas. Even in this case, no protection would be given to areas with conceivably low damage potential and the areas where protective measures would not bring about any substantial benefit.

Figures 4.2-3 to 4.2-5 show the location of protection areas specified in each of the above six alternative plans.

A 100-year flood, which is the objective flood of the Long-term Plan (LP), was employed in comparing of the alternative plans. At this stage, the protective works were assumed to comprise only the river channel improvement, and on this basis rough construction costs were estimated. The results of comparison are shown in Table 4.2-4, and a graphical comparison is given in Figure 4.2-6.

(3) Selection of flood control action areas

The selection of action areas in this Subsection aims to delineate areas which would be the objective of the Long-term Plan of the Flood Control Project. In this regard, the following items were taken into account in the selection process:

(a) A Long-term Plan should be flexible against any development needs that might come out in the future. Therefore provision should be made that the Long-term Plan would be compatible with the maximum possible development.

(b) The protection targets set out in Subsection 4.2.2 (1) should be satisfied, that is:

- Protection of more than 90% of the population in the flood vulnerable area.
- Protection of farmland to the maximum degree practicable.

Based on the comparison indices shown in Table 4.2-4 and Figure 4.2-6, the areas defined in Alternative-4 were selected as the action area of Flood Control Project. The reasons for the selection were as shown below:

(1) It is observed in Figure 4.2-6 that the cost effectiveness shown in terms of the "Damage reduction/Cost" ratio makes a bend at Alternative-4. This indicates that even if the protection area is expanded any further from this point, the cost-effectiveness would drop.

(2) The implementation of Alternative-4 would relieve some 80% of the affected population of flood damage. This value is close to the target of 90%. With regard to the remaining 10% of the affected population, non-structural measures could be effectively devised.

(3) Alternative-4 would protect some 60% of the agricultural land. Even if protection is expanded (as in Alternative-5), the incremental area of protected agricultural land is only minor, and thus Alternative-4 is deemed to realize protection to its practical maximum extent.

(4) If protection is extended further than in Alternative-4, the flood discharge in the downstream reaches will increase significantly.

(5) In terms of the cost-effectiveness, Alternative-1 would be rated best, as shown in Figure 4.2-6. Nevertheless, the protected population and farmland would be far less than targets, and hence would not be acceptable as the framework of the Long-term Plan.

The action areas were determined as described above. In practice, the Flood Control Plan should be coordinated in the overall framework of the comprehensive plan, by readily reflecting the development needs of the area. The details of actual formulation of the Flood Control Plan will be discussed in Chapter V.

4.2.4 Alternative Protective Measures

(1) Structural protective measures

The following structural measures were considered to be practical in view of river channel profiles, inundation conditions and basin topography of the Panay river:

(a) river improvements

a-1) channel improvement of the existing river
a-2) excavation of a floodway (diversion channel)

(b) flood control dams

(c) combinations of (a) and (b)

(d) polder dykes

Comprehensive structural measures will be formulated, with consideration to potential acceptability of specific structural measures in each objective area.

(2) Non-structural protective measures

Non-structural protective measures will be considered as a possible means of supplementing the structural measures. In areas where no effective structural measures will be undertaken, or where provisional plans will have to serve for a prolonged period of time, mitigation of flood damage by non-structural measures needs to be given substantial consideration (especially as a future prospect).

Non-structural measures are defined here to include broadly all protective measures other than the structural measures, which in the case of the Panay river basin would include:

(a) Flood plain management
(b) Structural modification of buildings
(c) Relocation of housing
(d) Flood forecasting and warning system

Such non-structural measures will be evaluated and quantitatively assessed on the basis of cost and benefit analysis. Other non-structural measures were discarded as being inappropriate to the Panay river basin, though the comments are included in Table 4.2-5.

4.3 Agricultural Development Plan

The chief crop in the Panay river basin is paddy. Climatic conditions in the basin are amenable to agricultural activities, in that no prominent dry periods exist in the year. As a result, the basin has widespread irrigated paddy production (8,500 ha out of the total paddy area of 40,960 ha, as discussed in Subsection 3.3.1), and still has the potential for further irrigation development.

One notable characteristic of the Panay river basin is that no significant differences exist between the unit yield of the existing irrigated paddy fields (3.2 ton/ha) and that of the non-irrigated field (2.8 ton/ha). This demonstrates that there is ample room to increase productivity of the existing irrigated paddy fields, by means of improving facilities and introducing better cropping practices.

