CHAPTER 4 DEVELOPMENT PLAN FORMULATION

4.1 Review on the Proposed Development Plans

4.1.1 Review on the Flood Control Plans

4.1.1.1 Proposed Plan for Flood Control

(1) General

The Report on the PD/CS Area Development Project presents 5 proposed flood control plans, namely, the Labangan Floodway, the West Diversion Channel, the San Antonio Reservoir, the Upstream Reservoir and the East Diversion Channel. These plans were analyzed for each component and various combinations. Although the quantitative analysis of the flood damage in the analysis was limited to that on the Candaba Swamp area, the following tentative priority ranking is given in the Report on the PD/CS Area Development Project.

Priority Ranking	Plan
1st	Labangan Floodway
2nd	West Diversion Channel
3rd	San Antonio Reservoir
4th	Upstream Reservoir for Irrigation and Flood Control
5th	East Diversion Channel

A brief description for the above projects is as follows:

(2) Labangan Floodway

This floodway is under construction at present by MPW. The effect of the floodway is expected to reduce flood peaks at Sulipan-Apalit and to reduce flooding in the Candaba Swamp according to the Appendix I of the said report. The project works were planned for implementation in two stages. The first stage works include the widening of channel a bottom width to 40 m with dike-to-dike width to 240 m most of which was completed except construction of dikes. This will increase the channel capacity up to 1,000 m^3/s. The second stage works provide for widening the channel bottom to 80 m and the dike-to-dike width to 280 m in order to increase capacity to 1,600 m^3/s. The cost of the second stage work is estimated at ₱18 million in 1977 price.

(3) West Diversion Channel

The West Diversion Channel will start from the Arayat-Apalit setback levee at a point about 1.5 km downstream from the town of Candaba.

The layout of the West Diversion Channel is shown on Fig. 4.1.1. The longitudinal profile and its typical cross-section for three design discharges are presented on Figs. 4.1.2 and 4.1.3, respectively.

This channel will shorten flood durations in the Candaba Swamp; it is also expected to reduce water level and flood risks at Sulipan and at the downstream of Calumpit, thereby decreasing flood damages in the nearby areas and in the Delta.

The effect of this channel is that the areas of about 7,000 to 9,000 ha inundated presently for about 60 to 80 days will be relieved from flooding. Furthermore, flooding caused by over-bank spills at Sulipan will be decreased by 2.3 m in water depth in case of 100-year frequency flood.

Three alternative plans for the main structure are designed with three different discharges of 500, 1,000 and 1,500 m^3/s. Out of them, the case of 1,500 m^3/s was adopted in the CANDOP simulations. The estimated cost was some ₱470 million in 1977 price.

(4) San Antonio Reservoir

This plan is prepared mainly for irrigation purpose. Under this plan, discharge from Rio Chico River Basin of about 3,000 km^2 will be stored in the San Antonio Swamp by constructing low dam which starts on the Rio Chico River at north of its confluence with the Pampanga River and runs along the eastern boundary of the swamp.

The San Antonio Reservoir would have a multi-purpose function, i.e. irrigation and flood control, however, the flood control capacity will be fulfilled in the early wet season.

(5) Upstream Reservoir for Irrigation and Flood Control

Potential reservoirs to be located in the Sierra Madre and Zambales foothills are studied by NIA for storage of water for irrigation purpose. The existing reservoirs of the Angat and Pantabangan and the 14 potential reservoir sites in the basin are shown in Fig. 4.1.4. All the potential reservoirs are located in the Pampanga River Basin except the Gumain Reservoir which would be located on the Gumain River, a tributary of the Pasag-Guagua River system.

In order to evaluate the reduction in flooding area and duration, the following alternative plans were examined:

a) Construction of reservoirs at 14 sites described above for irrigation purpose only.

b) Construction of the same 14 reservoirs for irrigation and flood control purposes; providing increased storage capacity in these reservoirs.

c) Construction of only 8 out of 14 reservoirs, operating for both irrigation and flood control.

A summary of the important characteristics of the various reservoirs is given in Table 4.1.1. The results of the simulation analysis of flood control for return periods of 10-year, 50-year and 100-year are presented in Table 4.1.2 which shows reduction of peak flood discharge at Cabiao on the Pampanga River in all cases of alternatives described above.

The results presented in the table show that the operation of only 8 out of 14 reservoirs for irrigation and flood control, which entailed a 20% reduction in the added effective storage volume, was not accompanied by an corresponding increase in flood peaks. The pre-feasibility analyses for these projects were not made in the Report on PD/CS Area Development Project.

(6) East Diversion Channel

This diversion channel will start from the Pampanga River at San Isidro at about elevation 19 m above MSL relieving the Pampanga River of about 50% of its normal flow along this reach. The course of this channel will circumvent the Candaba Swamp from the east, passing between San Miguel and San Ildefonso and reach Manila Bay through west of Baliwag and Pulilan. The length of this channel will be about 65 km.

The alignment of East Diversion Channel is presented on Fig. 4.1.1. The construction cost of the East Diversion Channel was estimated at about ₱1,000 million in 1977 price.

4.1.1.2 Review on Flood Control Plans

(1) General

The plans mentioned above were based on 100-year design flood discharge estimated from the runoff analysis on the basis of the principle of random events of daily rainfall. The flood discharges were reviewed from the standpoint of hydrological applicability in the Pampanga River Basin. And the peak flood discharge were compared with the values analyzed by the Team, together with the design discharges adopted by MPW. Furthermore, flood control effects by the upstream reservoirs were examined with regard to 100-year flood discharge.

(2) Flood Discharges estimated by PD/CS Project

In the study, the synthetic series of daily rainfall were adopted on the basis of the principle of random events of daily rainfall. Using these rainfall, 30 year daily discharges were calculated with the runoff simulation program named MM08. This called "natural discharge" during the period of 30 years from 1946 to 1975. The probable peak discharges were estimated as shown in Table 4.1.3, on the basis of the natural daily discharge.

However, such a synthetic rainfall series differs from the actual precipitation characteristics explained as follows:

a) Tropical typhoons, tropical storms and depressions which are the main causes of large floods in the Pampanga River Basin bring the successive heavy rainfall over as much as several days. The characteristics of the time-wise distributions of the synthetic rainfall are not similar to the observed rainfall data, although the total volume of calculated monthly rainfall is mostly same as the observed one.

b) In case of actual rainfall the high correlation exists usually among the adjacent rainfall stations on the distributions of daily rainfall. However, the intensity and distribution of calculated synthetic series of daily rainfall are so random and no relation exists among the adjacent stations in the basin. The outflow at the confluent points have therefore a tendency of smaller amount than the real flow when it is calculated from the synthetic rainfall data.

For example, the synthetic series of daily rainfall is compared with the observed data as shown on Fig. 4.1.5. The definite difference on the rainfall pattern can be recognized between two rainfall series. Furthermore, probabilistic evaluation is made on the peak discharge at some tributaries and at main channel stations for both calculated values and observed discharge data. The results are shown in Table 4.1.4. The values derived from the observed data are bigger than the ones from the synthetic rainfall at three stations out of four. Those differences are presumed mainly due to the different patterns of rainfall.

(3) Flood Discharge Analysis

Under these circumstances, the flood discharges were newly analyzed by the Team, adopting the design rainfall based on the historical flood rainfall pattern with probabilistic analysis on the observed data and using the runoff simulation model of storage function. The procedure and results of the analysis are described in the Appendix II.

(4) Comparison of Flood Discharge

For comparison purpose, the peak flood discharges at main river stations are summarized in Table 4.1.5 which shows differences in values as estimated by MPW, TAHAL and the Team.

As mentioned above, the adopted rainfall for runoff analysis by TAHAL is the synthetic rainfall. When it is calculated from the synthetic rainfall, the outflow at the confluent points have a tendency to smaller than the real flow.

On the other hand, the method for runoff analysis as adopted by MPW is the unit hydrograph as described in Appendix II, in which, it was not considered large rainfall such as May 1976 rainfall that was the biggest rainfall in the past with 7-day continuous rainfall 877 mm at Cabanatuan City. This fact implies an underestimate in runoff volume of flood hydrograph, although the estimated peak discharge may be accepted.

The method for runoff analysis adopted by the Team is the storage function method. The adopted coefficients of the method are obtained from the data on the past flood records. The calculated flood hydrographs meet with the observed values of the past floods of Oct. 1973, Aug. 1974 and May 1976 as described in Appendix II. Thus, the probable flood discharge as estimated by the Team may be accepted as resonable.

(5) Flood Control Effects by Upstream Reservoirs

In order to evaluate the flood control effect of the upstream reservoirs, the runoff calculation was carried out with regard to the Pantabangan dam as existing and the following planned dams as potential for flood control measure in future.

