THE REPUBLIC OF THE PHILIPPINES
MINISTRY OF PUBLIC WORKS AND HIGHWAYS
NATIONAL IRRIGATION ADMINISTRATION

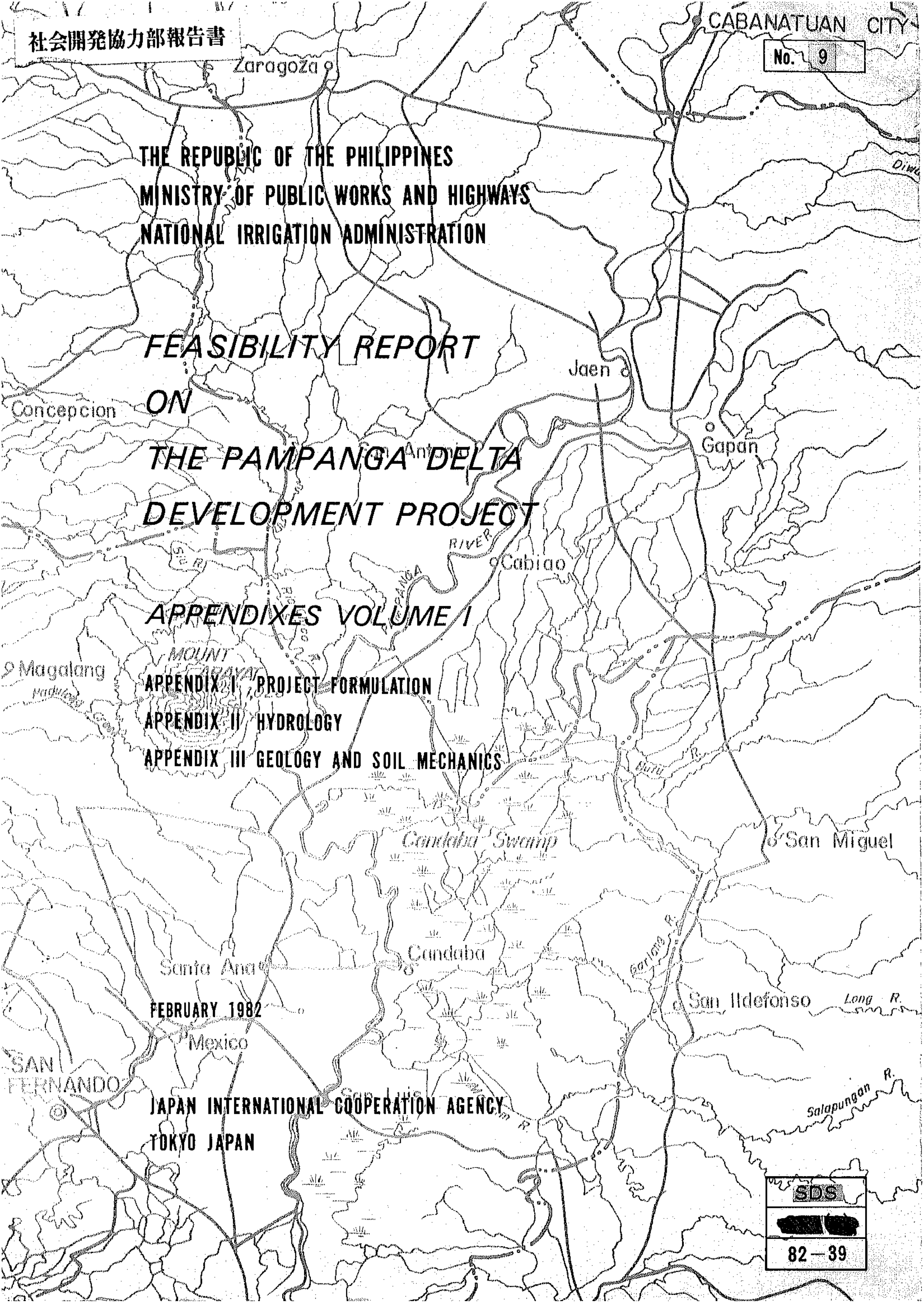
FEASIBILITY REPORT ON THE PAMPANGA DELTA DEVELOPMENT PROJECT

APPENDIXES VOLUME I

APPENDIX I PROJECT FORMULATION
APPENDIX II HYDROLOGY
APPENDIX III GEOLOGY AND SOIL MECHANICS

FEBRUARY 1982

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN



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LIST OF APPENDIXES

ABBREVIATIONS

Abbreviations used in this report are listed below:

1. Length and Height

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

2. Area

cm^2: square centimeter

m^2: square meter

km^2: square kilometer

ha : hectare

MSM : million square meter

3. Volume

lit, l : liter (= 1,000 cm^3)

m^3 : cubic meter

MCM : million cubic meter

4. Weight

mg : Milligram

g : gram

kg : kilogram

t (ton) : 1,000 kg

5. Time

sec : second

min : minute

hr : hour

yr : year

6. Electric Measures

kV : kilovolt

kW : kilowatt

kWh : kilowatt-hour

MW : megawatt

MWh : megawatt-hour

GWh : gigawatt-hour

6. Other Measures

% : percent

PS : horse power

°C : centigrade

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

lit/sec/ha, lit/s/ha : liter per second per hectare

cm/sec, cm/s : centimeter per second

t/ha : ton per hectare

ppm : part per million

No(s). no(s) : number(s)

SPT : standard penetration test

8. Currency

US $: US Dollar

₱ : Philippine Peso (US $1.00 = ₱7.50)

9. Other Abbreviations

ADB	-	Asian Development Bank
BPW	-	Bureau of Public Works
BCGS	-	Bureau of Coast and Geodetic Survey
BS	-	Bureau of Soils
BFCD	-	Bureau of Flood Control and Drainage
BPI	-	Bureau of Plant Industry
BAI	-	Bureau of Animal Industry
BAEcon	-	Bureau of Agricultural Economics
BAEx	-	Bureau of Agricultural Extension
BFAR	-	Bureau of Fisheries and Aquatic Resources
GOP	-	Government of the Philippines
IBRD	-	International Bank for Reconstruction and Development
JICA	-	Japan International Cooperation Agency
MND	-	Ministry of National Defense
MPH	-	Ministry of Public Highways
MPW	-	Ministry of Public Works
MPWH	-	Ministry of Public Works and Highways
MAR	-	Ministry of Agrarian Reform
MWSS	-	Metropolitan Waterworks and Sewerage System
NIA	-	National Irrigation Administration
NFA	-	National Food Authority
NPC	-	National Power Corporation
NEDA	-	National Economic and Development Authority
NWRC	-	National Water Resources Council
FSDC	-	Farmer's System Development Cooperation
MRRTC	-	Maligaya Rice Research and Training Center
UPCA	-	University of the Philippines College of Agriculture at Los Baños
M-99	-	Masagana-99 Program
PD/CS Area Development Project	-	Pampanga Delta/Candaba Swamp Development Project
OECF	-	Overseas Economic Cooperation Fund
PAGASA	-	Philippine Atmospheric, Geophysical and Astronomical Services Administration

NSDB	-	National Science Development Board
RP	-	Republic of the Philippines
TFFCRA	-	Task Force for Flood Control and Related Activities
UNDP	-	United Nations Development Program
USAID	-	United States Agency for International Development
IRRI	-	The International Rice Research Institute
NASUDECO	-	National Sugar Development Corporation
PASUDECO	-	Pampanga Sugar Development Corporation
CIS	-	Communal Irrigation System
RIS	-	River Irrigation System
PIS	-	Pump Irrigation System
USBR	-	United States Bureau of Reclamation
PRSC-PMO	-	Pampanga River Control System Project Management Office

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APPENDIX I PROJECT FORMULATION

CHAPTER 1 INTRODUCTION

This report entitled "Project Formulation" was prepared on the basis of the results through the various surveys and studies as follows;

- Data collection and review which was particularly made for the Report on PAMPANGA DELTA/CANDABA SWAMP AREA DEVELOPMENT/1 and IRRIGATION DEVELOPMENT PLAN FOR CENTRAL LUZON/2.
- Topographic survey for the San Antonio Swamp and the North Candaba Swamp (1/25,000, one meter contour interval), longitudinal and cross sectional survey of the Pampanga River and its major tributaries and topographic survey for the Pampanga Delta Area (1/25,000, ten meter contour interval)
- Hydrological surveys
- River survey
- Agricultural survey
- Agro-economic and socio economic surveys
- Soil Survey
- Geological and soil mechanical survey for the construction of the San Antonio Reservoir and river improvement
- Irrigation and drainage surveys
- Inland fisheries survey
- Environmental survey

The Report describes present conditions of the objective area, identifies the needs for the development, analyzes development potentials, formulates development projects and presents the most optimum plan in both flood control project and agriculture and irrigation project in the objective area.

/1: Pampanga Delta/Candaba Swamp Area Development Project, Department of Public Works, the Philippines and Tahal Consulting Engineers Ltd., 1978

/2: Irrigation Development Plan for Central Luzon, NIA and Engineering Consultants Incorporated, 1977

CHAPTER 2 GENERAL CONCEPT

2.1 Objective Area

The objective area is located in the lower central part of the Region III, Central Luzon along the middle and lower reaches of the Pampanga River, which comprises five provinces, namely; Pampanga, Tarlac, Bataan, Nueva Ecija and Bulacan provinces. Total land area of the objective area is around 3,200 km^2, out of which 47% are situated in Pampanga province, 19% in Bulacan province, 18% in Nueva Ecija province, 11% in Tarlac province and the remaining 5% in Bataan province. The objective area is the flat land, the elevation of which is ranging from EL. 0 m in the coastal plain up to about EL. 30 m in the upper stream side.

The objective area can roughly be divided into five components or areas, namely, San Antonio Swamp, Candaba Swamp, West Bank area, Pampanga River channel and lower coastal area. The San Antonio Swamp is located in the most upstream area in the objective area extending on both banks of the Rio Chico River with the approximate area of 820 km^2. The Candaba Swamp located in the left bank of the lower Pampanga has the total area of around 630 km^2. The West Bank area extends from around Mt. Arayat up to Masantol in the coastal area along the right bank of the Pampanga River with the approximate area of 860 km^2. The lower coastal area included in the objective area is around 890 km^2. The location in the objective area and the boundaries of the Pampanga River basin are presented in Location Map.

2.2 Needs for the Development

As mentioned in the preceeding section, the objective area is located in the lower central part of the Central Luzon, in which most of the socio-economic activity in the region is concentrated. Another characteristic of the objective area is that the area is situated in the short distance from Metro Manila, which adds more strategic values on the area not only for the development of the Central Luzon but also for the development of Metro Manila itself.

Despite this strategic location, economic activity and further development of the objective area is hampered by the natural conditions and shortage of infrastructures. Most of the objective area has suffered from flood caused by typhoons and tropical storms. Particularly, the San Antonio area, Candaba Swamp area and the lower coastal area are flooded annually during the wet season. Annually flooded area was estimated at around 811 km^2 which includes 234 km^2 of the San Antonio area, 253 km^2 of the Candaba Swamp area and 324 km^2 of the lower coastal area. Frequent floods in the objective area cause lots of damages not only for the agricultural crops and fishery but also for houses and properties, and the social infrastructures in the region. During the heaviest flood occurred in May 1976, total flooded areas including the San Antonio Swamp, Candaba Swamp and the lower coastal area were around 2,540 km^2 and the flood damages only for public properties were estimated at ₱443 million.

Furthermore, caused by the flood water the arable land in the San Antonio area and the Candaba Swamp cannot be used for agricultural production during the wet season, parts of which are now being used for production of paddy and vegetables only during dry season. Thus, the floods annually occurred affect the progress of the development in the objective area not only through causing the substantial damage on the area but also through providing constraints for further agricultural development.

There are considerable agricultural development potentials in the objective area. Available arable land in the objective area is around 1,260 km^2, most of which belong to very suitable soil group for agricultural development. Besides the land resources, there exist potential water resources from the Pampanga River and its tributaries as well as substantial volume of manpower. However, the hindrance to an efficient agricultural development in the objective area is the lack of adequate water supply system. Although irrigation system is introduced partially using small pumps on the area located in the right bank of the lower Pampanga River, the available water during the dry season is hardly enough to irrigate thousand hectares and the resulting yields of the crops are relatively low.

After completion of the Angat Irrigation Project and the Pantabangan Irrigation Project, as well as supplementary irrigation improvement projects, irrigated area increased to 62,000 hectares or 60% of the paddy field in the objective area. Following this large irrigation projects such as the Balog-Balog Irrigation Project and the Casecnan Transbasin scheme are now under planning by NIA. When all these projects are completed most of the arable area will be irrigated in the Central Luzon and the sizable area still under non-irrigated condition would be the area located in the west bank of the lower Pampanga River.

Caused by the frequent floods and lack of adequate water supply system agricultural productivity in the objective area is relatively lower compared to other areas in the Central Luzon. Average yield of paddy is 2.75 t/ha in the objective area, which is lower than that of 3.0 t/ha in all the Central Luzon. This fact and the uncertainty of obtaining good yields restrain the farmers from improving the lands and farming technics, and the resulting farm income remains low.

For improving this depressed condition and facilitating agricultural development in the objective area, installation of flood control and year round irrigation water supply system would be the most important factor and is urgently required.

2.3 Development Goal

Development goal for the Pampanga Delta Development is to meet the needs in the objective area mentioned above and includes the following items. Target year for the development is set at the year of 2000.

a. To improve flood conditions both in the Candaba Swamp and lower coastal area.

b. To attain self sufficiency of rice in the objective area and to enable the Central Luzon to keep the role of rice supply center to Metro Manila by increasing crop production.

c. To increase the regional income and to improve living standard in the objective area and to contribute to equitable distribution of income in the nation.

d. To reduce unemployment and to attain efficient manpower allocation in the objective area.

CHAPTER 3 PRESENT CONDITION

3.1 Natural Resources

3.1.1 Topography

The objective area is located in the lower central part of the Central Luzon and extends over an area of about 320,000 ha with the following distinct characteristics in topography.

a. Coastal Area

The coastal area is delta and almost flat with the elevation up to 1 m above MSL and is widely submerged during high tides and floods. Most of this area is used for fish ponds.

b. West Bank Area

The area is located between the Zambales foothills and the Pampanga River with the elevation from 2 m to 10 m above MSL. The area generally slopes down from west to east direction. This area is partially and temporarily inundated during floods or heavy precipitations of wet season caused by its low gradients and lack of sufficient drainage channel.

c. Candaba Swamp Area

The area is depression with the elevations from 1.0 m to 9 m above MSL. The north part of the swamp has an average elevation of 6 m, the average elevation of which decreases to 4 m below the town of Candaba. The swamp acts as a natural flood retarding basin capable of storing about 1.4 billion m^3 of water on the area of about 45,000 ha below elevation approximately 8.5 m. Physically, the Candaba Swamp is divided into 2 parts by dike along the Maasim River, the North Candaba and South Candaba.

d. San Antonio Swamp Area

The area is a natural flood plain of the Rio Chico River, with the elevation from 7 m to 12 m above MSL. The area below elevation 12 m has a natural flood retarding basin capable of a storing about 500 million m^3 water on the area of about 20,000 ha. The land gradients are about 1/500 on the west part and about 1/1,000 on the east part of the area.