In this Study, the areas with irrigation potential (including improvement of existing) were identified first, and development plans were formulated by comparison of merits. Technical and economic evaluations were made in selecting candidate areas for development. Contemplated irrigation areas were confined to the areas with more than 1,000 ha of irrigation potential, so that they would be eligible for development as National Irrigation Systems (NIS).

4.4 Municipal and Industrial Water Supply Plan

The largest demand center for municipal water in this basin is the city of Roxas. Currently, the water supply service of the Roxas city faces the problem of intrusion of saline water into the intake point. This Study will therefore provide an improvement plan for Roxas City Water District (ROX-WD).

Other towns in the basin still have a low level of consumption (less than 250 households per town; supply capacity less than 6 ltr/sec). Water supply to these towns is not so much a basin development issue as a specific facility plan, hence no further consideration is given to this issue.

4.5 Hydropower Generation Plan

Hydropower generation plans will be given consideration in relation to the dams proposed as flood control measures, as discussed in Section 4.2. In this Study, the formulation of plans and assessment of viability will be made for multipurpose dams, combining the functions of flood control and power generation.

As shown in Section 3.9, until the year 2030 water demand in the Panay river basin downstream of the prospective dam sites is likely to be smaller than the natural drought discharge of the Panay river. In planning dams, therefore, no allowance will be made for augmenting low flow excepting that the incremental discharge resulting from flow regulation effects of hydropower generation plans will be given quantitative assessment.

CHAPTER V. FLOOD CONTROL PLAN

5.1 General Description

5.1.1 Procedure of Planning

The procedures of planning for the Flood Control Project are shown in Figure 5.1-1 and will follow the following steps:

(1) Selection of protection areas

The protection areas of the Long-term Plan (LP) will be selected, as described in the Subsection 4.2.3.

(2) Formulation of Long-term Plan

An optimal facility plan, that would constitute the Long-term Plan, will be formulated with a design flood of 100-year flood.

(3) Formulation of Mid- and Short-term Plans

Within the framework of the Long-term Plan set forth above, Mid- and Short-term Plans will be evaluated as provisional measures. The protection level for these plans will be less than the 25-year flood.

(4) Considerations on non-structural measures

Non-structural measures, as described in Subsection 4.2.4, will be considered in combination with, or as substitutes for the structural measures discussed in (2) and (3) above.

(5) Formulation of a stagewise implementation program

A recommendation will be made concerning the stagewise implementation of the Flood Control Project, based on the discussion in (2), (3) and (4) above.

Results of studies in each step are described in subsequent sections.

5.1.2 Design Flood Discharge

Facility plans will be made based on the design flood employed for the action areas of Alternative-4 of the foregoing Subsection 4.2.3. Figure 5.1-2 presents the diagram of flood flow distribution under the present river condition.

5.1.3 Flood Control Facility Alternatives

As discussed in Subsection 4.2.4, this Study will examine the following structural measures:

(a) River improvement

a-1 : Improvement of existing channels
a-2 : Diversion plan (bypass floodways)

(b) Flood control dams

(c) Combination of (a) and (b) above

(d) Polder dykes

Relative merits of the facility plans will be evaluated by cost and economic viability. Polder dykes in item (d) will be contemplated as measures for the Mid- and Short-term Plans, but not in the framework of the Long-term Plan, because of their primary purpose of giving priority protection to specific areas.

The following basic criteria were used in the evaluation:

(a) Construction cost:

- Cost at 1984 constant prices.

(b) Economic cost:

- Economic cost calculated as 82% of estimated financial cost of local currency portion, and 100% of foreign currency portion.

(c) Flood control benefit:

- Benefits accured from reduction of flood damages, both at present and in future.

- Damage reduction estimated in accordance with procedures detailed in Appendix III.

- Future damage potential assessed by the criteria below:

  i) Future damage potential to increase at the rates specified in Appendix III, if high level flood protection (say, against 25-year flood or larger) is provided.

  ii) growth rate to be half of the specified rate if only low-level flood protection (say, less than 10-year flood) is provided.

  iii) growth rate to be 1/4 if no flood protection measure is provided.

  iv) Sensitivity analysis to be conducted on the case of no increase in future damage potential, if considered to be necessary.

- A part of the inland area to be protected by high levees would remain prone to inundation due to inland water. This residual damage assessed to be 5% of the calculated damage reduction.