River	Reservoir
Lubingan Cr.	Lubingan
Penaranda R.	Papaya
Sumacbao R.	Balintingon

To evaluate the reduction of peak flood discharge, the following 3 kinds of alternative plans were examined:

Case		Flood Control Capacity of Reservoir
1. No Reservoir		
2. Pantabangan Dam		$V = 330 \times 10^6 m^3$
3. Pantabangan Dam and 3 Potential Reservoirs	Pantabangan:	$V = 330 \times 10^6 m^3$
	Lubingan :	$V = 102 \times 10^6 m^3$
	Papaya :	$V = 92 \times 10^6 m^3$
	Balintingon:	$V = 154 \times 10^6 m^3$
	Total :	$V = 678 \times 10^6 m^3$

The storage capacity of the reservoirs is given in Table 4.1.6. The results of the calculation relating to flood control for 100-year return period are as follows:

Case	Cabanatuan		Cabiao	
	Qpeak (m^3/s)	Reduction (%)	Qpeak (m^3/s)	Reduction (%)
1. No Reservoir	4,273	-	5,581	-
2. Flood Control by Pantabangan Dam	3,572	16	4,895	12
3. Flood Control by Pantabangan Dam and 3 Potential Reservoirs	3,390	21	4,259	24

4.1.2 Review on Agriculture and Irrigation Plan

4.1.2.1 Review of the Report on PD/CS Area Development Project

In the Report on PD/CS Area Development Project (PC Report), the San Antonio Reservoir Project is proposed to irrigate the right bank area of the Pampanga and Rio Chico Rivers. The reservoir is to be constructed in the San Antonio Swamp. The principle features of the project are as follows:

a. Total irrigation service area — 55,000 ha
   - Gravity — (25,000 ha)
   - Pump — (30,000 ha)

b.	Reservoir capacity	1,560 MCM
	Dead volume	(450 MCM)
c.	Maximum water surface elevation of the reservoir	18.0 m above sea level
d.	Length of the reservoir dam	98.0 km
	Main dam	(44.0 km)
e.	Reservoir area	20,800 ha
f.	Objective crop of service area	paddy

The results of the review are as follows:

(1) Land Use and Cropping Pattern

Present land use map in the irrigation service area is not available in the Report. It is proposed in the PC Report that double cropping of paddy per year is to be applied to the whole irrigation service area.

Using available aerial photos, the land use of the irrigation service area (43,000 ha) excluding the overlapping area of Balog-Balog Irrigation Project was checked and studied. Out of the irrigation service area, 36,000 ha of paddy field, 7,000 ha of sugarcane field and 7,000 ha of residential and other miscellaneous area are recognized. The land emancipation program is now being undertaken for the land used for paddy and corn according to the criteria. In view of this fact, the diversification of the land from sugarcane field to paddy field would not be easily expected. This factor is to be fully considered for the study of cropping pattern in the future plan.

(2) Condition of Submerged Area by the San Antonio Reservoir

Land acquisition and resettlement is one of the most important aspects for the planning of the reservoir project. In the PC Report there is no information of inhabitants in the area to be submerged.

For the estimate of the inhabitants in the submerged area, the number of houses are counted by using available aerial photos on a scale of 1/8,000 provided by NIA and photos on a scale of 1/15,000 prepared by JICA. The number of houses is estimated at about 1,800 consisting of 11,000 persons within the reservoir area in case of high water elevation of 18 m.

Further, the area to be submerged and its land use were examined. The results are shown below:

	Results of the Examination	Report on PD/CS Area Development Project
Submerged area (ha)	27,000	20,800
Cultivated land (ha)	17,600	8,400

For the study of the planning of the San Antonio Reservoir and its project evaluation, special attention should be paid on the inhabitants and agricultural production accrued from the cultivated land in the reservoir area.

(3) Adverse Affects of Drainage Conditions Accrued from the Implementation of the San Antonio Reservoir

Implementation of the San Antonio Reservoir may worsen the drainage conditions for the surrounding area. Study on such affection of drainage has not been sufficiently carried out in the PC Report.

Drainage by pumping is essentially required for the specific area of about 9,000 ha extending over the right bank of the reservoir. Careful study for affection of drainage will be needed taking into consideration of the land use in the surrounding area.

(4) Technical Matters on the Reservoir

Evaporation from water surface of the reservoir is neglected in the PC Project. Based on the pan evaporation record at San Miguel, Tarlac province, total evaporation per annum is estimated at about 100 MCM in the reservoir area.

The planning of the reservoir is to be carried out taking into consideration of the evaporation.

(5) Maintenance of Existing Flood Control Capacity of the San Antonio Swamp

At present condition, the San Antonio Swamp has the natural flood control retention volume of about 650 MCM for the flood in 100-year return period. The construction of the reservoir in the swamp brings about diminision of natural flood control retention volume of the swamp. There is no mention about this matter in the PC Report. For making the reservoir plan, careful study is to be done so as to maintain the present natural flood control retention volume of the swamp.

(6) Water Requirement of Paddy

Design criteria for water requirement calculation of paddy in the PC Report appears impractical on the following points:

a. Value of Crop Coefficient (kc)

The water requirement calculation of paddy in the PC Report is estimated by pan method. The value of crop coefficient of paddy is rather big, which is about 1.3 at maximum, comparing with the previous studies such as the Upper Pampanga River Project and the Angat and Magat Project which crop coefficient of paddy is about 1.1 at maximum.

b. Puddling Requirement

Puddling water requirement for paddy was taken at 70 mm in the PC Report. This value is quite small taking into account of the farming practice in the Philippines. Water for land preparation except evaporation and percolation loss is actually over 150 mm in the country.

c. Overall Irrigation Efficiency

In the PC Report overall irrigation efficiency was applied to 80% for paddy field of which value is too big. It is practical that overall irrigation efficiency of less than 60% will be applied to the irrigation project with earth canal systems, having no farm ditches.

Water requirement calculation is to be carefully studied referring to the experiences of the other irrigation projects in the Philippines.

(7) Freeboard of the Reservoir

The San Antonio Reservoir has a large reservoir area with fetch length of more than 10 km. It is predicted that stronger wave action will occur in such a big reservoir.

In the PC Report freeboard of the reservoir dam is designed as 2 m above maximum water surface relevation. This value of freeboard is considered to be small from the safety view point. The height of freeboard is to be carefully studied.

4.1.2.2 Review of the Report on Irrigation Development Plan

In July 1977, NIA finalized the Report on Irrigation Development Plan for Central Luzon (NIA Central Luzon Report). In the Report the following five projects have been proposed in Pampanga province.

Project	Service Area (ha)
1. Gumain Reservoir	16,200
2. Tibu Reservoir	4,500
3. Malimura Reservoir	11,600
4. Pampanga Pumping	38,200
5. Southwestern Groundwater	3,800
Total	74,300 ha

It is concluded from the review of the Report that these irrigation projects are formulated systematically and reasonably.

The Pampanga pumping irrigation project, however, is planned to acquire irrigation water from the return flow which will be produced by the implementation of reservoirs in the Upper Pampanga River Basin. The construction of these reservoirs will require longer period.

It seems practical that the Pampanga pumping irrigation project be developed stagewise. As the first stage development, the pumping irrigation plan using the existing discharge of the Pampanga River will be needed to be studied.

4.2 Development Plan

4.2.1 General

On the basis of the results of the field investigation and preliminary study on the present condition of the objective area and in due consideration of the results of the review on the previous studies, basic concept for the development plan in both flood control project, and agriculture and irrigation project is formulated here for the study of the next phase.

4.2.2 Flood Control Plan

4.2.2.1 General

As mentioned in Chapter 2, annual inundated area is estimated at 820 km^2 within the objective area, which includes 230 km^2 swamp and its surrounding area and 330 km^2 of the lower coastal area.

To alleviate flood damages in these areas and to improve the sociopolitical conditions by enhancing their economic activity, the following flood control plans are considered to formulate an optimum flood control plan.

Case I	:	Flood control by the San Antonio Reservoir
Case II	:	Flood control by the West Diversion Channel
Case III	:	Flood control by improvement of the downstream channel of the main Pampanga River

In consideration of the effects from each plan, comparison was made on the above alternative plans. The above flood control plans were studied on the basis of hydraulic analysis. The hydraulic simulation for the above cases are illustrated in Fig. 4.2.1.

4.2.2.2 Design Flood Discharge

Level of a flood control plan should be determined taking account of economic importance of the objective area but also sociopolitical factors such as stabilization of people's livelihood and preservation of land for living and production. In the present comparative study, 100-year frequency is adopted as design flood which is the standard level adopted by MPW flood control scheme. The discharge distribution of the design flood under the existing condition is shown in Fig. 4.2.2.