3.1.2 Climate

The climate of the objective area is characterized by the distinct dry and wet seasons caused by tropical monsoon. The dry season extends usually from November to April and the wet season during the remaining months of the year. Climatic conditions are explained in this section using the data available from 68 rainfall stations and three meteorological stations located in the Pampanga River Basin. Summary of the climatic data is presented in Table 3.1.1.

Annual mean temperature is around 27°C in the objective area. January or February is the coolest month, while April or May is the hottest, and the fluctuation of the mean temperature is quite small in a year. Annual mean relative humidity in Cabanatuan City is 76.7%, maximum monthly mean relative humidity appears in August and minimum in April. Annual mean sunshine hour in San Miguel, Tarlac is 6.1 hours a day. Maximum monthly mean sunshine hour is observed in April and minimum in August.

Wind speed observed in the Pampanga River Basin is light, 2.4 km/hour and 3.8 km/hour at San Miguel, Tarlac and Cabanatuan City, respectively. Annual evaporations observed in San Miguel, Tarlac and Cabanatuan City are 1,768 mm and 1,815 mm. Monthly maximum evaporation appears in April and minimum in August.

3.1.3 Hydrology

3.1.3.1 Rainfall

In the Pampanga River Basin, the mean annual rainfall varies from less than 2,000 mm in the central part of the basin to over 2,800 mm in the mountainous eastern and southwestern portions. This variation is caused primarily by the effect of the topography and the rain-bearing seasonal winds. During the northern or northeastern monsoon period. October - January, the basin is shielded by the Caraballo Mountains on the north and northeast. During the February - April period, the basin is shielded on the east from the east trade winds by the Sierra Madre Mountains. During the remainder of the year, the basin is shielded from the southwest monsoon winds by the Zambales Mountains on the south.

Heavy precipitation generally occurs in the period of May through October during the southwest monsoon and August is generally the month of heaviest rainfall. More than half of the rainfall in the basin is associated with typhoons. Nearly 90 percent of the mean annual precipitation recorded at Cabanatuan City occurred during the period of May - October.

3.1.3.2 Streamflow

The annual pattern of the streamflow of the Pampanga River Basin varies widely according to the year, and the Pampanga and Rio Chico River Basins have almost the same characteristics throughout the year. The wet season flow appears during the months of June through November, but occasionally, June and November have a small discharge, less than 50 m^3/s at Arayat and 1 m^3/s at Zaragoza. The drought flow appears during the months of January through April, especially the streamflow becomes extremely small in March and April. The average minimum discharge of the past 14 years is 26.8 m^3/s at Arayat and 0.9 m^3/s at Zaragoza. December is a transitional month to the dry season flow and May is also a transitional month to the wet season flow, but occasionally, large discharge occurs in May caused by heavy rainfall.

3.1.3.3 Tide

Tides in Manila Bay range from -0.7 m to +0.8 m in MSL. According to the data collected from BCGS, the tide levels in Manila Harbor are as follows:

Elevation above Mean Sea Level (m)			
Mean Higher High Level (MHHL)	Mean High Level (MHL)	Mean Low Level (MLL)	Mean Lower Low Level (MLLL)
0.53	0.39	-0.37	-0.47

3.1.3.4 Water Quality

To know the quality of surface water of rivers, water sampling and analysis were carried out by the Team, during high-water flow condition in September 1980 and low-water flow condition in January 1981. The results of water quality analysis indicate that the water is generally acceptable for irrigation usage.

3.1.3.5 Seawater Intrusion

To know the frequency of seawater intrusion to the Pampanga River and the Labangan Floodway at present, the average distance of seawater intrusion in the affected period was estimated based on the result of calculation of salt wedge and the streamflow during the period from 1968 to 1978. The estimated distance of seawater intrusion and its affected period at present are as follows:

Depth	Pampanga River		Labangan Floodway	
	Distance (km)	Period (day)	Distance (km)	Period (day)
At Channel Bottom	22.7	145	11.3	338
At 1m below Water Surface	1.3	138	4.6	293

3.1.3.6 Sedimentation

In order to estimate sediment transport from the basin, sediment discharges were measured by the Team at 7 stations during the months of August through November 1980. Furthermore, for estimation of bed load of river channel, the grain size analysis was carried out on river bed materials of 41 samples.

Based on these data, the average annual sediments at 7 stations are estimated as follows:

River	Site	Catchment Area (km^2)	Ave. Annual Sediment ($t/km^2/yr$)
Talavera	Talavera Br.	401	262
Rio Chico	Zaragoza Br.	1,675	134
Bamban	Bamban Br.	206	1,213
Pampanga	San Isidro Br.	3,472	685
Pampanga	Arayat Br.	6,532	387
Pampanga	Candaba Br.	7,270	163
Pampanga	Sulipan Br.	7,715	59

3.1.4 Soil

3.1.4.1 General

The soil survey was carried in order to identify major soil groups and their distribution for the area to be irrigated in the objective area and to examine the adaptability of each soil for irrigation farming.

There are some data and information of soil survey in the objective area as follows:

1) Report on a semi-detailed soil and land classification survey of Candaba Swamp Development Project, prepared by Bureau of Soils, 1975

2) Report on semi-detailed survey of Pampanga Delta Development Project prepared by Bureau of Soils, 1975

3) Report on soil survey of Pampanga Province prepared by Department of Agriculture and Natural Resources, 1956

4) Report on soil survey of Tarlac Province prepared by Department of Agriculture and Commerce, 1940

5) Report on soil survey of Bulacan Province prepared by Department of Agriculture and Commerce, 1939

6) Soil map of Nueva Ecija Province prepared by Bureau of Soils

The field survey was carried out over the area of about 103,000 ha (hereinafter called the survey area) referring to the data mentioned above. Topographic maps on a scale of 1/50,000 were used as basic maps for the survey. In addition aerial photos on a scale of 1/30,000 were used for interpretation of soils with emphasis on the distribution of coarse sand, being yielded from the Zambales ranges.

Soils were inspected and classified from pits dug with the density of one pit per about 1,000 ha, at irregular intervals along roads, foot-paths and trails according to change in relief, drainage vegetation and soils. The soils were identified in the field and described according to the standards defined in "Guideline for Soil Profile Description" of the Food and Agriculture Organization of the United Nations. The pits were dug to a depth of about one meter.

One hundred eight (108) pits were dug out and 50 soil samples were taken from the representative soils. These soil samples are analyzed at Muñoz. The items of analyses are pH value, cation exchange capacity, exchangeable bases, total nitrogen, total carbon, available potassium and phosphate, free iron, and soil particle distribution.

3.1.4.2 Soil Classification

(1) Soil Mapping Units

Soil classification was proceeded on soil series level on the basis of the established soil series of the Philippines. Eight soil series were classified in the area to be irrigated in the objective area as follows:

1) Angeles soil series
2) La Paz soil series
3) Masantol soil series
4) Prensa soil series
5) Quingua soil series
6) San Fernando soil series
7) Tagolod soil series
8) Zaragoza soil series

Based on the surface soil texture, eleven soil mapping units were identified and delineated. The area occupied by each soil mapping unit and its extent are summarized at Table 3.1.2 and illustrated in Fig. 3.1.1.

(2) Main Features of the Major Soil Groups

a. Angeles Soil Series

The soils of Angeles series develop over the flat to slightly undulating land on the old alluvial terrace at the right side of the Pampanga River. The soils extend over the higher elevated land adjacent to La Paz soil series. The lands covered with these soils are well drained. The total land area amounts to 35,600 ha or 34.5% of the surveyed area.

The horizon sequence of the soils is A/B/C. The A horizon is composed of grayish yellow brown to whitish gray coarse sand or fine sand or sandy loam. Structure is single grain or weakly developed granular. The B horizon has a brownish gray sandy loam or sand with very weakly developed granular structure. Sometimes gravels are found. The C horizon is a grayish sand.

The soils have low to moderate inherent fertility and low content of organic matter. The pH value shows slightly acid to neutral. There is no problem of flooding.

Presently the lands covered with these soils are mainly grown by sugarcane. It is essential to apply proper amount of fertilizer and manure for ensuring high yield of agricultural production under irrigation.

The typical soil profile is as shown in Table 3.1.3.

Angeles coarse sand, Angeles fine sand and Angeles sandy loam were mapped, based on the surface soil texture.

b. La Paz Soil Series

The soils of La Paz series extend mainly over the land in the skirt of the Zambales range above the Pampanga River flood plain, situated in the right side of the San Fernando River. These soils develop the flat and or slightly depressed land in the dissected continental terrace. Total land area amounts to 26,000 ha or 25.2% of the surveyed area.

The horizon sequence of the soils is A/B/Cg. The A horizon has a thickness of about 15 cm with grayish brown sandy loam or silt loam. Structure is weakly developed granular or subangular blocky. The B horizon is composed of grayish brown sandy loam with weakly developed subangular blocky structure. The C horizon has sandy loam or sand.

The land covered with these soils is not or slightly subject to flooding and is somewhat poorly to poorly drained. With regard to chemical properties, pH values show neutral. Inherent soil fertility appears poor.

Presently the lands covered with the soils are used as paddy cultivation. The application of commercial fertilizer and liberal addition of organic matter would build up these soil to a high state of productivity.

The typical soil profile is shown in Table 3.1.4.

La Paz silt clay loam and La Paz sandy loam were mapped, based on the surface soil texture.

c. Masantol Soil Series

The soils of Masantol series occupy the land of the flat low-lying delta plains adjacent to and or above tidal swamp area. The lands covered with the soils extend over the poorly to very poorly drained land enclosed by Bebe-Sn. Esteban Diversion Channel in north and National Railway in south. The total land area is about 8,500 ha or 8.3% of total surveyed area.

The horizon sequence of the soils is A/Cg. The A horizon has a dark to brownish gray clay with thickness of about 30 cm. Structure is moderately developed blocky. The Cg horizon is bluish or grayish clay with moderately developed blocky structure.

As for chemical properties, the soils show neutral to moderately alkaline in pH value. The soils have high inherent soil fertility and organic matter content. The soils are moderately affected by salty tidal water.

At present most of the land covered with these soils are grown by paddy rice. The land is subject to flood slightly to severely. The installation of drainage facilities is requisite for increasing productivity of these soils under proper irrigation farming.

The typical soil profile is described in Table 3.1.5.

d. Prensa Soil Series

The soils of Prensa series extend over the undulating dissected fan terraced land in the skirt of Mt. Arayat. The surface drainage is good to excessive and the internal drainage is poor. The total land area is about 500 ha or 0.8% of the surveyed area.

The horizon sequence of these soils shows A/C. The A horizon has a grayish brown clay underlying dark grayish brown compact clay. A considerable amount of Mn/Fe concretions and gravels is found through the profile and its content increases with depth. The structure is moderately to strongly developed blocky.

pH value of the soils indicates slightly acid to neutral.

Presently lands covered with these soils are under paddy cultivation. There are no problems of flooding.

The typical soil profile is shown in Table 3.1.6.

e. Quingua Soil Series

The soils of Quingua series extend over the nearly level to very gently undulating land on the river terrace of the Pampanga River. The lands with these soils are well drained. The total land area amounts to 6,500 ha or 6.30% of the surveyed area.

The horizon sequence of these soils consists of A/B/C. The A horizon has brownish gray silty clay loam with moderately to strongly developed angular blocky structure. The thickness of the horizon is about 20 cm. The B horizon is yellowish brown silty clay loam and sandy loam with weakly developed subangular blocky structure. The C horizon has brownish gray silt loam with few Fe/Mn concretion.

These soils have a moderately high inherent soil fertility. The pH value is neutral to mildly alkaline. Permeability is moderately slow.

Presently the lands covered with these soils are grown by mainly paddy and diversified crops.

Typical soil profile is as shown in Table 3.1.7.

f. San Fernando Soil Series

The soils of San Fernando series extend over the flat low-lying flood plain enclosed by the Pampanga River and the San Fernando River. The lands covered with these soils are very poorly drained. The total lands area amount to about 10,400 ha or 10.1% of the surveyed area.

The soil sequence of these soils is A/B/Cg. The A horizon is dark gray or brownish black clay with a thickness of about 20 cm. The soils have strongly developed blocky structure. The B horizon is grayish brown and yellow clay with moderately grayish clay and clay loam with few manganese concretions.

Inherent soil fertility of these soils is moderate. The content of organic matter is moderate. The pH value shows neutral. The soils are slightly affected by salty tidal water during dry season.

Presently the lands covered with the soils are used as paddy cultivation. The installation of drainage facilities is required for the increasing productivity under proper irrigation farming.

The typical soil profile is shown in Table 3.1.8.

g. Tagolod Soil Series

The soils of Tagolod series develop over the nearly flat land on the low continental alluvial terrace. The soils extend over the land stretching from north to south along the Pampanga River, where is enclosed by San Fernando soil series in the low-lying area and Quingua soil series in the higher elevated land than Tagolod soil series. The lands covered with these soils are somewhat poorly drained. The total land area is 7,300 ha or 7.2% of the surveyed area.

The horizon sequence is A/B/C. The A horizon ranging from 15 cm to 30 cm thick is grayish brown to gray light clay with moderately developed subangular blocky structure. The B horizon has grayish brown and grayish light clay and silty clay with few Mn/Fe concretions. These soils have moderately developed blocky structure.

The pH value is neutral. Inherent soil fertility appears moderate.

Presently the lands covered with these soils are used as paddy cultivation. To ensure and maintain high yield of agricultural production, proper irrigation farming is needed under the installation of drainage facilities.

The typical soil profile is shown in Table 3.1.9.

h. Zaragoza Soil Series

The soils of Zaragoza series develop over the nearly flat land on the low continental river terrace, extending over the both sides of the Rio Chico River. The lands covered with these soils are somewhat poorly drained. The total land area is about 8,200 ha or 7.9% of the surveyed area.

The horizon sequence of these soils is A/B/Cg. The A horizon is dark grayish brown clay with moderately developed blocky structure. The thickness of this horizon is about 20 cm. The B horizon is grayish clay with few fine Mn/Fe concretions. The soils have moderately developed subangular blocky structure.

These soils have high inherent fertility and high content of organic matter. The pH value is neutral.

Presently the lands covered with these soils are grown by paddy or grass. To ensure and maintain high yield of agricultural production, proper irrigation farming is needed under the installation of drainage facilities.

The typical soil profile is shown in Table 3.1.10.

3.1.4.3 Land Capability

(1) General

The irrigation project in the Pampanga Delta Development Project aims mainly to increase rice production as described in Development Plan. Further most of possible area to be irrigated extend over the lands where are readily used as paddy field at present.

Under the circumstances, introduction of land capability classification with emphasis on land assessment for paddy cultivation is considered to be practicable and suitable in the Pampanga Delta Development Project.

In view of above consideration, land capability classification system for paddy prepared by the Ministry of Agriculture, Forestry and Fisheries of Japan is considered to be most suitable for its introduction to the study. In addition to land assessment for paddy, assessment is practiced for diversified crops.

(2) Specification of Land Capability Class

Lands are classified into four capability classes, I, II, III and IV.

Each class is defined as follows:

Class I :	Land has almost no limitations or hazards for crop production and/or risk of soil damage. They are regarded as either naturally fertile or of the greatest potentiality for crop production without any improvement practices.
Class II :	Land has some limitations or hazards and/or risks of soil damage, and some improvement practices are required for normal crop production.
Class III :	Land has many limitations or hazards and/or risks of soil damage, and fairly intensive improvement practices are required.
Class IV :	Land has greater natural limitations than those in Class III, but can be cultivated for some crops under very careful management.

Land capability class is determined on the basis of the degree of inherent soil limitations, hazards and risk of soil damages for obtaining proper yield and carrying out proper irrigation farming. There are eleven factors for assessment of land capability as follows:

a. Thickness of surface soil

b. Thickness of effective soil depth

c. Content of gravel in surface soil

d. Easiness of plowing

e. Permeability of soils under submerged condition

f. State of redox potentiality

g. Wetness of land

h. Inherent soil fertility

i. Poisonous materials

j. Hazard due to inundation

k. Topography

Further factors from item d. to h. consist of several subfactors for assessment of the land and land assessment is evaluated by subfactors synthetically.

The specifications of land capability class are explained as follows:

a. Thickness of surface soil/1

Class	Paddy	Diversified Crops
Class I	more than 15 cm	more than 25 cm
Class II	less than 15 cm	25 - 15 cm
Class III	less than 15 cm	less than 15 cm
Class IV	less than 15 cm	less than 15 cm

b. Thickness of effective soil depth/2

Class	Paddy	Diversified Crops
Class I	more than 50 cm	more than 100 cm
Class II	50 - 25 cm	100 - 50 cm
Class III	25 - 15 cm	50 - 15 cm
Class IV	less than 15 cm	less than 15 cm

c. Contents of gravels in surface soil

Class	Paddy	Diversified Crops
Class I	less than 15%	less than 5%
Class II	15 - 35%	5 - 15%
Class III	35 - 50%	15 - 35%
Class IV	more than 50%	more than 35%

/1: Surface soil is defined as the soil depth which plant root can penetrate easily for absorbing moisture and nutrient, usually ploughing horizon.

/2: Effective soil depth is soil depth up to base rock, hard pan, fragi pan or gravel layer which plant roots are not able to penetrate.

d. Easiness of plowing

Easiness of plowing is assessed by three subfactors: soil texture of top soil, stickiness of top soil and consistence when dry and moisture content.

Class	Soil Texture/1 of Top Soil	Stickiness of Top Soil	Consistence When Dry
Case I	coarse	non sticky	firm
Class I	medium	sticky	firm
Class I	medium	sticky	firm
Class II	medium	sticky	very firm
Class III	very fine	very sticky	very firm

e. Permeability under submerged condition

As far as assessment for permeability under standing water in paddy field is concerned, its assessment is synthetically carried out on the basis of two subfactors; soil texture of subsoil of 50 cm below plowing layer and compactness of subsoil of 50 cm below plowing layer.

Class	Texture/2	Compactness/3
Class I	very fine or fine	compact or medium
Class II	medium or coarse	compact or medium
Class III	medium or coarse	loose

/1: very fine: clay
medium : sandy or silty loam
coarse : sand

/2: very fine: clay
fine : clay loam
medium : sandy or silty loam
coarse : sand

/3: compact : more than 14 kg/cm^2 by hardness matter
medium : 14-1.4 kg/cm^2 by hardness matter
loose : less than 1.4 kg/cm^2 by hardness matter

f. State of redox potentiality

Reduction of soils in paddy field is assessed by three sub-factors; content of readily decomposable organic matter, content of free iron oxides in surface soils and gleyzation synthetically.

Class	Content of Readily Decomposable Organic Matter/1	Content of Free Iron Oxides/2	Gleyzation/3
Class I	low	high	weak or medium
Class I	low	low	weak or medium
Class I	medium	high	weak or medium
Class II	low	low	strong
Class II	medium	high-medium	strong
Class II	high	high	medium
Class III	medium	low	strong
Class III	high	high	strong
Class III	high	medium-low	medium strong

g. Wetness of land

This assessment factor is only applied to diversified crops.

Class I no hazard for overwetness or overdryness

Class II slightly hazard for overwetness or overdryness

Class III hazard for overwetness or overdryness

Class IV considerable hazard for overwetness or overdryness

/1: low : less than 10 mg NH4-N/100g
medium: 10-20 mg
high : more than 20 mg

/2: high : more than 1.5% for dry soil
medium: 1.5-0.8%
low : less than 0.8%

/3: weak : no gley horizon within 50 cm from the surface
medium: gley horizon exists within 50 cm
strong: gley horizon exists throughout profile or exists below plowing layer

h. Inherent soil fertility

Inherent soil fertility is assessed on the basis of cation exchange capacity and base saturation degree synthetically.

- for paddy

Class	Cation Exchange Capacity /1	Base Saturation Degree /2
Class I	high	medium
Class I	medium	high
Class II	high	low
Class II	medium	medium
Class II	medium	low
Class III	low	medium-low

- for diversified crops

Class	Cation Exchange Capacity	Base Saturation Degree
Class I	high-medium	high-medium
Class II	high-medium	low
Class III	low	high

/1: high : over 20 me/100g
medium: 20-6 me/100g
low : less than 6 me/100g

/2: high : over 50%
medium: 50-30%
low : less than 30%

i. Poisonous materials

Hazard due to poisonous materials such as sulfuric or sulfidic materials, saline, metals (Cr, Ni, Cu, Zn, As) is assessed for paddy and diversified crops as follows;

Class	Hazard
Class I	non
Class II	slight
Class III	medium
Class IV	severe

j. Risk of soil damages due to inundation

Risk of soil damages due to inundation is assessed as follows:

Class I	no risk if rainfall with high intensity occurs
Class II	Even if inundation occurs due to high rainfall intensity, excess water is drained out for a short period.
Class III	Inundation continues for a long period if rainfall with high intensity occurs.

k. Topography

Class	Paddy	Diversified Crops
Class I	less than 3°	less than 3°
Class II	less than 3°	3 - 8°
Class III	3 - 8°	7 - 15°
Class IV	over 8°	over 15°

(3) Land Capability

Based on the specifications of land capability class, each soil mapping unit is assessed as shown in Table 3.1.11.

The area occupied by each class and its extent are summarized in Table 3.1.12 and illustrated in Fig. 3.1.2.

3.1.5 Geology and Soil Mechanics

3.1.5.1 General Geology

Central Luzon Plain is a part of a geosynclinal basin, located between the ultra-basic and metamorphic rocks the mountain ranges of Sierra Madre in the east and of Zambales in the west. The objective area is located at the southern part of this geosynclinal basin, bordering on the Manila Bay.

The objective area is covered by recent sedimentary deposits composed of loosely compacted and poorly cemented cobbles, gravel, sand, silt and clay, overlie the older geologic units of the Central Plain. Mt. Arayat consists of pyroclastic and volcanic rocks.

3.1.5.2 Geology of Dam Axis Line of the San Antonio Reservoir

The dam surrounds the San Antonio Swamp. Surface materials of the Swamp are mostly composed of soft and unconsolidated clay or silty clay, occurring locally silt and/or silty sand.

a) Dam Site at the Downstream

The uppermost layer at the dam axis is composed of sandy materials with medium value of N-value under which clayey layer exists.

b) Dam Site at the Upperstream

The layers on the eastern part of the dam axis are composed of thick sandy materials. On the western, clayey layers are deposited. Both layers indicate medium and/or high in value of N-value.

Detail descriptions are shown in Chapter 4, Appendix III.

3.1.5.3 Geology for Route of the Canal and Related Structure Site

a) West Diversion Channel and Intake Site

The surface layer of the Channel Route and intake site are composed of soft clay or silty clay in general. The sub-surface layer of the Route consisting of soft clay indicates very low value of N-value and qc. The intake site conceived at Candaba for the Channel has low N-value until about 18 m from the ground surface. The intake site conceived at San Simon underlies sandy layer below 6 m from the ground surface, of which bearing capacity shows more than 10 in N-value.

b) Levee Embankment Route for Improvement of the Downstream of the Pampanga River

The clayey layer being intercalated by sandy materials is deposited throughout the profile on the route. The sandy materials exist at between 2 and 7.5 m from the ground surface. In general N-value for the layer shows low and becomes lower as location of the route nears the mouth of the Pampanga River.

Details are explained in Chapter 4, Appendix III.

3.1.5.4 Quarry

Mt. Arayat having basaltic rocks is available for quarry site for the Project. Although quality of these rocks is not always best for construction materials, these are useful for the materials for the Project because structures are not so large scaled.

Details are explained in Chapter 5, Appendix III.

3.1.5.5 Earthquake

It is reported that 190 times of earthquakes with magnitude of more than 5.0 occurred within 300 km of radius from Mt. Arayat for the period of 30 years between 1949 and 1978.

From the earthquake data, design earthquake coefficient is determined by using the Iwasaki's formula and probable return period based on the plotting position of earthquake data as non-annual exceedence series, and is recommended to be 0.12.

Details are explained in Chapter 6, Appendix III.

3.1.5.6 Soil Mechanics

Analysis of physical and strength properties of the soils relevant to the objective area was carried out for the design and construction planning of dam and levees. It has been confirmed that there exist soils suitable for embankment materials in the objective area. Details are shown in Appendix III and Data Book.

3.2 Socio-economy

3.2.1 Demography

Total population in Central Luzon is estimated at 5,184,000 in 1980. The population of the objective area is estimated at 1,792,000 in 1980 sharing 35% of the total population in the Central Luzon.

Out of the total population in the objective area, around 45% or 809,000 live in Pampanga province, about 36% or 654,000 in Bulacan province and the remaining 19% in three provinces, Tarlac, Nueva Ecija and Bataan provinces. Average population density in the objective area is 559 persons per km^2. The highest population density of 1,056 persons per km^2 is recorded in Bulacan province, while the lowest one of 162 persons per km^2 is registered in Bataan province. The overall population growth rate is 2.8% per annum from 1975 to 1980 in the objective area.

Total number of households in the objective area is 301,068 and the average family size is estimated at 6.0 persons. Out of the total households, 64,350 families or 21% belong to farm household. Relatively high percentage more than 30% of farm household is registered in Tarlac, Nueva Ecija and Bataan provinces, while that of Pampanga province and Bulacan province is low of 23% and 13%, respectively.

3.2.2 Regional Economy

The Region III, Central Luzon consists of six provinces, namely, Nueva Ecija, Bulacan, Pampanga, Tarlac, Zambales and Bataan. Total land area is about 18,000 km^2 out of which 33% or 6,000 km^2 are cultivated farmland. Although recent data are not available yet, the economic structure in the Central Luzon region is briefly hereunder.

Gross Regional Domestic Product (GRDP) of the Central Luzon was estimated at ₱6,222 million (at constant 1972 prices) in 1976 which shared around 9% of the Gross Domestic Product (GDP) in the nation. During the period of 1972-1976, the GRDP increased at the annual compounding growth rate of 5.4%. Per-capita GRDP was estimated at ₱1,368 (at constant 1972 prices) in 1976, which increased at an average growth rate of 2.0% during the past five years.

Agricultural sector is still the mainstay of the regional economy sharing around 37% of the GRDP and absorbing 43% of the labor force in the region. The growth rate of the sector was relatively low of 3.0% per year during the past five years from 1972-1976. Industrial sector is the second largest sector in the regional economy with the share of 35%. Particularly, manufacturing sector is the largest sub-sector in industrial sector was the share of 27%. Services sector is still small in the region and dominates around 28% of the GRDP. Both the industrial sector and the services sector expanded with relatively higher growth rates 7.2% and 6.8%, respectively, during the past five years. Details of the GRDP are presented below.

GRDP by Industrial Origin

	Value (Million Pesos at 1972 Prices)		Annual Compound Growth Rate
	1972	1976	1972-1976
Agricultural, Fisheries and Forestry	₱2,038	₱2,296	3.02
Industrial Sector	1,634.2	2,155	7.16
Mining and Quarrying	66.3	52	5.89
Manufacturing	1,337	1,673	5.76
Construction	208	393	17.24
Electricity, Gas and Water	22.9	37	12.74
Services Sector	1,362.3	1,771	6.78
Transport, Communication and Storage	124.3	216	14.81
Commerce	775	945	5.08
Services	463	550	4.4
Gross Regional Domestic Products	₱5,034	₱6,222	5.4

Source: SCO-NEDA, NAS - NEDA and NRO III

3.2.3 Regional Infrastructure

Total road length in the Central Luzon was 9,288/1 kilometers (km) about 33% of which or 3,086 km are paved with concrete or asphalt and the rest are gravel and earth road. The existing road network is extensive and fairly adequate enough to support the smooth flow of commodities and people.

Two main railway lines and some branch lines are operated by the Philippine National Railways. The two main lines, the North and South lines connecting to the north run 187 km long through the provinces of Bulacan, Pampanga, Tarlac and San Jose City in Nueva Ecija. Other lines run Meycauayan to Moncada with a total length of 132 km. The tracks and bridges of the railway are in substandard condition and need major repairs.

Furthermore, there exist two national ports and four private ports in the Central Luzon including the Port of Mariveles, which serves the transport need of the Bataan Export Processing Zone. There are also 12 airports consisting of three public airports, six private airports and three military airports.

/1: as of 1977

There are 71,243[/1] existing sources for water supply, out of which 49% are served by shallow wells, 48% by deep wells and 3% by springs and other sources. The existing system is in such state that it failed not only in coping with the rapid increase in population, but also in rendering the desired service. Electricity in the region is supplied by the National Power Corporation (NAPOCOR) through the Luzon grid which distributes electric power in all provinces of Luzon area. Electric cooperatives or private franchise holders purchase power from NAPOCOR and provide for the distribution of electricity among the household population. The electrification ratio in the Central Luzon was estimated at 68% as of December 1977.

Telecommunication will increasingly play a major role in regional economic activities. Nueva Ecija, Bulacan, Bataan and Pampanga will need additional telephone services as the promise of urban development looms large in these provinces. An inventory of existing telecommunication facilities shows that there are III wire-telegraphs in the region fairly distributed among its provinces and 127 offices are authorized to handle telegrams services. These are sufficient to service the need of 116 municipalities and five cities in the Central Luzon.

3.3 Agriculture and Agro-economy

3.3.1 Land Use

3.3.1.1 Land Use in the Objective Area

Dependable recent information on land use in the objective area is not available. The absolute land devoted to paddy field, sugarcane field and other major upland crops is estimated at the maximum harvested area during the period of recent three years from 1977 to 1979. The summary of land use in the objective area is shown in Table 3.3.1. Farm land consisting of paddy field, sugarcane field and other crop area in the objective area is 126,000 ha or about 40% of the objective area. Paddy is the main crop in the area. Paddy field occupies 101,500 ha or 80% of the farm land. About 60% of the paddy field is irrigated land.

However most of the irrigation system in the objective area is so simple and deteriorated. In addition considerable number of small pumps is used in the objective area by private farmers, of which the operation and management for these facilities are not properly functioned due to increasing oil price and shortage of spare parts. Furthermore water for irrigation is restricted during the dry season. Consequently irrigation water has not applied sufficiently in volume and in time, which results in the one of the factors in low yield of paddy as mentioned later. Further about 30% of the irrigated land is not irrigated during the dry season due to lack of water sources.

Following paddy, sugarcane is the second major crop, being cultivated in 21,000 ha or 6.6%. In the other crop area, corn is the major crop which occupies of about 60% of 3,500 ha.

/1: As of 1977

3.3.1.2 Land Use and Number of Houses in and around the San Antonio Swamp Area

Land use map in and around the San Antonio swamp area (see Fig. 3.3.1) is prepared by the use of aerial photos on a scale of 1/8,000[/1] and 1/5,000[/2].

The results of land use are as follows;

Grass and or Swamp Land	11,000 ha
Paddy Field	24,000 ha
Villages, Rivers, Road and Others	500 ha
Total	35,500 ha

Glass land extends over the low lying area and back swamp of the Rio-Chico River. The area is so called as San Antonio Swamp and seems to function as natural retarding basin. Most of paddy field occupy the higher elevated land than grass land, and are under rainfed culture.

For the estimation of number of households in and around the San Antonio swamp area, numbers of houses are counted from the interpretation of above aerial photos.

About 1,800 houses are recognized within the area of the proposed San Antonio Reservoir in Report on PD/CS Area Development Project. Supposing that one household with 6 persons lives in one house, 11,000 persons will be accounted. The distribution of houses in and around the San Antonio swamp area is illustrated in Fig. 3.3.2. The houses are concentratedly distributed in the following two places, one is the area with about 650 houses lying about 10 km northwest of the confluence of the Rio-Chico River and the Pampanga River. The other is the area with 600 houses, which is located at about 20 km north of that confluence.

3.3.1.3 Land Use in the Area to be Irrigated

The land use map in the right side of the Pampanga River, the area to be irrigated is prepared by the aerial photos on a scale of 1/8,000 as shown in Fig. 3.3.3.

/1: The aerial photos provided by NIA were shooted in 1976.

/2: The aerial photos were shooted by JICA during the period of December 1980 to January 1981.

3.3.2 Cropping Pattern and Farming Operation

3.3.2.1 General

In order to grasp the existing cropping pattern and farming operation prevailing into the objective area, field reconnaissance was carried out by the questionnaire method with coordination of BAEcon staff, paying attention on typical farmers under rice rainfed, rice irrigated and sugarcane cultivation. Sampling number of farmers in the reconnaissance are totally about 100 in Pampanga, Tarlac and Nueva Ecija provinces. The questionnaires collected from the above survey was analysed. In addition the results obtained from the above survey were confirmed by the door to door survey for the related governmental organizations such as BAEcon, BAEx, Municipality Office, Maligaya Rice Research and Training Center, PASUDECO, NASUDECO, Philippine Sugar Commission, etc.

3.3.2.2 Present Cropping Pattern

The main crop grown in the objective area is paddy, followed by sugarcane and diversified crops. The cultivation pattern is strongly affected by distribution of rainfall. The wet season paddy is planted on the onset of the monsoon, generally May to August and harvested at September to December. The dry season paddy is planted at the period of November to January. As for sugarcane, planting is practiced from October to April which coincides with the harvesting season. With regard to diversified crops such as mongo beans, peanut, corn, etc., these crops are grown without irrigation in both paddy field and upland area. In paddy field these crops are planted at the time after harvested of the wet season paddy, using soil moisture remained. Based on the result of the field reconnaissance and data from BAEcon, the area of the paddy field used for diversified crops is about 10 percent of paddy field. In the upland area, cultivation of diversified crops is entirely dependent on the rainfall.

3.3.2.3 Farming Practice

(1) Rice

Rice is the most important crop in the objective area. Farming is carried out by labour intensive form from the stage of seeding and harvest with the exception of isolated instances. All members of family contribute their labour. Carabao or oxen provide motive power for land preparation. In the objective area, improved high yielding rice varieties such as IR series, UPLB series and BPI series prevail. Among them IR-20, IR-36 and IR-42 are the major variety in the area. Additionally local varieties such as Wagwag and Veser have been spread in the objective area. The growing period is usually about 110 to 140 days for high yielding varieties and 160 to 180 days for local varieties.

Seed is selected from the last harvest or is provided through Bureau of Plant Industry. Seed is grown in nurseries covering about 1/20 to 1/25 of the field and remains in the nursery for about one month before transplanting to the field. About 75 kg of seed is applied per ha. Application of fertilizers and chemicals is practiced over the area and dosage of these varies largely depending on location. The estimated dosages of fertilizer per ha range from 25 kg to 70 kg of N, 4 kg to 15 kg of P_2O_5 and 1 kg to 13 kg of K_2O. With regard to chemicals, less than one liter is applied in spite of considerable damages due to stem borer, bacterial blight, tungro, grassy stunt, etc.

Farm operation is carried out by man power except for land preparation. Transplanting method is prevailing. Fertilization and weeding are done once or twice during growing period. Harvesting is done by sickles.

Typical farm input volume in Pampanga province is shown in Table 3.3.2.

(2) Sugarcane

PHIL, CAC and H37 varieties are prevailing in the objective area. Growing period of these varieties is usually twelve months. One ratoon crop is generally practiced because of drastic drop in ratoon yields. Seed pieces are planted at the rate of 30,000 to 40,000 pieces per ha. Fertilizers are applied at the rate of 70 to 110 kg of N per ha. Phosphoric and Potassium fertilizer are not applied. The conventional mechanized land preparation widely accepted by cane farmers consists of one to two plowing operation by tractor. Animal drawn plow or tractor-drawn cultivator is used in cane cultivation. Weeding is commonly done twice. Generally no herbicide is used. Sugarcane harvesting is generally done manually by cane knife.

Typical amount of farm input in Pampanga province is shown in Table 3.3.2.

(3) Diversified Crops

With regard to diversified crops including corn, mongo, peanuts, cassava, sweet potato, sorghum and vegetables, their cultivation is very simple. No fertilizer are applied in general. Farm operation is carried out manually. Management work is mainly weeding. These diversified crops are prevailing into rainfed land and are planted after harvesting wet season paddy in general.

3.3.3 Crop Yield and Production

Yield and total production of major crops at present condition are estimated on the basis of the data supplied by Bureau of Agricultural Economics and Philippine Sugar Commission. Yield and production of major crops fluctuate year by year due to variation of annual rainfall, flood damages, unexpected damages by diseases and insects, etc. The present yield and production are estimated as average value from 1977 to 1979 for paddy and sugarcane and from 1975 to 1979 for other major crops.

3.3.3.1 Paddy

The yield and production of rice for the objective area are shown in Table 3.3.3. The table indicates that with the exception of Nueva Ecija and Bulacan provinces the unit yields of paddy is considerably low especially Pampanga province. These low unit yields are considered to be accrued from the following major constraints encountered based on the reconnaissance field survey and results of analysis of farm economic survey:

a. Insufficient irrigation water in volume and in time

b. No or insufficient provision of drainage systems

c. Low farm input and limited extent of proper farming

d. Unexpected damages by insects and diseases and flood

Average unit yield of paddy for irrigated land in the objective area is 2.7 ton/ha for wet season paddy and 2.9 ton/ha for dry season paddy. For non-irrigated land unit yield is 2.1 ton/ha. The total production of paddy in the objective area amounts to about 350,000 tons. Details of unit yield and production are shown in Data Book.

3.3.3.2 Sugarcane

There are four sugar mill factories in the five provinces, PASUDECO, NASUDECO, TARLAC and PANIQUI. Out of them, foregoing three factories exist in the objective area. The yield and production of sugar are shown in Table 3.3.4 for the objective area.

Compared with the average value (4.8 ton/ha) of the whole Philippines unit yield of sugarcane is very low, showing 2.93 tons of sugar/ha. The reason of low yield is mainly due to uneven distribution of precipitation and low farm input. The total production of sugar in the objective area is estimated at 61,000 tons.

3.3.3.3 Other Major Diversified Crops

Yield and production of major upland crops are summarized at Table 3.3.5. Yields are generally low since no fertilizers are used without irrigation. Total productions of other major crops in the objective area are 2,000 tons of corn, 400 tons of mango, 10 tons of soybeans, 120 tons of peanuts, 2,900 tons of sweet potatoes, 300 tons of cassava, 400 tons of sorghum, 13,000 tons of fruit vegetables and 2,600 tons of leafy vegetables, respectively. Details are shown in Data Book.

3.3.3.4 Past Trend of Crop Yield, Acreage and Production

Past trend of unit yield, acreage and total production of major crops was examined for the study of estimation on unit yield and production in without project condition in the future. The past trend is estimated on the basis of least squares line method. The results are summarized in Table 3.3.6 and 3.3.7.

As for paddy, the unit yield indicates positive tendency at Pampanga, Bulacan and Nueva Ecija Provinces, suggesting the effect of irrigation project such as rehabilitation of the Angat irrigation, the Pantabangan irrigation project, etc.

3.3.4 Livestock

Livestock is not a main line of the agricultural activity in the objective area. There are no large scaled livestock raising in the area. Most farm households raise a few chickens, ducks or pigs in and around the paddy field on a small scale.

Many have either carabao or oxen. The livestock plays an important role in supply of protein sources for the local people and in provision of motive power and transportation measures in the objective area.

Number of livestock and poultry in the objective area is as shown in Table 3.3.8. Details in number of livestock in five provinces are shown in Data Book.

3.3.5 Land Tenure and Holding

The government has promoted land reform program since 1972. The programs apply to tenant farmers of private agricultural lands primarily devoted to rice and corn under a system of share crops or lease-tenancy. The tenant farmers will be deemed owners of a portion constituting a family size farm of up to 5 ha if not irrigated and up to 3 ha if irrigated provided the landowner owns more than 7 ha. In this case, the landowner may retain an area of not more than 7 ha if he is cultivating the area. This program is called Operation Land Transfer (OLT).

If the landowner possesses less than 7 ha of land, the share tenants should be converted to leaseholders with written and registered lease contracts. This program is called Leasehold Operations (LO). The price of rice and corn land under land reform programs is defined as 2.5 times the value of the average gross yield of the last three normal crop years excluding years of typhoons and other unexpected disasters. The tenants are required to amortize the full value of the land paying and interest rate of 6 per cent.

Through the land reform programs of OLT and LO, the situation of land tenure has changed in the five provinces related to the objective area. The tenurial status in five provinces is summarized in Table 3.3.9. Details are shown in Data Book. Table 3.3.9 indicates that the percentage of owner operator to total number of farm in Pampanga province is 4.5%, the lowest in the five provinces, following 8.5% in Nueva Ecija, 13.9% in Bataan, 19.1% in Bulacan and 20.2% in Tarlac. As for farm size, it is different according to land tenure categories. Average size is 1.78 ha for Pampanga province, 1.67 ha for Tarlac province, 2.30 ha for Nueva Ecija province, 1.67 ha for Bulacan province and 2.96 ha for Bataan provinces, respectively.

3.3.6 Marketing and Prices

3.3.6.1 Marketing Structure of Output

(1) Rice

There exist three kinds of marketing channels for rice distribution. The one is the channel from the National Food Authority (NFA). The NFA procures rice or paddy at government support prices through the following several systems.

- Direct Procurement - procurement transaction between the NFA procurement team and the farmer without intermediaries or middlemen personalities, i.e. a direct farmer's cooperative, and NFA buying and selling arrangement.

- Procurement through Millers Quedan - Miller-contractors procure paddy from farmers using their own funds at a price not lower than the government support price. These contractors then present the non-negotiable quedans for a sale to the nearest NFA office in the quantity corresponding to the stored paddy in their warehouse. Once bought by NFA, the paddy remains in the millers warehouse until ordered to be milled and delivered to NFA warehouse in the form of rice.

- Procurement through Payment-in-Kind - The NFA has entered into agreement with the various financial institutions and other government agencies that lend out financial and material help to farmers whereby the farmers deliver their produce to NFA as their payment-in-kind for the loans with respective agencies. The NFA, upon receipt of such produce, notifies the institutions the amount delivered by the farmers for them to credit the farmer's accounts.

The NFA in the five provinces distributes rice to licensed retilers in the provincial level and to the NFA other than five provinces which encounters the critical shortage of rice. The second one is the commercial channel through middlemen, warehouse, millers wholesalers and retailers. They purchase rice from farmers and sell it to wholesalers in general. Wholesalers in turn sell it to the licensed retailers. The third one is the channel through Area Marketing Cooperative (AMC's) and Farm Cooperative Marketing Association (FACOMA). These organizations are composed of small farmers. The farmers deliver to the AMC which in turn sells direct to supermarkets. FACOMA sells either direct commercial outlets or to the NFA. About 10 to 15% of total marked rice is through the channel of the NFA and the remainder through commercial and other organizations.

(2) Sugar

As for marketing of sugar, sugarcane produced by farmers or estate farms of sugar mill is milled in integrated Sugar Central Company Incorporated (NASUDECO), Pampanga Sugar Development Company Incorporated (PASUDECO), and Azucarera de Tarlac. NASUDECO is a semi-governmental cooperation. It collects sugarcane from its estate farm and also from private farmers. PASUDECO and Azucarera de Tarlac are the private company operate sugar mills wholly under the contract with farmers. After milling in NASUDECO, PASUDECO and Azucarera de Tarlac, sugar is sold to the Philippine National Bank from which all the cash payment is made to farmers. The sharing arrangement between farmers - millers is about 67:33. The sugar, then, delivers to the Philippines Sugar Commission (PHILSCOM), which is the governmental organization for controlling the sugar price and the amount to be sold. From PHILSCOM, a part of the sugar is exported overseas and a part to domestic consumption or reserve. In 1978/79 above three mills produced sugar of about 163,800 tons. Out of productions, 81,910 tons were distributed to export, 75,300 tons to domestic consumption and 6,600 tons to reserve.

3.3.6.2 Balance of Supply and Demand of Rice in the Five Provinces and Sharing of Rice

For the rough estimation of marketable surplus of rice in the five provinces, balance of demand and supply of rice is examined from 1970 to 1979 on the basis of following assumption.

1) Waste and seed requirement are taken as 10% of total production of rice.

2) Milling recovery rate from paddy to rice is 1:0.63.

3) Annual per capita consumption of rice is 120 kg taking into consideration of results of farm economic survey/1 and food consumption patterns survey/2

The results are as shown in Table 3.3.10. The table indicates the shortage of rice has occurred in Pampanga and Bataan provinces every year. Especially the shortage of rice in Pampanga province reaches about 50,000 tons of rice on an average from 1977 to 1979. These shortage of rice would be made up with the supply mainly from Nueva Ecija province. The marketable surplus of rice in the five privinces are estimated at about 60,000 to 130,000 tons. It is considered that most of these marketable surplus of rice have been inflowed into Metro Manila through the said channels of the NFA, the commercial and the agricultural cooperative sectors.

Table 3.3.11 shows the amount of rice inflows into the NFA, Metro Manila. The total amount in 1979 is about 90,000 tons of rice of which about 23% or 21,000 ton is occupied by the five provinces. Supposing that the NFA treats the rice of 15% of total marketed rice in Metro Manila, total marked inflow into Metro Manila is estimated at about 600,000 tons through the all channels. On the other hand, the amount from the five provinces is estimated at 140,000 tons of rice. This value is nearly same as the amount of marketable surplus estimated from the study of balance of demand and supply of rice.

The sharing ratio for supply of rice to Metro Manila by the five provinces is considered to increase in the future taking into consideration advantages that the five provinces are located at about 100 km northwest of Metro Manila.

/1: About 150 kg of annual per capita consumption is obtained from questionnaire survey for about 100 farmers.

/2: Food consumption patterns by staff of special study and division and the NFA, March 1980.

3.3.6.3 Distribution of Agricultural Input

At present some 15,000 tons of rice seed and 714 million pieces of sugarcane seed are used in the objective area. These amounts of seeds are obtained by retention from the farmer's production. In addition the rice farmers get the registered and or certified seed from seed growers under control of the Bureau of Plant Industry. Fertilizers and agricultural chemicals are distributed to the farmers by 97 dealers/1.

3.3.6.4 Crop Production Infrastructure Support Services

The number and capacity of rice mills and warehouses in the objective area are shown in Table 3.3.12. Details are explained in Data Book. The total number of rice mills amounts to 580. The milling capacity is estimated at about 6,500 tons per day of which value would be sufficient at present output. However, present processing facilities except the one owned by the NFA are so old that the NFA has encouraged to upgrade these facilities. The total number of warehouses is 480. The total capacity is 169,000 tons which would be sufficient at present output.

3.3.6.5 Prices for Agricultural Output and Input

For the economic evaluation, the estimation of economic prices for rice, sugar and fertilizer is examined on the basis of the information obtained from the governmental agencies and the some publications/2.

As a result, the economic prices estimated at the Balog-Balog multipurpose project is considered to be most practical for the evaluation. In this report the economic prices described in the said project are applied as follows:

Economic Farm Gate Price

Year	Paddy	Sugar	Fertilizer		
			N	P	K
	(₱/t)	(₱/t)	(₱/kg)	(₱/kg)	(₱/kg)
1980	1,490	1,840	5.2	5.6	2.9
1985	1,710	2,030	6.2	7.4	3.1

The economic and financial prices for rice, sugar and fertilizers are shown in Table 3.3.13 to 3.3.15.

/1: This figure does not include number of dealers in Pampanga province related to the objective area.

/2: Price Prospects for Major Primary Commodities prepared by the World Bank and Philippines Estimates of Shadow Prices and Country Parameters.

3.3.7 Agricultural Support System

3.3.7.1 General

Governmental organizations with respect to agricultural support system are centered in Manila or Quezon City running from there to the regional, provincial and municipality level.

The objective area belong to the Region III. The provinces related to the area are composed of five provinces such as Pampanga, Tarlac, Nueva Ecija, Bulacan and Bataan.

A number of government and non government organizations plays an important role in the function of the agricultural support for increasing agricultural production through the intensification program, extension and research work, seed multiplication work, credit, land reform, etc. The principal agencies are as follows:

- The National Irrigation Administration
- Ministry of Agriculture
  - The Bureau of Agricultural Extension
  - The Bureau of Plant Industry
  - The Bureau of Agricultural Economics
  - The Bureau of Soils
  - The National Food Authority
- Ministry of Agrarian Reform
- Philippine National Bank
- Rural Bank
- The Development Bank of the Philippines
- University of the Philippine College of Agriculture
- Central Luzon State University
- The International Rice Research Institute

Fig. 3.3.4 to 3.3.6 shows the organization chart of the Ministry of Agriculture and the National Irrigation Administration.

3.3.7.2 Masagana-99 Program

Masagana-99 program is the one of the agricultural supporting program in order to increase rice production. This program is controlled by the Bureau of Agricultural Extension. The program launched at 1972 and has given great effort in increasing of rice. Under the program a farmer gets a package of subsidized inputs with credit from the Government through Rural Bank, Philippine National Bank and other organizations. The interest rate is one percent per month. From Phase XIV (November to March 1980) production credit increases from ₱1,200/ha to ₱1,600/ha.

In the objective area, about 7,000 farmers take part in Masagana-99 Phase XIII (May to Oct. 1989) and 4,700 farmers in Phase XIV (November to March 1980). The Masagana area devotes about 30% in Phase XIII and 15% in Phase XIV for total planted area of paddy. The repayment of loan is considerably low, being 66% in Phase XIII and 4% in Phase XIV. The summary is shown in Table 3.9.16. Details are as shown in Data Book.

3.3.7.3 Research and Extension

The country's formula in attaining rice self-sufficiency can be attributed to the new technology, development of high hielding varieties, supervised credit, irrigation development, massive extension and information services and intensified marketing services extended jointly by the government and private sector.

The ramification of these technical know-how with the proper usage of farm inputs is the product of unceasing researchers of different agencies whose function and pledge are to increase production and higher farm income. Mentioning some agencies directly or indirectly responsible for research work are the following: International Rice Research Institute (IRRI) at Los Baños, University of the Philippines College of Agriculture (UPCA) at Los Baños, Maligaya Rice Research and Training Center (MRRTC) at Muñoz, Central Luzon State University (CLSU) at Muñoz, National Irrigation Administration (NIA), Ministry of Agriculture (MA) and other private agency.

The IRR alone carries hybridization of rice that is high yielding and resistant to diseases and insect pests. It also identifies unusual performance stability grown in varying environment of hot and cold.

UPCA and CLSU are responsible for researches of all crops in different angles to boost production and helps in molding stronger agriculture.

MRRTC which is operated by the Bureau of Plant Industry, researches work in rice varietal and improvement, crop production and processing, intensification of cultural and management practices, seed certification, etc. It also trains technicians and farmers who will directly apply the know-how to the farm.

NIA whose main function is to supply irrigation water now undergone research. It undertakes water management and study of land classification, irrigation extension and agro-economic research.

The Bureau of Plant Industry (BPI) carries the research and field trials on rice, and other field legumes, vegetables, fiber, beverager, spices, ornamental plants and others. The BPI carried out the work with regard to climatic condition, cultural practices and control of plants pests and diseases. The Bureau of Animal Industry helps to dessiminate animals and increase animal production. The Bureau of Agricultural Extension (BAEx) maintains extension work.

Private agency whose motive is either personal or help government in food production campaign found themselves involved and can not just ignore research like the chemical dealers and corporate farm.

Ultimately, the research effort would be meaningful and effective through better technology transfer and bridge the wide productivity gap between experiment station and farmers fields. Technology dessimination is carried out by efficient BAEx and BPI personnels and other private sectors like the bankers whose function are alike.

BAEx is responsible for the improvement of rural life through strengthening of agricultural extension and dissimination of useful and practical information on agriculture, soil conservation, livestock, home economics and rural life through field demonstrations, lectures and other means of imparting information. This extension work is completed by BPI on giving knowledge on plant care, insects and disease control and others.

The bankers like the Rural Bank, Philippine National Bank, Development Bank of the Philippine and other allied banks employ technicians. Though the hired technicians function is to assist in lending and collect loans they are obliged to do extension work to assure better repayment.

Technicians lessen the borden on extension work by forming different organizations like the Samahang Nayon, Irrigation Association, Rural Youth Officers, and other association who can help improve rural life. The association limit some benefits of non-members that members might enjoy from the government such as the loaning benefits, agricultural training and others.

The government who finds farmers insufficient funding made possible by the creation of M-99, Irrigation Development Program, Rice Applied Research Program, Training and Information Program and Intensified Marketing Program.

The M-99 intensify by the use of high yielding varieties, the proper use of the right amount of fertilizers, pesticides and herbicides and adoption of proper cultural practices beneficial to increase rice production. The package of the M-99 includes non-collateral production loans extended on a supervised scheme. The loaning rate which changes every year is ₱1,600 per hectare to date composed of cash and inputs.

To further help rice production the NIA is envisioned to irrigate the paddy of 130,000 hectare every year. This is further supported by the Farm Service Development Corporation (FSDC), in irrigation and in agricultural production.

Functions of all government agencies in research and extension work hold through in the objective area. Extension work tightens by frequent meeting, conferences and actual demonstration on farmers field to mould a well dedicated farmers.

3.3.8 Farm Economy

Dependable recent information on farm income in the objective area is not available. The survey results/1 conducted by National Census and Statistics Office (NCSO) are used. Average annual farm income in rural area by province is as follows;

Bataan province	₱1,329
Bulacan province	₱3,624
Nueva Ecija	₱2,905
Pampanga province	₱3,705
Tarlac province	₱5,960

On the other hand the average annual household total farm income in rural area in the Philippines is ₱4,588. Except the Tarlac province farm income is lower than that of the Philippines, which might be mainly due to flooding and low agricultural products.

As for the farm income in N. Ecija province, its value does not still realize the effect by the Pantabangan irrigation project implemented in 1974. The farm income in N. Ecija province will increase mucn in the near future.

For Bulacan province, farm income is medium in the five provinces. Remaining medium income level would be due to affect of flooding and due to the fact that its value does not still reveal the effect of the rehabilitation of Angat irrigation project in 1978. Present farm income would be increased.

The farm income in Pampanga province is also in medium class. It is considered in the analysis of present crop yields that increasing of farm income is restricted by low agricultural productivity.

/1: 1975 Integrated Census of the Population and Its Economic Activities, Phase II

3.4 Irrigation and Drainage System

3.4.1 Existing Facilities

3.4.1.1 General

At present, about 242,000 ha of the land areas or 30% of the total paddy field are irrigated in Region III, Central Luzon except Zambales province. Very few irrigation systems are available for diversified crops.

The existing irrigation facilities are classified into four categories; a) National Irrigation System, b) Communal Irrigation System (CIS), c) Pump Irrigation System, and d) Private and Other Irrigation System. Table 3.4.1 shows irrigated area of each system in five (5) provinces in Region III.

3.4.1.2 National Irrigation System (River Irrigation System)

National Irrigation System, which generally commands wider area, has been constructed and managed for operation and maintenance by National Irrigation Administration (NIA). There are seven systems under the National Irrigation System in Region III except Zambales, which irrigated 175,720 ha or 57.3% of the total paddy field in wet season and 159,420 ha or 52.0% of the total paddy field in dry season. Service area of each National Irrigation Project is tabulated in Table 3.4.2 and shown in Fig. 3.4.1.

Among the seven (7) systems, the Upper Pampanga River Project (UPRP) including Peñaranda River Irrigation System and the Angat Maasim River Irrigation System (AMRIS) have the reservoirs. The water released from the reservoirs through hydro-electric power plant is diverted for the irrigation purpose in the downstream. Owing to the storage in the reservoir most of the service area of these projects are irrigated both during wet and dry seasons. On the other hand, other National Irrigation Systems depend upon the natural flow of rivers and the service areas become 8,820 ha in dry season, much smaller than that of 30,120 ha during wet season.

Rehabilitation and upgrading of the Tarlac and San Miguel-O'Donnell River Irrigation Systems are being conducted at present by Tarlac Irrigation System Improvement Project (TISIP).

Some of Candaba Swamp Area and Lower Coastal Area are included in the Peñaranda River Irrigation System and AMRIS. There is no National Irrigation System in West Bank Area except Porac-Gumain River Irrigation System (PGRIS) which covers only 4-5,000 ha against about 50,000 ha of the existing paddy field in West Bank Area.

3.4.1.3 Communal Irrigation System

Communal Irrigation System (CIS) usually commands small area. CIS has been constructed by NIA and operation and maintenance are conducted by irrigators association with guidance of Farmers System Development Corporation (FSDC) and NIA. The number and service area of CIS in each province in Region III are shown in the following table.

Province	Number of CIS	Service Area
	(No.)	(ha)
Tarlac	57	19,985
Nueva Ecija	62	25,345
Pampanga	61	13,201
Bataan	66	5,401
Bulacan	48	3,965
Total	294	67,897

Source: NIA Regional Office

In the West Bank Area of the objective area, many CIS exist, but the water sources are from relatively small streams. Number of CIS existing in Pampanga province and some part of Tarlac province in connection with the West Bank Area is 59 systems irrigating 12,134 ha, about 25% of the paddy field in wet season as tabulated in Table 3.4.3. The approximate location of the service area of each system in Pamapnga and Tarlac provinces is shown in Fig. 3.4.2. Because of small quantity of water available in the water source during dry season, the area irrigated by CIS during dry season are quite limited to about 22%of the service area irrigated during wet season.

3.4.1.4 Pump Irrigation System

Pump irrigation has been developed to increase the irrigable area by NIA and FSDC. The existing number of pump irrigation projects and their service area in Region III are summarized in the following table.

Province	Surface Water Pump		Ground Water Pump	
	No. of Project (No.)	Service Area (ha)	No. of Project (No.)	Service Area (ha)
Tarlac	257	2,053	732	3,678
Nueva Ecija	81	410	825	3,572
Pampanga	368	5,172	2,132	10,266
Bataan	70	396	200	786
Bulacan	702	3,522	377	1,069
Total	1,498	12,003	4,256	19,331

Source: NIA Regional Office and NIA Pampanga Provincial Office

In the West Bank Area many pump irrigation systems are functioning. The number of pump systems and their service area in the West Bank Area are 2,428 systems and 15,848 ha, respectively as shown in Table 3.4.4, 3.4.5 and 3.4.6.

Pump irrigation system requires much cost for operation and maintenance especially for small scale pump due to high cost of fuel. In the lower area, irrigated area by pump is badly affected by the influence of salt intrusion during dry season.

3.4.1.5 Private Irrigation System

In addition to the above mentioned irrigation systems there are some private irrigation systems constructed and operated by private personnel or association without any financial assistance from the Government agencies. The number of the private irrigation systems and their service area are not clarified in the objective area.

3.4.1.6 Drainage System

In spite of the existence of many National Irrigation Systems, drainage system is rather insufficient especially in lower reaches in Region III. Excess water in the field is usually drained through natural streams and rivers.

In the West Bank Area, although the right bank of the Pampanga River from Mt. Arayat down to the Bebe San Esteban Cutoff Channel is protected from the flood of the Pampanga River by the setback levee, the lower area, south of Manila North Express Way, is feequently inundated during the wet season because of poor drainage.

3.4.2 Water Management System

3.4.2.1 Water Management System for National Irrigation System

After completion of the construction of the National Irrigation System, operation and maintenance of the system are conducted by NIA from the reservoir dam and/or the diversion dam to turnout on lateral and sublateral canals. Operation and maintenance of field ditch after turnout are conducted by irrigators association organized on every turnout and field ditch assisted by management technician or irrigation technician.

The irrigation fee is collected from benefited farmers for payment of operation and maintenance cost of the system. The irrigation fee charged to the farmers is 2.0 to 2.5 cavans or ₱130 to 162.5 per hectare for wet season and 3 to 3.5 cavans or ₱195 to 227.5 per hectare for dry season as shown in Table 3.4.7 in detail.

In UPRP including PRIS, AMRIS and TISIP, irrigation management technologist and technician are assigned for every 2,500 ha and 500 ha respectively, so that water management of the irrigation system is to be properly conducted and the limited irrigation water is to be efficiently utilized. The water management technician who is to be graduate of agricultural college is assigned in the field after completing one year training course. A typical organization chart for managing national irrigation system is shown in Table 3.4.8.

Number of permanent staff for managing each system is shown in Table 3.4.9.

3.4.2.2 Water Management System for CIS

The construction of CIS facilities is commenced after the irrigators association is organized by the benefited farmers with assistance of FSDC and an agreement for the repayment of the construction cost in installment in maximum 50 years without interest is made between the association and NIA. Operation and maintenance, and the collection of repayment are conducted by the association for which a technical assistance is provided by NIA and FSDC.

3.4.2.3 Water Management System for PIS

Small irrigation pumps with 4 and 5 inches diameter have been distributed by NIA to private personnel and irrigation pumps of which diameter is above 6 inches have been distributed by FSDC as it is necessary to organize a irrigators association for such a large pump.

Operation and maintenance are conducted by private personnel or associations obtaining a technical assistance from NIA and FSDC.

3.4.3 Existing Irrigation Development Plan

3.4.3.1 National Irrigation System

In NIA Central Luzon Report, 19 irrigation projects, 17 with reservoir, with the total irrigable area 283,120 ha are proposed as shown in Table 3.4.10 and the location of the proposed reservoir in the Pampanga river basin is indicated on Fig. 3.4.1.

Among those proposed national irrigation projects, the feasibility study on the Balog-Balog Irrigation Project has been completed and the feasibility study on the Casecnan Transbasin Diversion Project is being conducted now. The proposed service area of the two projects are also indicated on Fig. 3.4.1.

In the West Bank Area of the objective area there is no national project to be implemented soon.

3.4.3.2 Communal Irrigation System

According to five year development plan, 1980-1984, for Communal Irrigation System prepared by NIA, Communal Project Implementation Department, the construction plan of CIS in Pampanga, Tarlac and Nueva Ecija provinces related to the irrigation development plan in West Bank of the objective area is as shown in Table 3.4.11. Number of the proposed projects are 30 projects to irrigate nearly 10,000 ha. Those projects comprise the construction of new system, the renewal of the existing temporary dam to the permanent one, etc.

3.5 River Conditions and Floods

3.5.1 Present Conditions of Rivers

3.5.1.1 Catchment Area

The Pampanga River Basin, which includes the Pasag (Guagua) River Basin, is situated in the central part of Luzon and covers the southern slopes of the Caraballo Mountains, the western slopes of the Sierra Madre, the eastern foothills of the Zambales Mountains, and the major portion of the central plains. It is located between latitudes 14°44'N and 16°08'N and longitudes 120°21'E and 120°14'E. It covers wholly or partly the provinces of Pampanga, Bulacan, Tarlac, Nueva Ecija, Pangasinan, Zambales and Bataan provinces. A general map of the river basin is shown on Fig. 3.5.1.

The watershed area of the Pampanga River Basin at Sulipan gaging station covers an area of 8,910 km^2. The Pampanga River system includes the following 4 main watersheds.

	Watershed	Area (km^2)
A.	Upper Pampanga	3,512
B.	Rio Chico-Talavera	3,020
C.	Sierra Madre Mountains	2,375
	Sub-total for Pampanga Basin	8,907
D.	Zambales Mountains	1,596
	Total area of sub-catchment	10,503

The divided sub-basin of the Pampanga-Guagua Basin is shown on Fig. 3.5.2.

3.5.1.2 Topography

The Pampanga River Basin is divided into three kinds of topography; mountain, hill and plain. The mountains show dense contours of 100 m intervals on the map on a scale of 1:250,000 that is, they have steep slopes or their surface forms are very rugged. The Sierra Madre and the Zambales mountains make up the major part of them, including Mt. Arayat. They are composed of Mesozoic and Tertiary deposits and Tertiary and Quaternary volcanic rocks. The hills are represented by spares contours on the same map. The areas are distributed widely rolling gently at the foots of the mountain ranges on the east and west. They include the valleys between the mountains and the terraces on the river shores and are largely composed of diluvial deposit. The plains occupy the areas on the same map where almost any contour is not recognized, that means they are flat lands composed of alluvial deposit with swamplands included.

3.5.1.3 Characteristics of Major Streams and Swamps

a. Main Stream

The main stream of the Pampanga River has total length of 260 km from its source in the Caraballo Mountain Range to its mouth at Manila Bay. The distance to the main points from the river mouth is shown in Table 3.5.1. The main Pampanga River is divided into the following stretches taking into consideration of the topography and geology of the basin. Fig. 3.5.3 shows the longitudinal profile of the main stream.

From its source to Sapang Buho:

The river flows through the mountains from its origin to Rizal. The Pampanga River starts to the downstream reaches from the confluence of the Carranglan and the Pantabangan Rivers. At Sapang Buho, it joints the Santor River of about the same dimension. There is the Pantabangan Multipurpose Dam for irrigation, flood control and hydro-power at downstream from the confluence of the Carranglan and Pampanga Rivers.

From Sapang Buho to Arayat:

In the vicinity of Sapang Buho, the river flows through the valley between hills, with the bed slope of about 1/1,000. The river bed slope decreases gradually toward downstream, being 1/2,000 and 1/3,000 respectively in the vicinity of Cabanatuan and Cabiao, along with which the surrounding topography changes from hills to plains. The length of the stream in this stretch is about 108 km.

From Arayat to Calumpit:

The continuous levee is built on the right bank and the Candaba Swamp extends widely to the left side. Downstream from Candaba, the profile of the minimum water levels in the channel shows almost horizontal line during dry season. At the time of flood, the water surface slope is about 1/7,000. The Angat River joins it from the left at Calumpit. The length of the stream in this stretch is about 35 km.

From Calumpit to the river mouth:

This stretch forms a delta with the main stream branching into several channels. In the vicinity of Calumpit, there are three outlets leading to the delta from the Candaba Swamp, including a flood diversion channel. The three bridges of National Road No. 3 are these outlets.

b. Major Tributaries

Rio Chico River:

The Rio Chico River has the basin of 3,000 km^2, sharing for about 31% of the whole basin of the Pampanga River, and its tributary, the Talavera River, flow into the San Antonio Swamp, branching out small streams. The portion of the Rio Chico River upstream from Zaragoza is designated as the upper stream of this river. Talavera and other tributaries join it at this point. It is significant to designate the portions upstream from these points as upper basins, in view of the shapes of basins and the longitudinal profiles of the rivers. The Bamban River flows down from Mt. Pinatubo, and joins to the Rio Chico River at its right bank downstream from Zaragoza.

Angat River:

The basin of the Angat River covers 985 km^2, or about 10% of the whole basin of the Pampanga River. The Angat River is located in the southeastern part on the whole, and most of its basin is in maintainous district receiving much rainfall, with consequential yield of much runoff. The annual rainfall reaches 2,400 mm. There are the Angat Dam and the Ipo Dam. The water stored in these dams is used mainly for hydropower and drinking water supply to Manila. The Angat Dam contributes to flood control by the possible reduction of peak flows in the Angat River during early and out of the seasonal floods.

Tributaries into the Candaba Swamp:

Many tributaries flow into the Candaba Swamp, the principal ones among them are the San Miguel, the Garlang and the Maasim River. Their catchment areas are mainly hills, from which runoff has the direct influence on the water level of the swamp. They receive comparatively much rainfall.

Pasag (or Guagua) River:

The Pasag (or Guagua) River Basin is in fact a separate river basin from the Pampanga River. The basin drains four major tributaries rising in the southern and eastern slopes of Mt. Arayat and the eastern slopes of the Zambales Mountains. These include the Pasig Potrero, Porac, Gumain and Caulaman River basins which originate from the Zambales Range. All of these rivers discharge their flows into the San Fernando River or the complex rivers and channels in the delta area. The watershed area of the basin covers 1,600 km^2 or about 15% of the whole basin.

c. Swamps

The Pampanga River Basin is characterized markedly by its two swamps; Candaba Swamp lying between the Angat and Pampanga Rivers, and San Antonio Swamp between the Rio Chico and the Pampanga Rivers.

Candaba Swamp:

The Candaba has its huge retention volume of about 1.4 billion m^3, and acts to a certain extent on the overbank section of the Pampanga River, or as reservoir receiving only peak discharge of the rivers. Physically, the Candaba Swamp is divided into two parts by the Aris-Dilios dike, the North Candaba and the South Candaba. This dike was constructed by NIA within the framework of the Angat-Maasim River Irrigation System, flanks the left bank of the Maasim River and parts of the left bank of the Pampanga River from the confluence of these two rivers to a point near Apalit. The dike has a spillway length of about 200 m and an average elevation of 5.5 m above mean sea level, to prevent water spilling from North to South Candaba and prolong the period of agricultural activities there in the early part of the wet season. When the flood level exceeds the dike elevation, South Candaba will be inundated. The Elevation-Area capacity relations for the Candaba Swamp are shown in Table 3.5.2 and Fig. 3.5.4, based on the contour map as shown in Fig. 3.5.5 which was drawn on the basis of s = 1/5,000 topographic maps and s = 1/25,000 contour map surveyed by NIA and the check survey in the North Candaba by the JICA Survey Team.

San Antonio Swamp:

The area of San Antonio Swamp occupies about 120 km^2 in the northeast of Mt. Arayat, along the Rio Chico River, between the northern slopes of Mt. Arayat and the right bank of the Pampanga River. The area forms the lower portion of the natural floodplain of Rio Chico; its elevation varies approximately from EL. 7 to EL. 12 m above mean sea level, and the depth of water reaches up to 5 m during flood season. The area is drained by the Pampanga River channel which skirts the eastern slopes of Mt. Arayat.

The Elevation - Area - Capacity curves for the San Antonio Swamp are shown in Table 3.5.3 and Fig. 3.5.6 on the basis of the contour map shown in Fig. 3.5.7 which was drawn based on s = 1/5,000 topographic maps surveyed by NIA and the results of the check survey by the JICA Survey Team.

The San Antonio Swamp acts as a natural retarding basin not only for the Rio Chico River but also for the Pampanga River. To know flood control effect by the swamp under the existing condition, the hydraulic calculations were made with regards to the floods of 1973, 1974, 1976 and 100-year. The results show that the reduction ratio of peak discharge in 100-year flood is about 15% as shown in Table 3.5.4.

3.5.1.4 Carrying Capacity of River Channels

a) Cross-sections of River Channel

The cross-sectional survey of rivers was carried out by MPW with regards to the rivers as shown in Fig. 3.5.8, during the periods from Dec. 1980 to Feb. 1981. The interval of the cross-sections are 1 - 2 km. For the West Diversion Channel, the survey of longitudinal profile on the center line of the proposed channel was carried out. The content of the survey is summarized as follows:

River		Quantity
1.	Pampanga River	52 sections
2.	Hagonoy River	11 "
3.	Bebe San Esteban Cut-off Channel	4 "
4.	San Fernando River	20 "
5.	Labangan River	6 "
6.	Angat River	3 "
7.	Bagbag River	4 "
8.	Maasim River	13 "
9.	Cabiao-Candaba Floodway	8 "
10.	Total	121 sections
11.	Proposed West Diversion Channel	49 km

b) Carrying Capacity of River Channels

To estimate the carrying capacities of the existing river channels, the water surface elevations are calculated by the Standard Step Method of non-uniform flow in the sections mentioned above. The equation is as follows:

$$H_i = H_{i-1} + \frac{aQ^2}{2g}\left(\frac{1}{A_{i-1}^2} - \frac{1}{A_i^2}\right) + \frac{Q^2 n^2 X}{2}\left(\frac{1}{A_{i-1}^2\ R_{i-1}^{4/3}} + \frac{1}{A_i^2\ R_i^{4/3}}\right)$$

where, i: serial number showing a river cross-section

H: water level (m)

g: acceleration of gravity (m/sec^2)

Q: discharge (m^3/sec)

A: flow area (m^2)

X: distance between cross-sections i and i-1 (m)

a: correction coefficient for velocity distribution ($a = 1.0$)

n: manning's roughness coefficient

R: hydraulic mean depth (m)

The calculated results are compiled in DATA BOOK. The estimated carrying capacities are summarized as shown in Table 3.5.5.

3.5.2 Existing Flood Control Plans and Progress

3.5.2.1 Existing Flood Control Plans

The existing flood control system in the Pampanga Delta Area is the result of a continuous and dedicated effort since 1939. Its present configuration reflects almost entirely the design of the BPW Scheme III, briefly described in the Latter Section. This scheme is itself an outgrowth of an earlier plan developed in 1939 and subsequently updated. The flood control system consisting generally of earth dikes, diversion and cut-off channels and relief floodways, is based on the acceptance of the fact that the San Antonio and Candaba Swamps are part of the Pampanga River system. The design flood discharge and the main features of the flood control system are shown in Figs. 3.5.9 and 3.5.10 respectively.

The following is a short description of the main components of this system.

a) Arayat-Apalit-Masantol Setback Levee

This levee was designed to protect the lands to the west of the Pampanga against flooding from this river. A long continuous levee of about 42 km in length constructed to the west of the right bank of the Pampanga, it was laid out as an outer envelope of the Pampanga meanders from a point near Arayat, passing Apalit, down to Masantol where it connects with the northern levee of the Bebe-San Esteban Channel. Construction of this levee was completed in 1975. On the other hand, any levee is not planned on the left side between Arayat and Apalit facing to the Candaba Swamp, but the flood water exceeding the conveyance capacity of the normal river channels overflows into the Candaba Swamp and is stored in it so that the peak discharge of the flood is reduced.

b) Calumpit-Plaridel-Bustos Levee

This levee was constructed on the left bank of the Angat River to protect against flooding the lands south of it. Construction of the levee was completed in 1975. On the other hand, any levee is not planned on the right side between Pulilan and Apalit facing the Candaba Swamp in the same way as the section between Arayat and Apalit, but the flood water exceeding the normal conveyance capacity of the river channel overflows to the Candaba Swamp so that the peak discharge of the flood is reduced. In the sections extending Bagbag via Calumpit to Sulipan, the embankments of National Road No. 3 and Manila Railroad function as levees to protect the lower delta area from floods and three outlet channels are built through the three places mentioned above. When the water level of the Candaba Swamp rises above certain extent, the flood water inundates into the lower delta area not only flowing through the three outlet channels and the culverts built under the national road and the railroad but also overtopping the embankments of them.

c) Bebe-San Esteban Channel

This channel links the Pampanga River with the Pasag (Guagua) River at Masantol. The channel has been operated since 1958 and construction was completed in 1975. The channel is flanked by parallel dikes on the both sides and is provided with six (6) flood gates (three on each side) for combined flood control and irrigation purposes. The channel and its dikes are intended to accelerate the flood flow of the lower Pampanga River towards Manila Bay, and to protect from flooding the area in the delta.

d) Francis Flood Control and Irrigation Gate

This gate was constructed on the western bank of the Sulipan-San Miguel Channel. Completed in 1954, destroyed by flood in 1962, it was rebuilt in 1975.

e) Arayat-Cabiao Ring Levee

This levee encloses and protects against floods for the area of 45 km^2 laying between Arayat and Candaba, with its northern and western sections constituting the left bank of the Pampanga River, the eastern section functioning as the right bank of the Cabiao-Candaba Floodway, and the southern portion being the levee against Candaba Swamp. There is a special portion of the section facing to the northern part of the Candaba Swamp of which formation is lower than the others. The heightening works of the levee are being constructed. By the end of 1979, about 80% of the works were completed.

f) Cabiao-San Isidro Levee

This levee is to protect the paddy field extending to the left bank of the upstream of the Pampanga River around Cabiao against the floods of the river. The work was completed in 1978. On the other hand, there is no levee on the right bank of the Pampanga River between its confluence with the Rio Chico River and the Cabiao-Candaba Floodway. The flood water exceeding the conveyance capacity of the main river channel between Arayat and the floodway inundates over the San Antonio Swamp and is reserved in it so that the peak discharge of the flood is regulated.

g) Luyos-Bagong Sikat Cut-off Channel

This cut-off channel was constructed to straighten and shorten the course of the Pampanga River at Cabiao. The levee on the right bank between the Cabiao-Candaba Floodway and San Antonio was also constructed.

h) Labangan Floodway

The Labangan Floodway was designed to ease the flow constriction at Calumpit by conducting the flood flows from the Angat River through the Delta down to Manila Bay. To achieve this purpose it was planned to deepen and widen the Labangan River by dredging and to rectify and shorten its course by the excavation of several cutoff channels. To avoid flooding of adjacent agricultural lands and fishponds, the floodway was flanked by dikes. The first stage of this component was completed except dikes in 1979.

3.5.2.2 Progress of Flood Control Works and Present State

The needs for flood control in the Delta of the Pampanga River, one of the most highly developed agricultural regions of the Philippines, has long been recognized, but it was not until after the three successive major flood disasters of 1935, 1936 and 1937.

In 1938, the government prepared the initial plan for the project of the Pampanga River Control responding to widespread public clamor for flood control, investigations made by the Bureau of Public Works led to the formulation of a flood control scheme which with recommendation of technical advisers from U.S. Corps of Engineers, was approved and adopted by the Flood Control Commission in 1939. The flood control scheme was based on utilization of the huge natural retarding capacity of the Candaba and San Antonio Swamps. The scheme consisted of a system of levees, floodways, cut-offs and channel improvements. In 1939, construction was started with the organization of the Office of Pampanga River Control Project.

In 1940, the activity on the project was stop due to the advent of World War II. At the end of the war, with the multifarious problems of reconstruction and adjustment facing this Country, flood control was relegated to secondary priority. Work on the Pampanga River Control Project handicapped by inadequate financial support, continued at a slow pace.

In 1950, with agitation for the reclamation of the Candaba and San Antonio Swamps, a proposal in direct conflict with the flood control scheme, steadily built up. There was also a growing clamor for the protection of flood vulnerable areas in the lower plain of the Rio Chico River, a tributary of the Pampanga River, and for investigation of the possibilities of developing mountain reservoir sites for flood control storage and other multipurpose functions. Aware of these trends, the Bureau of Public Works continued, accumulating necessary topographic and hydrologic data.

In August 1960, a big flood occurred which caused lots of damages in the Pampanga Delta Area. Congress appropriated the budget for the project in 1961.

In 1962, Bureau of Public Works prepared a report on the "Proposed Reclamation of the Candaba and San Antonio Swamps". The report presents the plans and analysis of two potential plans of reclamation of the Candaba and San Antonio Swamps including flood control under each plan. The report also includes data for a plan covering flood control features in the Central Luzon area but with reclamation to a lesser extent.
In the report, the two reclamation plans are referred to as Schemes I and II and the flood control plan for Central Luzon with limited reclamation is referred to as Scheme III. A brief description of each potential plan is as follows:

a) Scheme I

As shown in Fig. 3.5.11, a copy of which is included herein, the plan consists of the following:

i) Labangan Floodway extending from Calumpit to the Manila Bay for a distance of 17 km. The floodway is 2 km wide. The pilot channel is 150 meters wide with 4.5 m average depth of excavation. The floodway will carry a large part of the discharge from the Pampanga and the Angat Rivers.

ii) Parallel levees along the banks of the Angat River to confine increased backwater heights extending from Calumpit to Baliwag, a distance of about 20.5 km.

iii) Candaba Floodway extending from the San Antonio Swamp to Calumpit, a distance of 47 km. This floodway will be 150 m wide and an average depth of excavation of 3.5 m.

iv) Parallel levees along the banks of the tributary streams draining the slopes east of Candaba Swamp. These streams are the Malimba, Bulu, San Miguel, and Maasim Rivers.

v) Parallel levees along the banks of the upper Pampanga River to confine increased backwater heights.

vi) Parallel levees along the banks of the Parua and Chico Rivers to confine increased backwater heights.

vii) Pumping systems in the Candaba and San Antonio Swamps to lift run-off into Candaba Floodway.

b) Scheme I-B

An alternative plan to Scheme I above outlines provisions for flood control and storage capacity in the Angat (already constructed), the Pantabangan (already constructed), and Talavera (under further study) multi-purpose dams. Schemes I and I-B are designed to pass 100-year maximum floods through the San Antonio and Candaba Swamps without inundation except for local rains which would be pumped into the floodway channel.

c) Scheme II

As shown in Fig. 3.5.12, 3 reproduction of which is also incorporated herein, provides for a hillbase intercepting channel as substitute for the system of parallel levees along the tributary streams draining hillside slopes into the Candaba Swamp.

d) Scheme II-B

An alternative to Scheme II also provides for flood control storage capacity in upstream reservoirs at Angat, Pantabangan and Talavera multipurpose dams.

e) Scheme III

As shown in Fig. 3.5.13 attached, provides for flood control and limited reclamation within the Candaba Swamp. However, the chief aim of this scheme is to protect the vast and fertile areas west of the Pampanga River between Calumpit and the foot of Mt. Arayat by erecting dikes along critical reaches of the Pampanga River and by constructing to expedite the removal of floodwater as quickly as possible.

Total estimated construction cost of the three schemes were as follows:

		(1962 price)
Scheme I	....	₱530,400,000
Scheme II	....	₱545,420,000
Scheme III	....	₱93,030,000

In connection with these studies, the Flood Control and Drainage Division of the Bureau of Public Works constructed a Fixed-bed hydraulic model of the flood plain of the Pampanga River extending from the San Antonio Swamp to Manila Bay. The model has horizontal and vertical scales of 1:1,000 and 1:100, respectively. The model was verified by using observed data in the prototype during the major flood of August 1960. The discharge ratio adopted for the model following careful verification tests is 1:500,000. Velocity ratio is 1:5 time ratio 1:200. This model was used to determine flood stages and profiles under Scheme III. This model was also used to determine flood stages and profiles under Schemes I and II. To obtain the discharge hydrograph as inflow of the model, the run-off analysis were made by use of unit hydrograph method. The discharge for a 100-year design flood under Scheme III is shown in Table 3.5.6.

All three schemes and corresponding alternative plans were submitted in 1962 to a team United States Agency for international Development (USAID) experts from the U.S. Bureau of Reclamation for further review and evaluation. In their report on "Review of Plans for Flood Control and Reclamation on the Pampanga River in Central Luzon" the team conclude:

i) Schemes I and II are rejected. They are not practical plans. They both accomplish adequate reclamation of the Candaba and San Antonio Swamps, but the costs of doing so is too great to warrant further consideration under present conditions. Not only the large construction cost, but also the expensive and difficult maintenance costs associated with keeping the systems in good operating condition further substantiate the recommendation for disapproval of Schemes I and II.

ii) Schemes III is endorsed. It is primarily a flood protection plan for much of the Pampanga River overflow plain, but also accomplishes a substantial amount of reclamation. It leads itself to a orderly program of construction and the features of the plan are such that reasonable modification can be made as found desirable from changing conditions and as future data become available. Aside from being formally reviewed by the USBR Team, Scheme III also bears the official mark of approval by the Flood Control Commission, as recommended by the U.S. Corps of Engineers.

In 1966, US Bureau of Reclamation prepared a report on "Central Luzon Basin Report". It describes the land and water resources development. The plan includes a reconnaissance appraisal for regulating and storage facilities essential for conservation and water control for purpose of irrigation, municipal and industrial use, flood control, and hydraulic power, but not evaluated in terms of costs and benefits. Fig. 3.5.14 shows the reservoir locations in the Pampanga River Watershed proposed by USBR.

In 1967, the Angat Multipurpose Dam in the upstream of the Angat River was completed by ADB fund. Although the water stored in the dam is used mainly for hydro-power, drinking water supply, the reservoir contributes to flood control by the possible reduction of peak flows in the Angat River during early flood season.

In 1973, the pilot flood forecasting and warning project in the Pampanga basin was established by the Typhoon Committee under technical assistance of Japan, in wake of the devasting floods in the past.

In 1974, the Pantabangan Multipurpose Dam in the upstream of the Pampanga River was completed by IBRD fund. The reservoir has flood control capacity of 330 million m^3 during flood season.

1977, UNDP prepared a report on the "Pampanga Delta/Candaba Swamp Area Development Project". With regards to flood control, the report proposed the following plans for flood damage alleviation projects.

a. West Diversion Channel

b. San Antonio Irrigation and Flood Balarcing Reservoir

c. East Diversion Channel

A brief of the plan is described in Chapter 4.

At present, implementation of flood control works based on BPW Scheme III, has been going on and off since 1939, depending on the availability of funds. By the end of 1979, an estimated 70 percent of the scheme was completed. The approximate status of implementation of its components, in percentage of the total amount of work is shown in Table 3.5.7.

3.5.3 Flood Discharge

After reviewing the previous reports and scrutinizing all the existing data, it was concluded to estimate the flood discharges by runoff simulation model of storage function on the basis of the historical flood rainfall pattern. There are many methods to estimate the discharge from the rainfall. Among them, the storage function method was adopted, because discharge hydrograph is necessary to study the storage effects due to discharge control by dam and retarding basin.

The storage function method needs the time-wise and an aerial distribution of rainfall. The typical flood from the past records were selected in consideration of aerial distribution of rainfall, magnitude of discharge and other elements. The selected flood is May 1976 which was a biggest in rainfall volume at Cabanatuan City and also a highest in water level at Arayat and Sulipan since 1960.

In runoff calculation, probability of exceedence of average rainfall over the Pampanga River Basin was estimated based on the correlation between the basin average rainfall and the rainfall at Cabanatuan City. The probable discharges were calculated for the return period of 5-year, 10-year, 20-year, 50-year and 100-year. The results are summarized as shown in Table 3.5.8. Details are described in Appendix II.

3.5.4 Flooding Mechanism and Flood Damages

3.5.4.1 Flooding Mechanism

Typhoons and tropical storms with rainfall lasting from one day to more than a week, and the topographic characteristic of the basin cause extensive floods in the lowlands, the delta, the swamps and the central basin.

Although the Pampanga River up to Arayat drains a relatively large area of about 6,500 km^2 its floods are of the flashy type considering their duration and the rates of rise and fall of their peaks.

Flood peaks from the Rio Chico and the Pampanga Rivers apparently reach their confluence at Arayat almost simultaneously, with an interval of a few hours only, in spite of the far from negligible routing effect resulting from upstream overland flow and flooding, among others, of the San Antonio Swamp which has a natural storage capacity of about 500 million m^3.

After the confluence, as the Pampanga continues to flow southwards, whenever the water stage in it rises above the crest of the Cabiao-Candaba Floodway (about EL. 9m), part of the river's flow is diverted into the Candaba Swamp depression. The remaining excess flow, above carrying capacity of the Pampanga spills over into the same swamp through various openings in the river's left bank.

Flooding of the San Fernando and Pasag (Guagua) Basins from the Pampanga River is prevented by the Arayat-Apalit-Masantol Levee.

The flooding of the Candaba Swamp thus appears to occur according to the following sequence. During initial inflow from the east (or from the Pampanga through the openings in the levee) in the early part of the rainy season the area gradually fills up as there is little or no outflow. Depending mainly on the inflow from the east, floods can cover areas of up to 100 km^2 which remain under water throughout the rainy season. During flood stages in the Pampanga, which usually occur in the later part of the rainy season, from mid-July, when flows in the river exceed carrying capacities, the natural levee on the Candaba side is occasionally overtopped, levels in the Candaba depression adjust readily to those of the Pampanga, and the whole Candaba area turns into a huge floodplain conveying excess carrying discharges from north to south.

Although the Candaba depression has been artificially divided by a dike along the Maasim River as described in the foregoing Section, this dike is not intended to stop floods higher than EL. 5.5 m. These higher floods overtop the dike and flow from Candaba North through Candaba South towards the outlets near Sulipan and Calumpit.

The flow constriction at Calumpit acting as a downstream control causes backing up of the water in the Pampanga River and in the Candaba Swamp.

A natural levee along the Pampanga, as a result of its own sedimentation process and the lack of internal waterways and drains prevents waters trapped inside Candaba to drain rapidly into the Pampanga upon recession of its levels.

The flooding mechanism in the middle reaches of the Zambales Range tributaries is much less complicated, and is mainly the result of the sudden change in slope of their entrance into the Delta area.

Flooding in the lower Delta is the result of the almost simultaneous convergence of flows from a catchment area totalling some 9,000 km^2 upon an area of only about 450 km^2. Even though a dense and intricate channel network and several estuarine rivers exist there, this system is completely inadequate to evacuate the flood. As a consequence, during floods, practically 90% of this area is inundated for considerable lengths of time. Fig. 3.5.15 shows possible inundated area and typical flood flow directions.

3.5.4.2 Flood Damages

Frequent flooding in the Pampanga Delta Area causes lots of damages to housing and property, agricultural crops and fish-ponds, roads and communications networks and other infrastructural services in the area, including the irrigation water supply and the drainage and flood control works. The major floods in the past are as follows:

1.	August	1937
2.	August	1948
3.	October	1950
4.	August	1960
5.	May	1966
6.	July and August	1972
7.	May	1976
8.	August	1978

Among the above major floods, the floods of July 1972 and May 1976 are remarkable. The former was a largest flood in rainfall volume and the latter was also a largest flood water stage at Sulipan Bridge since 1960. The storm characteristics of these floods are as follows:

a) Flood of 1972

The flood was at first caused by the tropical storm Edeng (July 6-8, 1972), then secondly by the typhoon Gloring (July 17-20, 1972) and by the typhoon Huaning (July 21-31, 1972) and finally by the tropical depression Isang (July 29 - August 1, 1972).

The amount of point rainfall at Gapan from July 6 to Aug. 4 was 1,431.3 mm. The maximum daily point rainfall at Gapan was 164.6 mm on July 6, and the maximum 2-day point rainfall was 326.2 mm on July 6-7.

The daily discharge at San Agustin, Arayat exceeded 1,700 m^3/s from July 9 - August 8. The maximum daily discharge at San Agustin, Arayat was 2,722 m^3/s on July 20.

b) Flood of 1976

The flood was caused by the typhoon Didang which crossed the Luzon Island from May 21 to May 23, 1976. The typhoon made a loop over Central Luzon while crossing the Luzon Island.

The amount of point rainfall at Gapan from May 21 to May 25 was 636.4 mm. The maximum daily point rainfall was 208.6 mm on May 23.

The daily discharge at San Agustin, Arayat exceeded 1,700 m^3/s from May 24 to May 30. The maximum daily discharge at San Agustin, Arayat was 2,780 m^3/s on May 25, 1976.

c) Inundation Area and Flood Damages

The inundation areas due to the flooding in the objective area are estimated about the floods of 1960, 1966, 1972 and 1976 as shown in Table 3.5.9, on the basis of the flood marks and the maximum water level at gaging stations.

The data on the flood damages for the floods of 1960, 1976 and 1978 are shown in Table 3.5.10.

3.6 Inland Fishery

3.6.1 General

There are several kinds of inland waters in the objective area, rivers, lakes and reservoirs, swamps, rice fields and brackish delta areas. At present, following fisheries activities in these waters are being operated under the administration and promotion of the Bureau of Fisheries and Aquatic Resources (BFAR) as shown below:

	Type of Water	Fishing	Stocking	Culture
1)	Rivers	0	0	X
2)	Lakes and Reservoirs	+	0	+
3)	Swamps	0	0	+
4)	Rice Field	X	X	0
5)	Freshwater Pond	X	X	0
6)	Brackish Water Pond	X	X	*

Remarks: X: no activities
0: active (year-round or seasonally)
*: very active (year-round)
+: experimental stage

3.6.2 Fishing and Stocking

Year-round fishing is operated in rivers, lakes and reservoirs. Tendency of over-fishing is observed in rivers. In case of the Pampanga River, its fish production was estimated at 300 kgs/ha in 1978/1. On the other hand, fishing in lakes and reservoirs is not so popular yet. The fishery hatchery stations of BFAR are producing the fingerlings of fresh-water fish such as carps, tilapias, tawes and mudfish. During 1978, 2.44 millions of fingerlings were produced and stocked in these waters.

Seasonal fishing is operated in swamps, especially Candaba Swamp (about 5,800 ha), after the rainy season, when the water level of the swamp goes down and fishes come down to the lowest parts. Swamps are usually owned by a few land-owners. For example, Candaba Swamp is shared by 187 land-owners (average 31.0 ha). They charge 85% of fish catch as fishing fee to the people who want to catch fish in the swamp during

/1: Socio-Economic Profile of Mt. Arayat & its Vicinity, 1978, Magalang Arayat Task Force (MARATAF) Pampanga, Region III.

the fishing season. But, during rainy season, free fishing is allowed to all the people when the swamp is filled up with water. No official records are available by national level on the productivity of Candaba Swamp. But it was estimated about 360 kg/ha by the Study Team of PD/CS Area Development Project in 1977/1.

3.6.3 Fish Culture

In the Philippines, the policies, programs and priorities for aquaculture development was set forth in the Presidential Decree No. 704 of 1975. This Decree emphasizes the following objectives for fisheries development, of which these are relevant to aquaculture:

(1) Attainment of self-sufficiency

(2) Export promotion

(3) Development of rural area

(4) Initiation of impact projects

To answer these national policies, the administration and promotion of fishery development is vested on BFAR. Accordingly, at present, almost all kind of inland waters except rivers are the target waters for the development of fish culture. Fish culture activities in the objective area are as follows:

(1) Some owners of Candaba Swamp constructed dikes and enclosed lower parts of the swamp. They stock fish fingerings and try to feed them to increase fish production before they harvest in dry season.

(2) The cage culture project at Pantabangan Reservoir showed a higher total yield than predicted by the Freshwater Fish Culture Center of Central Luzon State University (CLSU).

(3) Ricefield fish culture seems to have great potentiality to answer the national policies for fishculture development.

Significant progress was achieved with the growing of high-yielding, insect-resistant rice varieties in paddies with fish/2. Results of trials indicated good rice production without use of insecticides. Standing crops of Tilapia mossambica and Cyprinus carpio averaged 69 to 208 kg/ha/season.

/1: Fisheries Development Studies, 1977, Pampanga Delta/Candaba Swamp Area Development Project

/2: Rice-Fish Culture and Green Revolution, 1976, Grover, J.H., FAO Technical Conference on Aquaculture, Kyoto, Japan

A nation-wide field testing program for ricefield fish culture was conducted in the country in 1978 prior to field demonstration. Yield of fish averaged 201 kgs/ha/season/1, as shown in Table 3.6.1. It shows 310 to 590 kgs/ha/season in the objective area, Pampanga. But, in 1979, it reached only 96 kgs/ha/season/2. It seems that the technology of ricefield fish culture has not been established yet among the people in the objective area.

(4) Freshwater pond is called as back-yard fishpond in the Green Revolution Project. It is not popular yet in the objective area. The result of field testing program was 30 to 1,500 kgs/ha/year/3, as shown in Table 5.6.2. These results are much lower than that of the experiment (more than 3,000 kgs/ha/year) conducted in fertilized ponds by using mono sex tilapia/4.

(5) Brackish delta area of 28,500 ha in the objective area was used as milkfish pond in 1978 according to Fisheries Statistics of the Philippines. Total production was about 25,600 metric tons, and average productivity was 866.5 kgs/ha/year. The productivity of a milkfish pond is strongly influenced by the salinity of the pond water and soil conditions/5. In the objective area, the upper part of the Delta shows lower productivity (750 kgs/ha) than that of the lower part of the Delta (1,050 kgs/ha) as shown in Table 3.6.3. The municipalities comprising the Lower Delta and Upper Delta are classified as follows:

Upper Delta - Balagtas, Bocaue, Marilao, Guagua, Sexmoan, Minalin, San Fernando, Bacolor

Lower Delta - Paombong, Meycauayan, Valenzuela, Guiguinto, Malolos, Bulacan, Hagonoy, Macabebe, Masantol, Obando

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/1: Annual Report, 1978, MOA

/2: RDC Report to the President, 1979, Regional Development Council, NEDA, Region III, San Fernando Pampanga

/3: Socio-Economic Profile, 1978, Province of Pampanga

/4: Culture on male Tilapia mossanbica produced through artificial sex reversal, 1976, FAO Technical Conference on Aquaculture, Kyoto, Japan

/5: Technical Report, 1977, First ASEAN Meeting of Expert on Aquaculture

3.6.4 Situation of Inland Fisheries

It is revealed that various kind of inland fisheries activities exist in the objective area but freshwater fisheries seem to be still required much amount of economic and technical input. It is apparent that, at present, the inland fish production is mainly coming from brackish-water ponds (milkfish ponds).

Total inland fish production in the objective area in 1978 was 25.6 x 10^3 metric tons, which was 79.7% of the total fish production of 32.1 x 10^3 metric tons (including municipal and commercial fish production). On the other hand, in the national level, the inland fish production was 118.7 x 10^3 metric tons, which was 8.5% of the total fish production of 1,400 x 10^3 metric tons in the Philippines as shown in Table 3.6.4.

The situation of inland fisheries in the objective area, especially milk fish culture in the Delta area, is quite different from that of the national level and possesses quite important role for the regional economy.

3.6.5 Existing Studies

3.6.5.1 Master Plan Study

Master plan study on the development of inland fisheries in the objective area was carried out by the study group of UNDP PROJECT/PHI 74/015 and the report was issued in 1977.

In this report, the projected demand during 1975-1985 was estimated at 1.76 million tons in 1980 and 2.27 million tons in 1985 with the average annual rate of 5.75%. On the other hand, the total fish production in the Philippines during 1974-1978 was increased from 1.27 million tons to 1.58 million tons of which average annual increase rate is about 5.66%. Accordingly, it can be said that the trend of fish production by national level during the time followed to that of the projected demand.

The master plan proposed following development strategy:

a. Regional water management to protect the fishpond areas from floods, freshwater intrusion and pollution,

b. The introduction of additional farms of fish culture to reduce the dependence on the supply of milkfish fry,

c. A development effort aimed at raising the yields in existing fish firms,

d. Development of fish culture in new swampy area, and

e. Development of fresh water area for fish culture.

3.6.5.2 Blackish Fish Pond

Interview survey on the farm management of fishpond in Bulacan was carried out by BFAR in 1973. Table 3.6.5 shows the condition of farm management by different scale of fishpond.

Following characteristics of a farm management are obtained:

a. Pond operations above 30 ha are managed by the caretaker of the pond. Owners do not reside the job side. In many cases, ponds are leased to the person who has a technique of pond operation of which lease fee is usually occupied more or less 20% of the total operation expenses.

b. The expenses of pond maintenance, harvest and repair increase by the scale of the ponds. Those expenses occupy more than 15% of the total expenses for the small scale operation (0.55 ha) but, above the scale of 10 ha, it is kept below 15%.

c. The expense for the purchase of fry of fingerling is one of the biggest expense for one item and always occupies more than 15% in any scales.

d. The income of operation much depends on the sales of bangus (milkfish). Other kind of fishes can not grow well under the suitable pond condition for bangus.

e. Productivity of the fish pond is below 2 tons/ha/year in any pond scale and is independent on the pond scale. Productivity might be affected by other kind of environmental condition.

f. Net income will increase in proportion to the pond scale. But net income per ha is independent on the pond scale. Under the present condition, pond operation does not have any favor with the scale merit.

3.6.5.3 Candaba Fishing

For the development of freshwater fishery in the objective area, the characteristics of fish fauna of the Pampanga River should be clarified. But, as of now, sufficient data on this item are not available.

Candaba swamp area is yearly flooded by the water from the Pampanga River during rainy season. And much fish grow during the season and are caught after the flood.

This area is divided and owned by few land owners. Fishing is free during the rainy season but restricted to the land owners during the dry season. 85% of fish production goes to the land owners and the remaining 15% goes to the caretaker of the area.

According to the sales record of fish catch by one of the owner in 1975, following characteristics of fish fauna in Candaba swamp were obtained:

a. Several types of carp formed most dominant niche, the second was gurami and the third was few types of catfish.

b. Total fish production of the year was 10.6 tons from the water area of 330 ha, in other words, the productivity is 32 kg/ha.

The productivity of Candaba area seems to be low, which may be caused to lack of sufficient water area during the dry season in the area.

But, in the statistical record of the Government, the productivity is reported to be 360 kg/ha in 1975. The difference should be cleared in future for the developmental use of the area.

3.6.5.4 The Influence of the Labangan Floodway Construction to the Fishpond Operation in the Delta Area

In the Delta, fishpond areas are formed in wide range. Assessment survey was carried out to know the influence of the construction of floodway to the fishpond operation by using the case of the Labangan Floodway of which construction was started in early 1970.

Fig. 3.6.1 shows the location of Labangan Floodway and the water channel systems of fishponds along the Floodway. Following matters were clarified by the interview to the caretakers:

a. Frequency of flood has decreased since the end of the construction.

b. In the upper location such as St. 6, 7, 8 and 9, the increase of production was clearly observed, which was caused by the stronger salt intrusion after the construction.

c. In the lower location, the influence was not so clearly observed, but it was observed that the caretakers can control their ponds in good condition (to make grow lablab) more easily, compared with the previous time.

d. During the flood in 1980, some areas such as St. 2, 5, 9, 10 and 13 was not affected by the flood. Those areas have strong and tall dikes or locate in the lowest part of the Delta.

e. Almost all the fishes in the pond will escape from the pond once it is flooded even in few inches.

From these informations, it is concluded that the flood control by dredging or floodway gives much benefit to the fishpond operation.