(d) Construction period;

- River improvement	:	4 to 8 years according to the scale of the work
- River diverion	:	5 years incl. preparatory works
- Dam	:	5 years incl. preparatory works
- Polder	:	3 years incl. preparatory works

(e) Discount rate : 8% per annum

5.2 Formulation of Long-term Master Plan (LP)

5.2.1 River Improvement Plan

(1) Action 'stretches' for improvement

River improvement plans would provide for improvement of river channels in the flood control action areas selected for Alternative-4 as described in Subsection 4.2.3 of Chapter IV. In the intervening non-protection areas, too, the existing river channels, which would constitute the low flow channels, would be improved wherever necessary. The length of improvement would be 109 km in total. The action 'stretches' of the river improvement plan are shown in Figure 4.2-4.

(2) Facility plan

The following aspects were considered in relation to planning of river channel improvement and its cost estimation:

- A compound section was employed, to accommodate the relatively large design flood discharge.
- The channel section was determined so that the planned water level would not significantly exceed the present flood water level.
- The capacity of existing channels would be enlarged mostly by widening of sections. The capacity of improved channel would be about 2- to 3-year floods, but widening would not exceed twice the existing channel width.
- River improvement would be conducted along the present river course as much as possible, and straightening of river channels, such as by shortcut channels, would be kept to a minimum. Alignment of planned levees would basically envelop the present river course.
- Project cost estimation would include the costs of channel improvement such as earthwork, bank protection and groin work, together with other items such as drainage sluices, bridges to be reconstructed, and engineering fees for investigation and design.

(3) Economic evaluation of improvement plans

An economic evaluation was made of estimated project costs and benefits. The results of evaluation are detailed in Table 5.2-1, and summarized below.

Economic Evaluation of Independent River Improvement Plans

Work	Construction cost (₱ x 10^6)	Present Values/1 (₱ x 10^6)			EIRR
		Cost (C)	Benefit (B)	NPV (B-C)	(%)
All improvement/2 stretches	5,593	2,691	919	-1,772	2.8

Notes: /1 At discount rate 8% p.a.

/2 In this calculation, improvement work was assumed to be applied to the Pontevedra and Hamulauon rivers.

The EIRR of the Independent River Improvement Plan was assessed as 2.8%, which is indicative of its economic unfavourability. Therefore, alternative facility plans including floodway and flood control dams will be studied in the subsequent subsections.

(4) Flood water level and discharge

The flood water level and discharge at the base point Panitan, with the above river improvement plan implemented, are shown in next page.

Water Level and Discharge After Improvement
(Panitan Base Point)

Probable flood (year)	Present condition		After improvement	
	Water Level (El. m)	Discharge (m^3/sec)	Water level (El. m)	Discharge (m^3/sec)
100	10.30	2,670	12.00	4,520
50	9.55	2,270	10.71	3,570
25	8.70	1,830	9.43	2,750
10	7.55	1,370	7.81	1,880
5	6.60	1,040	6.83	1,435
2	5.80	790	5.77	1,040

5.2.2 Diversion Plan (Bypass Floodways)

(1) Alternative diversion plans

The following six floodways were contemplated in this Study. The locations are shown in Figure 5.2-1.

(a) FW-1: Mambusao - Balacuan bypass floodway

This plan would divert the flood discharge of the Mambusao river 1.3 km upstream of Mambusao town and across the Balacuan lowlying areas. The proposed floodway would be aligned along the existing Balacuan river with a total length of 8.3 km (Figure 5.2-2). The catchment area at the diversion point is about 305 km^2, and the 100-year flood at this point is 2,300 m^3/sec. Taking away the present capacity of the Mambusao river of 300 m^3/sec, the design discharge of the proposed floodway would be 2,000 m^2/sec.

This plan would relieve flood damage in the areas downstream, the diversion point, but it would inevitably inundate the lowlying areas of Balacuan from the beginning of the flood season.

(b) FW-2: Mambusao - Sapian bypass floodway

As an alternative to case (a) above this diversion plan would divert the flood discharge of the Mambusao river at 1.5 km downstream of Mambusao town and bring it northwards to the Sapian Bay, thus decreasing the flood discharge in the Panay river. The total length of the diversion channel would be 8 km. The channel would run through low paddy fields for the first 1 km, through hilly undulating areas for the next 4 to 4.5 km and then through lowland fishpond areas for the last 2.5 to 3.0 km. The catchment area at the diversion point is 330 km^2. Figure 5.2-3 shows the route of the proposed floodway. The capacity of the diversion channel was determined to be 2,000 m^3/sec, by applying the same method as in (a) above.