4.2.2.3 Flood Control Plans

(1) Flood Control by San Antonio Reservoir

The purpose of flood control by the San Antonio Reservoir is mainly to reduce flood water level and flood duration in the area downstream from Arayat. Although the San Antonio Swamp acts as a natural retarding basin at present as stated in Chapter 3, the aim of this flood control plan is to control more effectively by means of reservoir operation.

The following 2 alternative plans are studied for comparative purpose.

- Plan-1: Existing swamp area are fully used for reservoir area.
- Plan-2: Existing swamp area are partially used for reservoir area.

To examine the effects on flood control in the downstream area, the hydraulic calculations by simulation model were carried out with regard to various storage capacities of flood control. In the calculation of the Plan-2, the H-V curve of the San Antonio Swamp is used as shown in Table 4.2.1. The results of the calculation are shown in Table 4.2.2 which shows that the following storage capacities are required to keep the same water level as the existing in the area downstream from Candaba.

Plan	Storage Capacity of Reservoir
Plan-1	$V = 420 \times 10^6 m^3$
Plan-2	$V = 100 \times 10^6 m^3$

Furthermore, the decrease in flooded area of the Candaba Swamp is comparatively small as compared with the storage capacity of the reservoir. Consequently, these flood control plans are not recommendable.

(2) Flood Control by West Diversion Channel

The purpose of the West Diversion Channel is to reduce flooding of the Candaba Swamp and the area downstream from Sulipan by diverting a part of the flood discharge from the Pampanga River reaches to the Guagua River through the new channel to be constructed. With regard to the route of the channel, the following 2 alternative plans are studied for comparative purpose. The routes of the planned diversion channel are shown in Fig. 4.2.3.

Plan-1: Between Candaba and the lower reaches of the Pasag River.

Plan-2: Between San Simon and the lower reaches of the Pasag River.

To examine the effects on flood control in the downstream area from Candaba, the hydraulic calculations by simulation model were carried out for the diverting discharge of $Q = 1,500\ m^3/s$ in maximum. The results are shown in Table 4.2.3 and Fig. 4.2.4. The calculated reduction of the water levels are as follows:

Plan	North Candaba Swamp	South Candaba Swamp	Sulipan
Plan-1	0.44 m	0.36 m	0.34 m
Plan-2	0.08 m	0.44 m	0.41 m

As shown in the above table, the reduction of water levels are small, especially for Plan 2. The planned longitudinal profile and standard cross-section of the West Diversion Channels (Plan-1 and Plan-2) are shown in Figs. 4.2.5 to 4.2.8.

(3) Flood Control by Channel Improvement of the Pampanga River

The purpose of channel improvement of the Pampanga River is to protect the land of the South Candaba Swamp and the land downstream Sulipan Calumpit against flooding from the Pampanga and Angat Rivers by constructing levee along the rivers as shown in Fig. 4.2.9. The improvement works mainly consist of embankment of levee, widening and excavation of the river channel on the stretch between Candaba and 7 km downstream from Masantol of the Pampanga River.

Using the hydraulic simulation model, the calculations were carried out to determine the flood discharge distribution and the cross-sections of the channel to be improved. For determination of the channel section, trial and error procedure was adopted. After several tentative calculations, the design discharge distribution and the channel section to be improved were determined.

For comparative purposes, the following 2 alternative plans for 100-year design flood are studied according to stretch to be improved.

Plan	Design Flood	Stretch to be improved	Length
Plan-1	100-year	Candaba - Masantol	32 km
Plan-2	100-year	Candaba - Sulipan	19 km

The design discharge distributions of the above plans are shown in Fig. 4.2.10. The planned longitudinal profile and channel cross-sections for Plan-1 are shown in Figs. 4.2.11 and 4.2.12, respectively.

4.2.2.4 Benefits and Costs

(1) Benefits

Benefits that will accue from executing flood control works are given as effects of decrease in flood damages. Based on the inundation areas under the present conditions as shown in Table 4.2.4, decrease in inundation areas by flood control project are estimated as shown in Tables 4.2.5 and 4.2.6. Using these values, the decrease in flood damages is estimated as shown in Tables 4.2.7 and 4.2.8.

The following values are applied to estimate the flood damages.

i) Unit price in irrigated area was estimated on the basis of the values as follows:

Gross income = ₱7,695/ha
Production cost = ₱2,831/ha
Paddy yield = 4.5t/ha

ii) Unit price in unirrigated area was estimated on the basis of the values (without project) as follows:

Gross income = ₱3,557/ha
Production cost = ₱2,065/ha
Paddy yield = 2.08t/ha

iii) Damage to fish pond was assumed at ₱3,464/ha/year.

iv) 35% of agricultural damage was assumed as other damages such as damage to livestock, houses, public facilities and so on, based on the damage survey report for the flood of 1960.

(2) Construction Cost

Construction costs are composed of cost required for civil works, acquisition and compensation, contingency and engineering & administration. Cost required for civil works is accounted by multiplying work qunatity by unit cost. Cost for contingency is assumed at 15% of the total costs for civil works, aquisition and compensation. Engineering & administration cost is also assumed at 8% of the sum of the above-mentioned costs. The estimated construction costs for flood control projects are shown in Tables 4.2.9 and 4.2.10.

4.2.3 Agriculture and Irrigation Development Plan

4.2.3.1 General

(1) Rice Marketing in Metro Manila

As described in section 3.3.6, the five provinces including the objective area is one of the rice supply bases to Metro Manila, supplying about 25% of the total consumption of rice in Metro Manila at present. The population of Metro Manila will increase high growth rate year by year and the demand of rice in Metro Manila will subsequently increase. This fact indicates that the five provinces including the objective area are required to keep the role of rice supply center to Metro Manila for the projected future.

Based on the studies with demand and supply in rice demand of rice in Metro Manila in the target year of 2000 is estimated at 1,140,000 tons. Supposed that the share of rice supply from five provinces to the total demand of Metro Manila is kept to be about 25% as present, amounts of rice to be supplied by the five provinces account for 285,000 tons of rice in the target year. On the other hand marketable rice produced in the five provinces is estimated at about 112,400 tons in the target year. The difference between supply and demand in rice reaches 172,600 tons of which value indicates that the incremental rice production made by new irrigation projects will be able to find out in the market of Metro Manila.

(2) The Subjective Area for Irrigation Development

The farmland in the objective area is approximately 126,000 ha, consisting of paddy field of 101,500 ha and upland field of 24,500 ha. At present, about 60% of the paddy field is served by the national, or communal irrigation systems and private pump irrigation systems, and the remaining area is under rainfed condition.

Out of the total objective area, most of the area in Nueva Ecija and Bulacan provinces is covered by national irrigation system such as the Upper Pampanga River Irrigation Project, the Peñaranda River Irrigation Project and the Angat-Maasin River Irrigation System, and the productivity of rice is relatively higher and will be expected to increase considerably. While, in Pampanga and Tarlac provinces mainly located at the right bank of the Pampange River, the productivity remains low. This low productivity in the area is mainly due to the following reasons.

a. The lack of irrigation facilities including regulating reservoir to provide irrigation water during the dry season.

b. The deterioration of existing irrigation systems.

c. The lack of proper drainage systems.

Under this situation, about 70,000 ha of farm land comprising 52,000 ha of paddy field and 18,000 ha of sugarcane field in Pampanga and Tarlac provinces are considered as the area to be improved in the objective area.

Out of this area, 36,000 ha is selected as the subjective area for irrigation development in the Pampanga Delta Development Project, deducting the area as follows:

a. About 5,000 ha in Tarlac province to be already included in the Balog-Balog Irrigation Project.

b. About 13,000 ha in Pampanga province to extend over the left bank of the Pampange River.

c. About 16,000 ha in Pampanga province to be included in partly Tibu and Gumain Irrigation Projects which are now being planned by NIA.

(3) Basic Concept and Strategy for Development

The basic concept for agriculture and irrigation development in the objective area is set mainly to increase rice production by increase of unit yield of paddy and expansion of irrigated area during the dry season. As there exist some sugarcane fields in the objective area, increase of sugar production is considered necessary for the raising of income of sugarcane planters which is also included in the basic concept for the agricultural development.

For the purpose, agriculture and irrigation development are formulated as follows:

- To introduce improved irrigation farming practice
- To provide year round irrigation by gravity by means of the effective use of water sources accrued from the San Antonio Reservoir and by means of pumps
- To provide drainage facilities

4.2.3.2 Proposed Farming Development

(1) Proposed Cropping Pattern and Land Use

As described in section 4.2.3.1, the basic concept for agricultural development in the objective area is to increase the rice and sugar production. It is proposed that double cropping of paddy per annum and sugarcane will be practiced under proper irrigation and drainage facilities.

There are fifteen (15) alternative plans of the irrigation project for the area to be conceived irrigation service area in the objective area as mentioned in section 4.2.3.3. The irrigation service area for each alternative plan ranges from 11,000 ha to 38,200 ha. These lands are now used by paddy field, sugarcane field and grass and/or swamp land. About 60% of the paddy field are irrigated, remainder are under rainfed. The sugarcane fields are under rainfed.

The emancipation program is now being carried out for the rice and corn field. The maximum land, owned by landowner is set to be 7 ha in the program. In view of this fact the diversification of the land from sugarcane field to paddy field would not be easily expected. Accordingly the present land use pattern will not be changed in the future in principle.

After the implementation of the irrigation projects, the project will provide:

- To change sugarcane field from rainfed land to irrigated land
- To change rainfed paddy land to irrigated paddy land
- To provide irrigation water to the lands with irrigation facilities where are not irrigated during the dry season due to shortage of water
- To change grass and/or swamp land to irrigated paddy field during the dry season

The multi-cropping index of each alternative plan is estimated as Table 4.2.11.

Cropping calendar of crops is studied taking into consideration of climate, irrigation water supplied from the rivers, agronomic characteristics, etc. The proposed cropping pattern is illustrated in Fig. 4.2.13.

With regard to paddy the climatic condition of the objective area is favourable for its cultivation in view of high temperature, high relative humidity and sufficient sunshine hours. Since there is no limiting or adverse factor for germination of seed and reduction division of paddy because of high temperature through out the year, seeding of paddy can be practiced at any time. However setting of harvested period shall be considered so as to exclude the period with high rainfall intensity and long rainy days for the smooth operation of harvest and processing. Plantphsiologically important factor for attaining high yield of paddy is how to increase the photosynthetic efficiency of the rice plant. Critical growth periods in terms of sunlight requirement are about 15 days just before heading and about 25 days just after heading. The framework of cropping calendar should be designed so as to get sunny weather during these periods as much as possible. Furthermore special attention was paid on expansion of irrigable area as much as possible, taking into consideration of balance of consumptive use of rice plant and effective rainfall and river discharge available for irrigation water.

(2) Proposed Farming Practice

Proper farming practice is the most essential factor for realizing full exploitation of the agricultural potentiality in the area. For the purpose high yielding and/or improved varieties will be introduced. Proper amount of fertilizer and chemicals will be applied through proper farming practices. Farm input for paddy and sugarcane is summarized at Table 4.2.12. The design criteria for irrigation farming is summarized at Table 4.2.13 for paddy and Table 4.2.14 for sugarcane.

It is expected that there will be no substantial changes in farming practices and farm input for future without project condition. The farm inputs for paddy, sugarcane and mongo beans are estimated and summarized in Table 4.2.15.

(3) Anticipated Yield

Unit yields of farm crops are estimated both for future without and future with project conditions.

Unit yield of farm crops without project condition is estimated on the basis of past trend of unit yield described in section 4.3. As for the sugarcane and diversified crops, the trend of unit yield shows decreasing or no tendency. The yield without project is set as same value of present unit yield. It is expected in future without that yield of paddy will increase 0.2 ton per ha more than present unit yield.

Unit yield of farm crops in future with project condition is estimated on the basis of the results of well irrigated area in and around the area of irrigation project, the experimental data of the Philippine Sugar Commission, the Maligaya Rice Research and Training Center and the International Rice Research Institute and the past data of Masagana-99 program. The expected unit yield of paddy will be 4.5 tons/ha for wet season and 5.0 tons/ha for dry season, respectively. Yield of sugarcane will be expected to be 6.35 tons of sugar per ha.

For the achievement of the anticipated yield, optimum application of farm inputs mentioned in previous section will be required together with effective water management.

The yield will increase gradually from the present level and reach the target yield in the 5th year after the completion of the irrigation facilities.

The future unit yield of crops both for without and with project conditions is summarized in Table 4.2.16.

(4) Crop Production

Total production of the farm crops is estimated by multiplying the anticipated unit yield with the future cultivation area both for future with project and without project conditions.

Crop production for both future with project and without project conditions is estimated for the twenty two alternative plan for the irrigation project and is summarized in Table 4.2.17.

(5) Marketing

As described in Chapter 3 "Marketing and Prices", the five provinces related to the objective area is one of the rice supply area to Metro Manila. The population of Metro Manila will increase with high growth rate year by year and the demand of rice in Metro Manila will subsequently increase. This fact indicates that the five provinces including the objective area are reauired to keep the role of rice supply center to Metro Manila for the projected future and the role becomes more important if considered short distance from the consumption center.

For investigating the marketability in Metro Manila, balance of marketable surplus of rice from the five provinces and demand of rice in Metro Manila is preliminary examined based on the following assumptions.

a. Population in the five provinces and Metro Manila will increase as forecasted in Table 4.2.18. /1

b. Forecast of rice production in the five provinces is made based on the past trend and forecast made by Region III of production in each province.

c. Waste and seed requirement are taken as 10% of total production.

/1 : Source: Philippine Year Book 1979
National Census and Statistics Office

d. Milling recovery rate from paddy to rice is 63%.

e. Per capita consumption of rice is assumed at 120 kg for the five provinces and 105 kg for Metro Manila.

The marketable surplus of rice from the five provinces is summarized in Table 4.2.19. The demand of rice in Metro Manila is shown in Table 4.2.20.

In the target year of 2000, marketable rice in the five provinces is estimated at about 112,400 tons. Total demand of rice in Metro Manila is estimated at 1,140,000 tons. Supposed the share of the rice supply from the five provinces to total demand in Metro Manila is 25, 20 and 15%, amount of rice to be provided by the five provinces is as follows:

Sharing Rates of Rice Supply to Demand	Demand of Rice in Each Sharing Ratio	Marketable Surplus of Rice in the Five Provinces	Difference
			(ton)
25%	285,000	112,400	172,600
20%	228,000	112,400	115,600
15%	171,000	112,400	58,600

As a result, amount of rice to be shared is much larger than marketable surplus of rice from the five provinces. This projection indicates that the incremental rice production made by new irrigation project will be able to find outlet in the market of Metro Manila through the channels from the National Food Authority, Commercials and Marketing Cooperative and Farm Cooperative Marketing Association.

With regard to sugar, sugar produced by new irrigation project will be outleted to export, domestic consumption and stock through the Philippine Sugar Commission.

4.2.3.3 Irrigation Plan

(1) Water Sources

The water sources for irrigating the subjective area are 1) San Antonio Reservoir and 2) water from the Pampanga River. In order to formulate the most optimum irrigation project, fifteen (15) alternative plans, thirteen (13) for San Antonio Reservoir and 2 for water from the Pampanga River by pump are studied as tabulated at Table 4.1. The general layout of each alternative irrigation plan is illustrated on Fig. 4.2.14 to Fig. 4.2.16.

(2) Description of Alternative Plans

In the First Interim Report submitted on March 1981, twenty two (22) alternative plans had been studied based on the map of the San Antonio Swamp provided by MPW. However, due to considerable change of contour lines found through the field survey conducted from November 1980 to February 1981 by the JICA Survey Team, the number of alternative plans to be studied is identified at fifteen (15).

(a) San Antonio Reservoir Plan

Taking the following aspects into consideration, two cases of different dam axises are planed with 13 alternative plans studied.

- Diminition of the natural flood retention volume of the San Antonio Swamp due to the construction of the reservoir.
- Environmental impacts accured from the implementation of the reservoir construction, such as resettlement problem, loss of properties of inhabitants and agricultural land, drainage conditions of the surrounding affected by the reservoir, etc.
- Utilization of the swamp land.
- The maximum use of storage capacity of the reservoir.
- The maximum water surface elevation of the reservoir is limited at 18 m. With regard to the dam axis, one is the study on location proposed by the PD/CS Area Development Project Study Report. The other is the study which location is shifted at about 12 km upper stream of the location proposed above. (See Fig. 4.2.15)

The former for alternative plans 1 to 8 has the merit with regard to effective storage capacity which will be able to provide the year round irrigation water for entire 36,000 ha.

In comparison with the former, the latter for alternative plans 9 to 13 has the following merits though the storage capacity is smaller than the former plan.

- The number of houses and inhabitants in the reservoir area is smaller.
- The swamp area can be irrigated during the dry season.
- Considerable part of the natural flood retention volume can be maintained.
- The area of which drainage conditions are worsen by the implementation of the reservoir is smaller.

Furthermore alternative studies were carried out for above two plans from the stand point of following two factors.

- Method of Maintaining the natural flood retention volume of the Swamp:

  One alternative in this regard is to increase the reservoir capacity in addition to the capacity required for irrigation purpose. Another alternative is to increase the discharge capacity in downstream of the river.

- Treatment of Dead Water of the Reservoir:

  Irrigation water from the reservoir is supplied by gravity in principal. Accordingly, the storage capacity of the reservoir below intake water surface elevation is considered as dead water. Since the dead water volume is, however, relatively larger, the full utilization of water except sediment load by pumping is to be considered.

The maximum water surface of the reservoir is limited at 18.0 m.

Combination of studied aspects for each alternative plan is tabulated in Table 4.2.21. Table 4.2.22 and Table 4.2.23 show the principle feature of alternative plans.

(b) Water from the Pampanga River

Alternative studies were carried out for two cases 14 and 15. Intake method is assumed by pump in accordance with NIA Central Luzon Report.

- Irrigation service area, 38,200 ha, is determined taking into account return flow accrued from various irrigation projects with reservoir on the upperstream of the Pampanga River proposed by NIA Central Luzon Study Report.

- Irrigation service area, 11,000 ha, is determined based on the present discharge available in the Pampanga River.

(3) Irrigation Water Requirement

(a) General

According to the cropping calendar proposed as shown on Fig. 2.1 irrigation water requirement is calculated.

The evapo-transpiration of paddy and sugarcane is estimated on the basis of the surface water evaporation from the standard class-A pan and crop coefficient for the study because pan evaporation data for comparatively longer period is available in the Pampanga River Basin.

The irrigation water requirement is estimated in monthly basis by the following manner.

- Evapo-transpiration

  Estimations of evapo-transpiration of crops by the product of crop coefficient and standard class-A pan evaporation.

- Crop Water Requirement

  Addition of percolation water and water requirement for a nursery period and land preparation work to evapo-transpiration.

- Irrigation Water Requirement

  To deduct effective rainfall from the crop water requirement.

- Diversion Water Requirement

  To add operation and conveyance loss to irrigation water requirement.

(b) Estimation of Evapo-transpiration of Paddy and Sugarcane

Evapo-transpiration of paddy and sugarcane is estimated in accordance with the following formula:

$$ET = KcPE$$

where, ET: monthly crop evapo-transpiration (mm)

Kc: monthly crop coefficient

PE: monthly pan evaporation (mm)

- Pan Evaporation

  Pan evaporation data are available in San Miguel, Tarlac (1968-1979), Baliwag, Bulacan (1970-1979) and Cabanatuan City. The average of pan evaporation at San Miguel and Baliwag is used for the study as shown in Table 4.2.24. Pan evaporation at Baliwag for 1968 and 1969 is estimated from the data at San Miguel by the method of correlation and regression analysis.

- Crop Coefficient (Kc)

  o Paddy

  In the agricultural research stations of NIA Region III at Sabang, Baliwag, Bulacan, evaporation and evapo-transpiration of paddy has been observed by NSDB - NIA water management improvement project since 1970. The crop coefficient (Kc) of paddy is determined based on the analysis of the

(c) Estimation of Crop Water Requirement

Crop water requirement is estimated as follows:

Paddy = Evapo-transpiration + deep percolation water + water requirement needed for land preparation and nursery bed

Sugarcane = Evapo-transpiration

- Deep Percolation

Water loss due to deep percolation is assumed at 2.5 mm per day for the study applying the deep percolation rate of southwestern region in the NIA Central Luzon Study Report.

- Land Preparation

The water requirement for land preparation in paddy field is calculated in the following formula:

$$LP = SS + Kc \times (tl/tm)\ PE + tl\ P + SP$$

where, LP: water requirement for land preparation (mm)

SS: water requirement for land soaking (mm)
140 mm for wet season
110 mm for dry season

Kc: coefficient for evaporation from muddy or shallow basin of water, 0.7

tl: number of days for land preparation, 25 days

tm: number of days in month, 30 days

PE: pan evaporation (mm/month)

P: deep percolation loss, 2.5 mm/day

SP: depth of ponding for transplanting, 25 mm

Water requirement for land preparation for sugarcane is not considered.

- Nursery Water Requirement

For the nursery of paddy, crop coefficient is assumed as constant at 0.8 and 5% of total paddy field is considered necessary for nursery.

data obtained through the aforesaid project for 15 crops, 6 crops for wet season and 9 crops for dry season, as shown on Fig. 4.2.17. As the growing period varies depending on varieties of paddy, Kc is determined for the percentage of the total duration from transplanting to terminal drainage for each crop.

The crop coefficient relative to the respective growing stages obtained from the said figure are as follows:

Percent of Growing Stage	10	20	30	40	50	60	70	80	90	100
Crop Co-efficient	0.80	0.93	1.01	1.09	1.16	1.20	1.21	1.18	1.09	0.97

The measurement of evapo-transpiration of paddy has been conducted in the actual field at Barangays of San Jose Malino and Sabanilla both in Mexico, Pampanga by the JICA Team with cooperation of NIA provincial office as one of the reference study. The results of the measurement are shown in Data Book.

- Sugarcane

  The following crop coefficient for sugarcane which is assumed on monthly basis after transplanting or harvesting for ratoon crop on the basis of the report on NIA Central Luzon Study Report and Balog-Balog Project Report is applied for this study.

Month after Transplanting or Harvesting	1	2	3	4	5	6	7	8	9	10	11	12
Crop Coef Coefficient	0.50	0.50	0.60	0.80	1.00	1.00	0.90	0.85	0.80	0.75	(0.70)/1	0

- Monthly Crop Area Factor and Monthly Crop Coefficient for two crops paddy, one crop paddy and sugarcane are shown in Table 4.2.25.

/1 : Only half month is considered because of terminal drainage executed on 45 days before harvesting.

- Crop Water Requirement

Monthly crop water requirement of two crops paddy, one crop paddy and sugarcane from 1968 to 1978 are calculated in the aforesaid procedure. The average annual crop water requirement is 2,021.3 mm for two crops paddy and 1,014.5 mm for one crop paddy and 1,193.8 mm for sugarcane. Monthly crop water requirement for each case is included in Data Book.

(d) Estimation of Irrigation Water Requirement

Irrigation water requirement for the crop is estimated as the difference between the crop water requirement and the effective rainfall.

- Effective Rainfall

The effective rainfall is estimated on the basis of the curve used in NIA Central Luzon Report as shown on Fig. 4.2.18. The curve defines the effective rainfall for diversified crops and paddy from a total monthly rainfall.

For the irrigation study the average of rainfall at San Fernando and Arayat is used as shown in Table 4.2.26. The average annual rainfall is 1,920.2 mm.

Monthly effective rainfall for two crops paddy, one crop paddy and sugarcane estimated from 1968 to 1978 are calculated as contained in Data Book.

The average annual effective rainfall is 997.2 mm, 230.7 mm and 714.1 mm for two crops paddy, one crop paddy and sugarcane, respectively.

- Irrigation Water Requirement

Accordingly, monthly irrigation water requirement is estimated for two crops paddy, one crop paddy and sugarcane as contained in Data Book.

Average annual irrigation water requirement for two crops paddy, one crop paddy and sugarcane are 1,044.3 mm, 763.9 mm and 479.2 mm, respectively.

(e) Diversion Water Requirement

Diversion water requirement for irrigation is estimated by dividing the irrigation water requirement by the overall irrigation efficiency.

The irrigation efficiencies are assumed as follows for this study:

(Unit: %)

Systen Component	Rice		Sugarcane
	Wet Season	Dry Season	
Field Application	70	80	60
Conveyance System	80	80	80
System Operation	85	85	85
Overall	48	54	41

Monthly diversion water requirements for two crops paddy, one crop paddy and sugarcane for 11 years from 1968 to 1978 are estimated as contained in Data Book.

The annual average diversion water requirements are estimated at 1,979.1 mm for two crops paddy, 1,417.3 mm for one crop paddy and 1,168.7 mm for sugarcane.

(f) Unit Diversion Water Requirement

The design water requirement for the irrigation system capacity is set at the second maximum value of the monthly diversion water requirement evaluated for 11 years from 1968 to 1978.

Unit diversion water requirement of each crop for designing irrigation facilities is shown as follows:

Crop	Unit Diversion Water Requirement (m^3/sec/1,000 ha)
Two crops paddy	1.76
One crop paddy	1.78
Sugarcane	1.27

(4) Drainage Requirement

(a) General

The drainage facilities are to be provided to remove the excess water in the fields taken place due to the heavy rainfall during storm and to create adequate conditions of drawdown in a harvesting period.

The unit drainage requirement is estimated on the basis of the rainfall with certain probability and a draining period for removing of standing water up to permissible water level referring to the NIA design criteria.

Unit Drainage Requirement is calculated in the following formula.

$$R = \frac{I - D}{T}$$

where, R: unit drainage requirement (mm/day)

I: design rainfall (mm)

T: drainage period (day)

D: detained depth (mm)

The drainage requirement is estimated for drainage areas for the irrigation service area, and surroundings of the San Antonio Reservoir in which the drainage problem is to occur due to the construction of the reservoir.

(b) Design Rainfall

Design rainfall is defined as maximum daily rainfall in 10-year return period. It is estimated by probability analysis of rainfall data at Arayat, Pampanga Province and San Miguel, Tarlac Province for the irrigation service area and its surrounding area and surrounding area of the San Antonio Reservoir respectively. Design rainfall is estimated at 200 mm/day for both data at Arayat and San Miguel.

(c) Drainage Period and Detained Depth

Drainage period and detained depth is assumed at one day and 100 mm/day, respectively.

(d) Unit Drainage Requirement

The unit drainage requirement for the area needed for drainage is estimated at 100 mm/day or 11.6 ℓ/sec/ha.

(5) Water Utilization

(a) Selection of Basic Year for Irrigation Planning

The year 1977 was chosen from eleven years as a basic year of which rainfall is 1,920.2 mm equivalent to the drought year in five year return period.

(b) Determination of Design Water Requirement

The water requirement was estimated on the basis of proposed cropping pattern for each alternative plan. The design water requirement is taken as the second maximum value of the monthly diversion requirement estimated for eleven years from 1968 to 1978 as follows:

Alternative Plan	Design Water Requirement /1 (ℓ/sec/ha)
1 - 4	1.70
5 - 8	1.74
9	1.71
10 & 11	1.69
12 & 13	1.78
14	1.61
15	1.61

(c) Determination of the Scale of the San Antonio Reservoir

The deficit of irrigation water and the required storage capacity of the reservoir for each alternative plan was estimated on the basis of water balance study between diversion water requirement and inflow to the reservoir for the period of 1968 to 1978 under the following criteria./2

- Maximum annual shortage should not be greater than 50% of the annual irrigation water requirement.
- Maximum combined shortages in any two consecutive years should not be greater than 75% of the irrigation water requirement.
- The average annual shortage over the 1968 to 1978 period should not be greater than 7%.

/1 : Detail Calculation is contained in Data Book.

/2 : Water balance calculation is contained in Data Book.

The required storage capacity for each alternative plan is calculated as follows:

Alternative	Irrigable Area (ha)	Reservoir Capacity Required /1 for Irrigation Purpose (MCM)
1 to 4	36,000	570
5 to 8	26,700	390
9	36,700	495
10 & 11	27,700	330
12 & 13	20,000	215

In the study topographic map with one meter contour interval prepared by JICA shown on Fig. 4.2.19 is used for preparation of H-A and H-Q curves shown on Fig. 4.2.20 and Fig. 4.2.21 in the reservoir and water surface elevation of irrigation intake is fixed at 12 m for alternatives of dam axis in the downstream as same as the Report on PD/CS Area Development Project and 13.8 m for alternatives of dam axis in the upperstream taking into account of sedimentation in the reservoir.

(d) Discharge Available at Arayat

Maintenance flow of the Pampanga River is taken at 10 m^3/sec at Arayat for planning of alternative plan 15. This flow is equivalent to second annual minimum monthly discharge for 14 years from 1965 to 1978.

The available monthly discharge for irrigation purpose excluding river maintenance discharge from the actual discharge is shown in Table 4.2.27.

The irrigation service area of alternative plan 15 is determined on the basis of the available monthly discharge applying to the criteria for deficit discussed in the preceding section.

/1 : Criteria used in the Report on Irrigation Development Plan for Central Luzon.

4.2.3.4 Design and Cost Estimate

(1) Preliminary Design

(a) General

For estimating the construction cost, preliminary design for the reservoir dam and irrigation facilities is conducted.

(b) Design of Reservoir Dam and Related Structures

- Location of Dam Axis and Levee

Dam axis for alternative plans 1 to 8 traverses the Rio Chico River at about 8 km north of the town of Arayat. The right abutment of the dam reaches to Mt. Arayat. On the left bank of the Rio Chico River, the levee is constructed toward to town of San Antonio along the right bank of the Pampanga River.

On the west of San Antonio town, the levee changes the direction to the north-west toward the west of the town of Zaragoza. And the levee is connected with the existing river bank along the left bank of the Talavera river. On the right bank of the Rio Chico River, the levee is started at left bank of the Cutcut river at about 3 km east of the town of Conception. The levee is constructed along the Rio Chico River to north. And the direction is changed to the west at the north of the town of La Paz. (See Fig. 4.2.19)

For releasing the area near Licab and San Juan from the submergence or wave effect the levee is to be constructed.

The total length of the levee ranges from 81 km for alternative 1 at maximum to 67 km for alternative 8 at minimum.

Dam axis for alternative plans 9 to 13 traverses the Rio Chico River between confluences of the Cutcut River and the Bamban River taking the topographical conditions into account. On the left bank of the Rio Chico River, the levee is constructed in the direction of east toward the barangay of San Marino. At the west of San Marino, the levee changes the direction to north-west. Further, after the west of the town of Zaragoza, the levee is constructed along the existing levee of the Talavera River by about 5 km in south so as to include the grass land behind the existing levee in the reservoir.

On the right bank of the Rio Chico River, the levee is constructed along the Rio Chico River in the direction of north up to the railroad bridge between Victoria and Guimba.

For releasing the area near Licab and San Juan from the submergence or wave effect, the levee is to be constructed.

The total length of the levee is approximately 72 km for alternative to 9 to 13. (See Fig. 4.2.19)

- Typical Section of Dam

Typical dam section is designed as shown in Fig. 4.2.22, freeboard of the dam is to be 4 m taking the wave action into consideration as a fetch length of the reservoir is longer than 10 km.

Slope of dam is to be 1 to 2.5. Crown width of dam is 6 m. Berm is to be provided at 5 m below the top with 5 m wide for dam height more than 5 m and 10 m wide for dam height more than 10 m.

Based on the analysis of the geological investigation and soil mechanical tests conducted by the study team, preliminary study was carried out for checking the stability of the typical section of the dam.

- Drainage Facilities for the Area Affected by the Reservoir

The construction of the reservoir in the San Antonio Swamp worsens the drainage condition in surrounding area.

Pumping drainage on the right bank of the reservoir is required for alternative plans 1 to 8. And area to be drained by gravity is tabulated as follows:

Reservoir Water Surface Elevation	Alternative 1 to 8 (Downstream Dam Axis) (ha)	Alternative 9 to 20 (Upperstream Dam Axis) (ha)
Right Bank		
Upto 16 m	25,000	25,000
Upto 18 m	26,000	31,000
Left Bank		
Upto 16 m	16,000	12,000
Upto 18 m	23,000	19,000

Based on the area above measured and design drainage requirement, the gravity drainage facilities are preliminary designed.

The area to be drained by pump is illustrated on Fig. 4.2.23.

Actual head and discharge of pump drainage for reservoir water surface elevation are indicated on Fig. 4.2.24. Pump with axial flow type is used for the purpose on the preliminary design.

- Bridge

The bridge which crosses the Rio Chico River and the road connecting Zaragoza with La Paz will be submerged after the implementation of the San Antonio Reservoir. The bridge is to be newly constructed.

- Diversion Weir on Bamban River

In case of alternative plans, 9 to 13, a facility is required to divert the discharge of the Bamban River to the reservoir except flood discharge so that the discharge of the Bamban River is not drained directly to the Rio Chico River in the downstream of the reservoir. Accordingly, a diversion weir located at about 4 km south-east of Conception is planned and the preliminary design is conducted.

- Irrigation Pumping Facilities for Dead Water Utilization

For utilizing dead volume of the reservoir pumping scheme is considered for alternative plans 2, 4, 6 and 8. The required head and discharge for each pumping scheme are calculated as shown in Table 4.2.28.

In accordance with the above calculation, the preliminary design of pumping facilities is carried out.

(c) Design of Irrigation and Drainage Facilities

The design of irrigation and drainage facilities for alternative plans 1 to 4, with 36,000 ha of the irrigation service area is carried out on preliminary basis as a representative case for cost estimate. General layout is shown on Fig. 4.2.14.

Intake of the irrigation water is located at the right abutment of dam on foot of Mt. Arayat, and Head Reach is constructed along the contour line on foot of Mt. Arayat. The length of Head Reach is about 12 km. Main Canal I diverted at the north of Arayat town is constructed along Set Back Levee of the Pampanga River and irrigates 19,000 ha. Main Canal II diverted at end of Head Reach is constructed to the direction of southwest upto the Pasig-Potreto River.

The irrigation water lifted up by a booster pump at the end of the Head Reach is conveyed to north by Main Canal III and to south by Main Canal IV.

Main drains are constructed along Main Canal III and IV and the Abacar River and the San Fernando River are rehabilitated for the purpose of proper drainage of the service area.

Irrigation and drainage facilities are planned to command one block of about 100 ha at minimum. Irrigation canal density is about 28 m/ha.

The irrigation pumping facilities for alternative 14 and 15, of which water sources are the discharge of the Pampanga River are installed at just upperstream of the Arayat bridge. Pumping facilities of alternative plan 14 and 15 are designed for 63 and 15 m^3/s respectively.

(2) Cost Estimate

(a) General

The construction cost is estimated based on the following assumption and the results of detailed cost estimate of the Balog-Balog Project.

- The exchange rate used is:

  US$1.00 = ₱7.50

- Construction works are to be carried out on the contract basis.

- The contingency is applied to only the physical allowance. It is estimated at 15% of the total construction cost. The engineering fee is estimated at 8% of construction cost for dam and 6% for irrigation works.

- The annual operation, maintenance and replacement costs include the project operation cost consisting of staff salaries and other maintenance and repair of the project facilities and replacement cost of mechanical and electrical works. The electric energy cost for pumping schemes is based on the rate for Luzon grid of National Power Corporation. Mechanical and electrical facilities are replaced after economic useful life of 35 years.

- Unit costs applied for cost estimate are mainly taken from the report on the Balog-Balog Project unless otherwise to be discussed.

Cost estimate for the project facilities is described hereinafter.

(b) Dam and Related Structures

The construction cost estimate of dam is conducted on dam earthworks, drainage of surrounding area, bridge for road between La Paz, Tarlac and Zaragoza, Nueva Ecija and diversion weir from Bamban River.

The quantities of dam earthworks are estimated as shown on Fig. 4.2.25 and Fig. 4.2.26 related to the crest elevation of dam based on the dam axis drawn on the contour map of the San Antonio Swamp shown on Fig. 5.1 and the typical dam section shown on Fig. 6.1. Quantity of major earthwork items for each alternative plan is shown in Table 4.2.29. The construction cost of dam earthworks is shown on Fig. 4.2.27 applying unit prices as shown in Table 4.2.30. The construction cost of dam structures such as spillway, intake and so on is considered 10% of earthwork cost.

The construction cost of drainage facilities is estimated for gravity drain and pumping drain separately. In case of gravity drain, earthwork quantity and construction cost according to the water surface elevation of the reservoir are estimated based on the preliminary design as shown on Fig. 2.2.28.

For the pumping drainage, the drainage discharge and construction cost are estimated based on unit drainage requirement as shown on Fig. 4.2.23 and Fig. 4.2.24.

For the bridge, the construction cost is estimated at ₱40,000,000 and the construction cost of Bamban diversion weir is ₱7,700,000, those cost breakdowns are shown in Table 4.2.31 and Table 4.2.32 respectively.

Construction cost of pumping facilities for utilizing dead water of the reservoir is shown in Table 6.1.

Construction cost of the downstream river improvement for maintaining the natural flood retention volume of the San Antonio Swamp by means of the downstream improvement is shown in Table 4.2.33.

Total construction cost of dam for each alternative is shown in Table 4.2.34.

(c) Irrigation Facilities

As described in the preceding section, the preliminary design of irrigation facilities for alternative 1 to 4, 36,000 ha of service area, is carried out as a representative case. Work quantities and construction cost for major work items of the irrigation facility are estimated as shown in Table 4.2.35.

Unit cost of irrigation facilities applied for other alternative is 10,570 ₱/ha excluding the cost of Head Reach and the booster pump from the above calculation. 15% of the above cost is added as a miscellaneous works.

The construction costs of pumping facilities of alternative 14 and 15 are shown in Table 4.2.36 to Table 4.2.39.

The construction cost of irrigation facilities of each alternative is shown in Table 4.2.40.

(d) Total Construction Cost

The total construction cost of each alternative is shown in Table 4.2.41.

(e) Operation and Maintenance Cost

Operation and maintenance cost of the project facilities is estimated as follows:

Item	Description
Dam	0.5% of Construction cost
Pump and Mech. Works	2.0% of Construction cost
Irrigation Facilities	₱350/ha

Energy cost of pump operation is estimated for respective pumping scheme. Average annual required energy for each pumping scheme is shown in Table 4.2.42. Energy cost of the irrigation booster pump for alternative 1 to 4 is estimated at ₱6.5 x 10^6 annually as shown in Table 4.2.43.

Annual operation and maintenance cost including energy cost of irrigation pumping schemes are summarized in Table 4.2.44. Energy cost of drainage pump for alternative 1 to 8 is shown on Fig. 4.2.24.

Annual operation and maintenance cost of each alternative is shown in Table 4.2.45.

(f) Economic Construction Cost

Economic construction cost for evaluation is estimated at a value deducting tax and contractors profit, 3% and 15%, of Peso Currency portion of the construction cost discussed in preceding section. Ratio of Peso and foreign currency portions of the construction cost are assumed as follows:

Item	Ratio (%) Peso	Ratio (%) Foreign
Dam:		
Civil Works	50	50
Pump and Mechanical Work	30	70
Irrigation Facilities:		
Civil Works	55	45
Pump and Mechanical Works	35	65

Economic construction costs of dam and irrigation facilities for each alternative are estimated as shown in Table 4.2.46 and Table 4.2.47.

The economic construction costs for each alternative plan are shown in Table 4.2.48.

For implementing the construction of the project facilities, 6 years and 5 years are required for the San Antonio Reservoir Plan with alternatives 1 to 13, and Pumping Plan with alternative 14 and 15, respectively as shown on Fig. 4.2.29.

Annual disbursement schedule of construction cost is also indicated on Fig. 4.2.29

Further, ratio of construction costs of major irrigation facilities and minor irrigation facilities are assumed at 60% and 40%, respectively.

4.2.3.5 Irrigation Benefit

Irrigation benefit to be expected is defined as the difference of primary profit from crops between future with project and without project conditions. On the basis of the estimated production cost and gross income primary profit for each crop per ha is calculated both on future with and without project conditions. The summary of the results are shown as follows and Tables 4.2.49 to 4.2.57 show the details.

(Unit: ₱/ha)

	With Project			Without Project		
	Gross Income	Production Cost	Primary Profit	Gross Income	Production Cost	Primary Profit
1) Paddy						
Irrigated (wet)	7,695	2,831	4,864	4,104	2,181	1,923
Irrigated (dry)	8,550	2,955	5,595	4,549	2,306	2,243
Rainfed (wet)	-	-	-	3,557	2,065	1,492
2) Sugarcane	12,891	4,448	8,443	6,861	3,102	3,759
3) Mongo beans	-	-	-	1,840	832	1,008

Applying the primary profit per crop estimated above to crop area, total primary profits accrued from agricultural production in each alternative for the irrigation project are estimated both on without project and with project conditions. Based on this result, irrigation benefit is calculated. The benefit will be expected to increase linearly year by year. The build-up period is applied to five years. The irrigation benefit at full stage is summarized as follows:

(Unit; 10^3 ₱)

No. of Alternative Plan	Irrigation Benefit
1 to 4	255,000
5 to 8	196,000
9	252,000
10 & 11	184,000
12 & 13	132,000
14	268,000
15	67,000

Details are shown in Table 4.2.58.

CHAPTER 5 EVALUATION

5.1 General

As mentioned in the previous chapter, twenty two alternatives for both flood control and irrigation project are identified in order to formulate the most optimum plan in the Pampanga Delta Development Project. Four (4) alternative plans for flood control are identified from the standpoint of flood control method by the construction of the West Diversion Channel and improvement of the downstream channel of the main Pampanga River. Fifteen (15) alternative plans for irrigation are made in view of mainly water source owing to the San Antonio Reservoir and pumps for the main Pampanga River.

In this chapter the evaluation for the above flood control and irrigation projects is synthetically carried out in view of economic, financial and socio-economic aspects.

5.2 Flood Control and Irrigation Benefits

Flood control benefits are the expected reduction of flood damages for farm crops, fisheries, houses, public facilities and so on, and the expected development effect for the land having not been utilized during the wet season under the condition of complement of West Diversion Channel or improvement of channel of the Pampanga River. Irrigation benefits are expected to be the difference of net income of crops between future without project and with project condition. Flood control and irrigation benefits to be expected from each plan are summarized as follows:

(1) Flood Control Benefits

	($₱10^3$)
- West Diversion Channel Project	
Plan - 1	4,620
Plan - 2	1,960
- Channel Improvement Project of the Pampanga River	
Plan - 1	94,350
Plan - 2	34,970

(2) Irrigation Benefit

	($₱10^3$)
- San Antonio Reservoir Irrigation Project	
Plan - 1 to 4	255,000
Plan - 5 to 8	196,000
Plan - 9	252,000
Plan - 10 and 11	184,000
Plan - 12 and 13	132,000
- Pumping Irrigation Project	
Plan - 14	268,000
Plan - 15	67,000

5.3 Negative Benefit

In case of the irrigation projects with the San Antonio Reservoir (Plans No. 1 to No. 13), considerable land will be submerged. The land to be submerged is estimated at from 13,500 ha to 27,000 ha according to the alternative plans. The economic cost for the cultivated land within the submerged area is evaluated in terms of negative benefit. The negative benefit is defined as the loss of the primary profit which is expected to accrue from the land to be submerged. The land to be submerged consists of paddy field and grass/swamp land at present, most of the paddy field is rainfed area. The negative benefit estimated for the alternative plans accounts for ₱15,052 x 10^3 at minimum and ₱27,954 x 10^3 at maximum as shown in Table 5.3.1.

5.4 Economic Cost

Economic construction cost for the projects is estimated taking into consideration deducting tax and contractor's profit, 3% and 15%, respectively for Peso currency portion of the construction cost. Ratio of Peso and foreign currency portions of the construction cost is assumed as follows:

Item	Peso (%)	
	Peso	Foreign
Flood Control Project		
Civil Works	40	60
Structures	35	65
Irrigation Project		
Civil Works for Dam	50	50
Pump and Mechanical Works related to Dam	30	70
Civil Works for Irrigation Facilities	55	45
Pump and Mechanical Works for Irrigation Facilities	35	65

As far as land compensation cost for the land to be submerged by the San Antonio Reservoir is concerned, land compensation cost is evaluated in terms of negative benefit mentioned in previous section. The economic construction cost for flood control and irrigation projects is summarized below:

(1) Flood Control Project

	(₱10^6)
- West Diversion Channel Project	
Plan - 1	673.6
Plan - 2	538.1
- Channel Improvement Project of the Pampanga River	
Plan - 1	823.2
Plan - 2	655.1

(2) Irrigation Project

	($₱10^6$)
- San Antonio Reservoir Irrigation Project	
Plan - 1	2,252.9
Plan - 2	1,985.9
Plan - 3	2,028.9
Plan - 4	1,828.9
Plan - 5	1,842.0
Plan - 6	1,608.0
Plan - 7	1,664.0
Plan - 8	1,449.0
Plan - 9	2,031.5
Plan - 10	1,723.7
Plan - 11	1,609.7
Plan - 12	1,358.2
Plan - 13	1,309.2
- Pumping Irrigation Project	
Plan - 14	669.5
Plan - 15	182.5

5.5 Internal Rate of Return

Based on the benefit and economic cost, internal rate of return for the flood control and irrigation projects is calculated under the following assumption. The results are summarized in Table 5.5.1.

- The project life for the development projects is assumed to be 50 years for the evaluation.
- All the conversions from Peso to U.S. Dollar are made at the exchange of Peso 7.5 = US$ one.

Sensitivity analysis is applied to three alternative cases for each project. The results are shown in Table 5.5.1.

5.6 Environmental Impacts Accrued from the Implementation of the San Antonio Reservoir

It is predicted that implementation of the San Antonio Reservoir will bring about the environmental and socio-economic impact in and around the area to be submerged.

The major impacts accrued from the implementation of the San Antonio Reservoir are as follows:

5.6.1 Resettlement of Farmers in the Reservoir Area

Implementation of the San Antonio Reservoir requires resettlement of farmers in the reservoir area. The number of farmers to be resettled is very big, ranging from 5,600 at minimum to 10,700 at maximum depending on alternative plans. The number of houses and farmers is summarized in Table 5.6.1.

5.6.2 Loss of Agricultural Production

As mentioned in section 5.3, considerable extent of the cultivated land will be submerged after the implementation of the reservoir. The cultivated land to be submerged ranges from 9,500 ha at minimum to 18,000 ha at maximum according to the alternative plan. In terms of agricultural production, 20,000 to 37,000 tons of paddy and 400 to 700 tons of mongo beans are lost annually.

5.6.3 Adverse Affect to Drainage Conditions

The implementation of the dam will provide adverse affect to drainage in the surrounding area. The degree of its affection varies depending on reservoir water surface elevation and location of dam axis. These drainage problems will still remain after the implementation of drainage canals and pumps.

5.6.4 Affect for Rural Community

The community life of the people living in the adjacent area will be seriously affected.

5.7 Synthetic Assessment for the Projects

5.7.1 Flood Control Projects

As mentioned in Chapter 4, four (4) alternative flood control plans comprising two (2) alternatives for the West Diversion Channel and two (2) alternatives for the Channel Improvement of the Pampanga River, are studied adopting design flood discharge of 100-year return period as follows:

Plan	Improved or Constructed Channel		Expected Decrease Flooded Area
	Stretch	Length	
West Diversion Channel			
Plan - 1	Candaba - Manila Bay	42 km	North & South Candaba Swamp
Plan - 2	San Simon - Manila Bay	31 km	- do -
Channel Improvement of the Pampanga River			
Plan - 1	Candaba - Masantol	32 km	South Candaba Swamp and delta area
Plan - 2	Candaba - Sulipan	19 km	South Candaba

The study makes it clear that the alternative plans for the West Diversion Channel indicate smaller flood control benefit and lower economic viability than the Channel Improvement Plan - 2, although the construction cost of the west Diversion Channel Plan - 1 is almost the same with that of the Channel Improvement Plan - 2. The plan for the Channel Improvement of the Pampanga River shows the comparatively higher flood control benefit. Therefore, it is considered reasonable for the flood control project to propose the plan for the channel improvement of the Pampanga River. Plan - 2 of the Channel Improvement is the modified plan described in the previous Interim Report, on the basis of new data on river cross-sections, contour maps of the San Antonio and Candaba Swamps and soil mechanical investigation. The results of the study on Plan - 2 indicate low internal rate of return below 4%. Furthermore, the improvement works on the stretch from Candaba to Sulipan by Plan - 2 will give some adverse effects on the downstream area below Sulipan owing to small and middle class floods, although the peak discharge of design flood would not be increase. The said adverse effects are considered as increase in length of flood period and in inundation water depth on the downstream below Sulipan. In order to remove these adverse effects, it is necessary to improve the river channel on the stretch between Sulipan and Masantol. The plan for the Channel Improvement (Plan-1) including the stretch between Sulipan and Masantol was studied. The results of the study indicates high flood control benefit and high value of internal rate of return of 8.6%. Accordingly, the Plan-1 for the Channel Improvement is the most optimum flood control plan for the final target.

The results of the evaluation and effect on the flood control alternative plans are summarized in Table 5.7.1.

5.7.2 Irrigation Projects

The alternative plans of 1 to 8 are the irrigation plan with the San Antonio Reservoir of which dam axis is located in the downstream of the Rio Chico River. These plans produce considerably bigger irrigation benefit, however, indicating low internal rate of return (5.5 to 7.5%) due to large amount of construction cost. Further these plans involve the resettlement problems on the people in the reservoir area. The number of the people accounts for 9,600 to 11,000.

The plan of 9 to 13 are the reservoir plan of which dam axis is located at 12 km upperstream of the location proposed in the above alternative. Although resettlement for about 1,000 peoples is still needed. Internal rate of return for the plans shows low ranging from 5.2 to 7.3% due to huge amount of construction cost, although irrigation benefits are as big as the alternative plans of No. 1 to No. 8.

The Plan-14, pumping irrigation project, produces the biggest irrigation benefit and indicates the highest internal rate of return with 19.2% among the all alternatives. There is no problem with regard to resettlement of peoples. This plan, however, is planned to entirely acquire irrigation water from the return flow which will be produced by the completion of all reservoirs in the upper Pampanga River Basin proposed in NIA Central Luzon Report. Realization of this project will not be expected in the near future because the implementation of the said reservoirs will require much longer period.

The Plan-15 is the pumping irrigation project using the existing discharge of the main Pampanga River. This plan indicates the second highest value of internal rate of return with 18.5%. There exist no problems on the resettlement of the peoples. The scale of the project, however, is the smallest among the all alternative plans, of which area covers about 30% of the subjective area for irrigation development.

It is concluded from merits and demerits of the plans that the Plan-15 is the most optimum plan for irrigation development projects in view of economic, financial and social aspects. Table 5.7.2 summarizes the results of evaluation and effects on each alternative plan.