(c) FW-3: Panitan bypass floodway

Because of the limited capacity of the river channel at Panitan town a large flood at present overflows a saddle (col) on its right bank. This plan would provide a floodway on the right-bank saddle, and would accommodate flood flow in excess of the existing capacity of the present river channel, which would be left without widening. The entrance of the floodway would be located at 2.3 km upstream of the Panitan town, and outfall would be about 1.8 km downstream of the Panitan town. The total length of the floodway would be about 2.2 km. The route of this floodway plan is shown in Figure 5.2-4.

With the catchment area at the Panitan town being 1,987 km^2, the 100-year flood discharge was estimated to be 4,600 m^3/sec. While the present capacity of the existing channel after improvement is 1,800 m^3/sec at 100-year flood level, the balance of 2,800 m^3/sec would be the design discharge of the floodway. It should be noted that weathered tuff breccia outcrops on the river bank near the proposed entrance point. The invert of the channel, therefore, should be set above the weathered rock zone.

(d) FW-4; Panitan Bailan bypass floodway

This plan aims at decreasing the incoming flood discharge into the Panay - Pontevedra rivers by diverting the flood flow eastward to Pilar Bay. The entrance point of the floodway would be the same as for (c) above, and the total length of the floodway would be about 11.5 km. The floodway would run through low paddy fields for the first 9 km, through a low plateau for the next 0.5 km and in the existing Malagit river for the last 2.5 km. The route of the floodway is shown in Figure 5.2-5.

The design capacity of the floodway would be 4,100 m^3/sec, which is the balance of the 100-year flood at the Panitan point, 4,600 m^3/sec, over the present bankful capacity of 500 m^3/sec in the Pontevedra river reaches.

(e) FW-5: Cogon bypass floodway

This plan would divert the flood discharge of the Pontevedra river about 4 km downstream of the Panay/Pontevedra bifurcation, and direct it northeastwards to the Hamulauon river. The total length of the floodway would be about 9.5 km, slightly shorter than the existing river course of the Pontevedra river of 11 km. The route of the floodway is shown in Figure 5.2-6.

With this plan realized, the existing Pontevedra river below the diversion point would accommodate a bankful discharge of 500 m^3/sec in the event of a flood, with only partial improvement work provided. Since the 100-year flood is estimated to be 4,600 m^3/sec at the diversion point, the design discharge of the proposed floodway is 4,100 m^3/sec.

(f) FW-6: Hamulauon bypass floodway

The estuary of the Pontevedra river has been aggraded by siltation, and as a result, the clogged river mouth is lowering the capacity of the river. Land adjacent to the lower Pontevedra river, downstream of the Pontevedra town, is dominated by fishponds, and soil conditions are not suitable for constructing high levees. Therefore the height of levees, if constructed, would be 3 m at a maximum. Because of the constraints of clogged river mouth and limited levee height above, the river channels would have to be about 1,500 m wide, if the Pontevedra river is ever to be improved. In this case, significant negative effects would be inflicted on the surrounding land use.

By contrast, there has been no serious siltation at the mouth of the Hamulauon. The Hamulauon floodway plan would take advantage of this by diverting part of the flood flow into a new floodway to be constructed along the Hamulauon river. In this case, the Pontevedra river would accommodate about 1,500 m^3/sec of flood discharge and the remaining 3,100 m^3/sec would be flushed by the floodway. The route of the floodway is shown in Figure 5.2-7.

(2) Comparison with river improvement plans

Bypass floodways are basically the alternative options to river improvement plans for specific stretches. Table 5.2-2 presents the river improvement plans comparable with the floodway plans above.

Because the same flood control benefits would accrue from provision of floodways and their comparable river improvement alternatives, the merits of these plans can be determined by comparison of costs. The comparison, as summarized in Table 5.2-2, shows that FW-5 would be better rated than the river improvement alternative but in other cases the river improvement alternatives rated better.

(3) Economic comparison of floodway Plans

The river improvement plans of 1) river stretches P1 and P2 only and 2) all the protection stretches of LP, both inclusive of the floodway FW-5, were subjected to economic evaluation. The results are summarized below: