3) The existing flood control facilities are of small scale and are provided sporadically. Preparation of a basin wide flood control master plan and funding for its implementation are needed.

5.2 Principles for Planning

5.2.1 Approach to Planning

In order to integrate the flood control plan into the water resources development master plan, a framework plan, a long-term plan, and a short-term plan are contemplated.

The framework plan would be a basinwide flood control plan with a design discharge equivalent to 100-year flood, which embodies the ideal flood control system in the Cagayan river basin, meanwhile the long-term plan would be a basinwide flood control plan with a reduced design discharge of 25-year flood in line with the framework plan. Several schemes encompassed in this plan will be selected and included in the master plan which is to be implemented by the year 2005. Further, a few schemes will be selected to form a short term plan as an urgent flood control plan.

In general two approaches are conceivable to attain flood mitigation in a basin, i.e., structural and non-structural measures. Structural measures mainly aim to alleviate the causes of floods by constructing dikes, diversion channels, flood control dams, retarding basins, etc. On the other hand, the non-structural measures mainly aim to reduce damageable properties in the flood prone areas by means of flood plain management, flood warning, evacuation and so on. These are listed in Table 5.2.

Structural measures are the conventional approach to flood mitigation and will be the principal measures for the future, since they realize flood control effects directly within a relatively short period. On the other hand, the non-structural measures are adopted mainly to complement the effects of structural measures. Non-structural measures are a somewhat political approach supported by legislation and establishment of consensus among the people and the authorities concerned, and taking time to realize substantial effects.

In this study, discussion will focus mainly on flood control plans by means of structural measures. However, non-structural measures such as watershed management, afforestation and reforestation, flood warning and evacuation should also be maximised and should be combined with structural measures in order to establish an effective and economical flood control system in the Cagayan river basin.

5.2.2 Candidate Schemes

In order to mitigate flood damages in the Cagayan river basin, flood prevention and bank protection are necessary. Revetment and groyne works are the principal counter measures for bank erosion through protecting river banks directly from flood flow or stabilizing river courses. Channel normalization can also be a measure for this purpose by keeping flood flows away from critical banks. These bank protection measures can be provided from place to place where they are needed.

A diking system and channel normalization to remove obstacles to smooth flood flow are also direct flood prevention measures. Construction of cut-off channels and improvement of Magapit narrows are conceivable measures for channel normalization. Since these flood prevention measures would inevitably incur, more or less, concentration of flood runoff in the lower reaches, flood prevention measures should be contemplated within comprehensive basinwide considerations.

Flood control dams contribute to flood prevention over extensive downstream reaches by lowering the peak discharge through the flow regulation function of the reservoirs. Various possible damsites have been identified in the basin. However, no specific site for a retarding basin has been found in the basin. Instead, the channels of the upper Cagayan river and tributaries are deemed to have considerable retardation functions contributing to flood peak reduction in the middle and lower reaches of the Cagayan river.

Accordingly the flood control plan of the Cagayan river including the major tributaries is to be studied in line with the following principles:

1) Flood control dams should be considered in the upper watershed. A dam reduces the peak flood discharge over extensive lower reaches.

2) The existing channel retardation function should be conserved in the upper reaches of the Cagayan river and tributaries. In these reaches, efforts should be concentrated on bank protection measures.

3) For the middle and lower reaches of the main river, diking systems should be provided as well as bank protection measures so as to protect lowlying lands from flooding due to runoff from the extensive upper basins. Channel normalizaton to accelerate smooth and swift drainage of flood water should also be undertaken. Improvement of Magapit narrows could be a key to the flood control in these reaches.

5.2.3 Criteria for Planning

(1) General

1) The framework plan will be formulated against a 100-year flood. The 25-year flood will be applied to the long-term plan, master plan and short-term plan.

2) The non-uniform flow calculation method will be applied to examine the channel flow of the main river and major tributaries. In this respect, the following coefficients of roughness will be adopted:

- $n = 0.040$: for low water channel
- $n = 0.060$: for high water channel confined by dikes
- $n = 0.10$: for flood plain

(2) Diking System

1) The river width between dikes (W : m) shall be more than $10\sqrt{A}$, where A is basin area in km^2. This relationship is applied in the design of rivers in Japan (Fig. 5.7.) under comparable conditions.

2) Dike alignment will be delineated with smooth lines so as to envelop existing river courses and lowlying lands along the river and to protect existing builtup areas and public facilities as much as possible.

3) The dike is not provided where the lands to be protected by the dike are narrower than the design river width. In these reaches the existing channel retardation function shall be conserved.

4) The standard dike section shown in Fig.5.8 will be applied. The section follows the Technical Standards for River and Sabo Works, Ministry of Construction, Japan.

(3) Flood Control Dams

1) For a single purpose flood control dam, a concrete gravity type dam is assumed in the framework and long-term plans.

2) The constant-ratio constant-amount outflow method is assumed for reservoir operation.

3) Flood control shall be started when the inflow magnitude reaches to the minimum channel capacity in the lower reaches of the dam in terms of specific discharge or average channel capacity in the reaches from Alcala to Tuguegarao.

4) The flood control capacity of a reservoir shall be as large as possible considering the site conditions. However, the outflow ratio shall be more than 0.1 for 100-year frequency flood hydrograph so that the flood control capacity may be recovered within a

certain short period and be ready for further floods.

(4) Unit Construction Costs

1) All costs are expressed in peso-currency at the price levels as of December 1985. Exchange rates of currencies are assumed to be US$1 = ₱19 (= ¥200) on the basis of the prevailing the rates as of Dec. 1985.

2) Two kinds of construction costs are estimated, i.e., economic costs and financial costs. The economic cost is used for comparative studies of alternative schemes and evaluation of the project. The financial cost consists of local and foreign currency portions.

3) The construction costs are estimated using standard unit construction costs. The standard unit construction costs for flood control facilities are summarized in Tables 5.3. and 5.4. Unit construction costs for dams are discussed later and presented in CHAPTER IX.

4) In estimation of the financial unit construction costs the results of previous studies and actual costs incurred by DPWH and other authorities for their projects were referred to.

5) The economic unit costs except land costs were estimated on the basis of the financial costs after deducting transfer costs and shadow rate. In this respect, transfer costs and shadow rate are assumed to be 18 % of the financial costs. The economic unit costs for land are evaluated on the basis of production foregone.

(5) Assessment of Flood Damages

1) The flood damages in the basin comprise flooding damage and bank erosion damage. Each category of damage is evaluated by a specific method.

2) The flooding damage is assessed as follows:

- Direct and indirect damages are evaluated separately.
- Direct damages comprises following damageable items;
  a) Damages to buildings consisting of residential buildings (house and household effects) and other buildings (building structures and movables)
  b) Damages to agricultural crops consisting of irrigated paddy, rainfed paddy, and upland crops
  c) Damages to livestock
  d) Damages to infrastructure

- Direct damages to buildings and agricultural crops are estimated from damageable values of properties multiplied by damage ratios. The applied damage ratios depending on the flooding condition is shown in Table 5.5.

- Direct damages to livestock and infrastructure are estimated in constant proportion to other damages as follows;

  a) Livestock: Assumed to be 12.6% of damages to agricultural crops.
  b) Infrastructure: Assumed to be 86 % of damages to buildings including movables referring to the past flood damage recorded.

- Indirect damages including income loss and emergency costs due to flooding are estimated applying the constant ratio of 5 % to the total direct damage.

3) Some bold assumptions are introduced to assess the bank erosion damages as follows;

- Following are enumerated as damageable items;

a) Building damages
b) Agricultural damages
c) Highway damages
d) Loss of residential land

- The damageable area is defined as an area probably subject to bank erosion damages during the project life if the bank protection works are not provided. Two types of bank erosion are considered, i.e., continuous bank erosion and river course change.

  a) Continuous bank erosion: The damageable areas of this type are estimated applying the bank erosion rate.
  b) River course change: The damageable area of this type are assumed to be the areas enclosed by the existing river channel and the possible river course. The possible river course is arbitrarily assumed examining the topographic and geomorphological nature of the existing channels.

- Average annual bank erosion damages are estimated on the basis of the damageable value in the damageable area.

- Unit damageable value of building and agricultural crops are assumed to be same as those for the estimation of flooding damges.

4) Intangible damages: In addition to the flooding and bank erosion damages mentioned above, the floods also affect the people's social life and economic activities to some extent although they are not to be evaluated in terms of monetary value. These damages are so called intangible damages.

- Damages to people's livelihood,
- Damages to traffic and transportation,
- Damages to business activities in commercial and industrial sectors,

- Loss of life and injury,
- Degradation of sanitary condition and
- Losses for emergency activities for flood proofing, flood fighting, evacuation and rescue, flood recovery works, etc.

(6) Economic Evaluation

1) The benefit of a flood control project is measured as the reduction of damages due to flooding and bank erosion.

2) For the estimation of flood reduction benefit, probable flood damages for different return periods such as 2, 5, 10, 25, 50 and 100-years are estimated.

3) The bank protection benefit is estimated from the annual bank erosion damages.

4) The benefit is estimated under constant and variable property conditions of the basin.

   - Constant property condition: The values of properties in the basin are assumed to be constant in the future at the existing condition as of the end of 1985.

   - Variable property condition: The values of properties in the basin are assumed to vary year by year depending on the economic development and enhancement of people's livelihood in the basin.

5) The following assumptions are introduced to estimate the properties in the future;

   - Damageable values of buildings including movables are assumed to increase at the same rate as the projected per capita GRDP (index) in Region II. In the year 2005, it is estimated to increase to 2.4 times the damageable values in 1985.

- Damageable values of agricultural crops are assumed to increase linearly up to the year 2005 and keep constant level afterwards. The agricultural property in 2005 are estimated based on the proposed master plan for agricultural development.

5.3 Framework Plan

5.3.1 Development of Schemes

A diking system, improvement of Magapit narrows, and a flood control dam are the major flood control components for the Cagayan river basin. The flood control dam would have the function of regulating flood runoff, and improvement of Magapit narrows would accelerate drainage of flood water from the flood prone areas. Both of these can be executed independently. A diking system would restrict inundation water from the river. Since the system would be liable to cause concentration of flood discharge in the lower reaches, system should be so planned as to avoid extreme concentrations and the implementation thereof should be scheduled so as to cope with the inevitable concentration.

(1) Diking System

A diking system is a fundamental measure to be complemented by other flood control components such as narrows improvement and flood control dams. In order to grasp the hydrological effects of the diking system, runoff calculations for the 100-year flood were conducted under the existing basin condition with and without the diking system. The results are shown later in Table 5.7 as Alt.0D.

With continuous diking along the Cagayan river, the flood discharge would increase by up to 127 % of the existing runoff. The flood discharge with the diking system would provide a basic value for flood planning. The runoff is called the basic flood discharge.

(2) Improvement of Magapit Narrows

Narrows improvement schemes are studied against the basic flood discharge, i.e., 100-year flood discharge with diking system.

As an ideal scheme, channel excavation for the entire stretch of narrows from Sta. 30 km to 65 km was contemplated to eliminate the backwater effects of the narrows.

The study results show the requisite excavation works at Magapit section (Site-M), Nassiping section (Site-N) and upstream channel from Nassiping (Site-UN). The quantities of excavation are summarized below. The total excavation volume for the complete narrows improvement would be 144,140,000 m^3.

- Site-M (Sta.30.0 km - 33.3 km): 68,228,000 m^3
- Site-N (Sta.52.0 km - 59.0 km): 43,194,000 m^3
- Site-UN (Sta.59.0 km - 66.0 km): 32,718,000 m^3

For the Nassiping section another site including a cut-off channel (Site-N2) was also studied. The excavation volume of Site-N2 is 43,321,000 m^3 which is almost same with Site-N. However, the works for Site-N2 may be more difficult, since it would pass through a hill with a height of 30 m. Consequently, Site-N2 is abandoned.

The narrows improvement scheme would require a considerable amount of excavation and stagewise implementation is recommended. For stagewise improvement, the following alternative schemes were contemplated;

- Alt. 1 : Sites-M + N + UN (Complete improvement)
- Alt. 2 : Sites-N + UN
- Alt. 3 : Site-UN
- Alt. 4 : Site-N

For each alternative, the flood water level was calculated for the 100-year basic flood discharge and the surface profile is depicted as shown in Fig. 5.9.

The effects of the alternative improvement works are represented in terms of the reductions of water level at Sta. 65 km located in the vicinity of Alcala. The respective water level reductions of Alt. 1, 2, 3 and 4 are estimated to be 4.69 m, 3.58 m, 0.59 m and 3.08 m from EL. 23.02 m. The reductions per unit excavation volume in $cm/10^6m^3$ are 3.3, 4.7, 1.8 and 7.1 respectively.

Channel excavation for Alt. 4 would appear to be the most effective to lower the flood water level at Sta. 65 km among the alternatives. Thus Alt. 4, a scheme to improve only Nassiping section, is selected as a candidate scheme for the framework plan.

(3) Flood Control Dams

Fourteen potential dam sites have been selected for hydro-power, irrigation and flood control purposes through the screening works. Out of the 14 dams, 8 dams located at the lowest sites of relevant tributaries are selected for the flood control study, since they are expected to have direct effects of flood peak reduction in the downstream reaches. They are Cagayan No. 1, Mallig No. 2, Siffu No. 1 , Ilagan No.1, Pinukpuk, Addalam , Chico No. 4, and Disabungan dams. According to the dam screening study, 4 dams, namely Cagayan No. 1, Mallig No. 2, Siffu No. 1 and Ilagan No. 1 dams, have higher efficiencies for flood control.

A scheme to provide flood control capacity for the existing Magat reservoir was also studied , since the existing Magat dam is situated at a suitable site for flood control. In this scheme Alimit No. 1 dam is proposed to complement the functions of existing Magat reservoir sacrificed to flood control.

Therefore, 9 dams consisting of 8 selected dams and Magat dam with Alimit No. 1 dam are encompassed in the framework plan study.

For the Magat dam with flood control capacity, studies were carried out in combination with the proposed Alimit No. 1 to complement the water supply capacity of the existing reservoir for flood control purposes. According to the preliminary water balance study using the flow duration at Alimit No. 1 site, a capacity of about 200 MCM of Magat reservoir could be apportioned to Alimit No. 1 dam.

Principal features of the flood control dams are summarized and shown in Table 5.6. The effective flood control space except for Cagayan No.1, Addalam and Alimit No. 1 in the table is calculated based on the flood runoff hydrograph estimated for 100-year 4-day rainfall. The capacities of Cagayan No. 1 and Addalam dams are set at the limits of the topographic site conditions. The scale of Alimit No. 1 dam is designated as the complementary space of Magat reservoir. For these dams, outflow ratios corresponding to given capacities are calculated by trial and error method. Sediment space is determined so as to store the sediment yield for 100 years, where the sediment yield rate is assumed to be 1,500 m^3/km^2/year.

(4) Basinwide Flood Control Alternative Plans

Combining the schemes presented in the preceding subsections, six basinwide flood control alternative plans were examined for comparison as follows (Fig. 5.10);

1) Alternative plan-OD: A plan consisting of only diking system with existing Magapit narrows.
2) Alternative plan-5D: A plan consisting of 5 flood control dams and diking system with existing Magapit narrows. The 5-dams included are Cagayan No. 1, Mallig No. 2, Siffu No. 1 , and Ilagan No. 1 dams and Magat dam with Alimit No. 1 dam.
3) Alternative plan-9D: A plan consisting of 9 flood control dams and a diking system with existing Magapit narrows. The 9-dams included are Pinukpuk, Addalam , Chico No. 4 and Disabungan dams in addition to the 5 dams mentioned above.
4) Alternative plan-ODM: A plan consisting of a diking system with improved Magapit narrows.

5) Alternative plan-5DM: A plan consisting of 5 dams and a diking system with improved Magapit narrows.

6) Alternative plan-9DM: A plan consiting of 9 dams and a diking system with improved Magapit narrows.

5.3.2 Comparative Studies

The design discharge distribution for each plan was determined for 100-year flood according to the runoff analyses under the respective alternative plans as shown in Table 5.7.

The flood control framework plan includes channel and dam works. The channel works include those for dike embankments, revetment, narrows improvement, cut-off channel, bank protection, drainage sluice and appurtenant facilities. The dam works include those for river diversion, dam and spillway.

Preliminary designs of these channel and dam works were carried out and economic project costs for respective alternative plans were estimated. The project costs includes those of main works, compensation, engineering and administration and contingencies.

The preliminary design of channel works was carried out as presented in the ensuing paragraphs. The preliminary design of concrete dams for flood control purposes was carried out on the basis of the structural design criteria mentioned in CHAPTER IX.

1) Dike embankment and revetment works: Diking systems along the main river and major tributaries were designed for the design high water levels calculated with design discharge of the 100-year flood. Quantities of works were duly estimated. Revetment works for the dikes were designed where the river course came closer to the dike. Proposed sites were selected on the topographic maps of scale 1/25,000.

2) Narrows excavation works: Only the Nassiping section is subject to excavation for the Magapit narrows improvement.

3) Cut-off channel works: In order to accelerate smooth flood flow and to economize the channel works, cut-off channel works are proposed in the markedly meandering reaches.

4) Bank protection works: Bank protection works are to be provided for stabilizing the river course and preventing the bank erosion. River training works in braided river are also included in these works. The following sites are selected for bank protection works:

- Existing critical bank erosion sites and sites susceptible to bank erosion.
- Sites necessary for channel normalization and river training.
- Sites where the river channel comes close to towns, villages, highways and other important public facilities.

5) Drainage sluice works: Drainage sluices will be provided together with dikes for the land side water drainage of the areas protected by dikes. In the present study it is assumed, as a rule of thumb, that one sluice of size 1.5 m x 1.5 m x 2 gates would be installed for 4 km^2 of drainage area, or 3 sluices for 2 km long of dike considering the average drainage basin width.

6) Appurtenant facility works: Four bridges crossing over the Cagayan river need compensation works for the project. They are Magapit, Buntun, Gamu and Naguilian bridges. Three bridges except Magapit bridge need reconstruction because of the channel improvement by diking systems.

On the basis of the preliminary design, project costs of basinwide flood control plans are estimated and summarized below.

- Alt. OD : ₱35,688 x 10^6
- Alt. 5D : ₱36,466 x 10^6
- Alt. 9D : ₱45,796 x 10^6
- Alt. ODM: ₱38,278 x 10^6
- Alt. 5DM: ₱34,394 x 10^6
- Alt. 9DM: ₱45,603 x 10^6

As seen in the above table, alternative plan 5DM which consists of 5 flood control dams and Magapit narrow improvement is the lowest in cost among the alternatives. The second and third least costly alternatives, Alt. OD and Alt. 5D, include long high-dikes which may need more scrupulous maintenance works for their entire services period. Alternative plan 5DM is thus selected for the framework plan.

5.3.3 Principal Features of Framework Plan

A general location map and longitudinal profile of the flood control framework plan are shown in Figs. 5.11 and 5.12. The economic project cost for the plan is estimated and shown in Table 5.8. Principal features of the flood control framework plan are summarized in Table 5.9.

5.4 Long-Term Plan

Flood control long-term plan is a basinwide flood control plan which aims to protect flood prone area from 25-year flood on the basis of the framework plan. The master plan are to be formulated through combining the schemes selected from those encompassed in the long term Plan.

5.4.1 Preliminary Design

Design flood discharge is calculated based on 25-year flood under the condition with diking system, 5 flood control dams selected for the framework plan, and improved Magapit narrows. Dimensions and operation rules of the flood control dams are same with those of framework plan. The excavation volume of Magapit narrows and alignment of diking systems in the framework plan is observed to formulate the long term plan. The excavated materials of narrows could be used to reclaim adjacent lowlying lands along the Cagayan and the Chico rivers to create flood free settlement areas or lands for public facilities. Study for effective usage of the excavated materials should be included in the next stage works.

The design discharge distribution for the long-term plan is shown in Fig. 5.13. The design flood discharge at river mouth is estimated to be 17,900 m^3/s which corresponds to 70.5 % of that of framework plan.

Longitudinal profile with design water levels is shown in Fig. 5.14. The diking systems are designed same manner as in the framework plan study. Work quantities and economic project costs were estimated and are shown in Table 5.10. The project cost for the long-term plan amounts to ₱27,543,000,000.

5.4.2 Economic Evaluation

The benefit of the flood control long-term plan is assumed to be the reduction of probable damages due to flooding (flood reduction benefit) and bank erosion (bank protection benefit). The benefit is estimated under constant and variable property conditions of the basin.

(1) Benefit under Constant Property Condition

Probable flood discharges of the present river condition (without project) are calculated for the different magnitudes of rainfall. The results are shown in Table 5.11.

Possible flood damages without project are estimated by dividing the flooding areas into several blocks. The total flood damages thus estimated are shown in Table 5.12. Average annual flood damage without project are estimated to be ₱3,793,000,000 over the basin against the probable flood up to 100-year flood.

Probable flood discharges and their damages were also calculated for the river condition with improved narrows and dams. The results are shown in the said Tables 5.11 and 5.12.

Flood damages will be eliminated up to 25-year floods by the combined effect of Magapit narrows improvement, 5 flood control dams, and the diking system. In addition to these, benefits of narrows improvement and dam works are expected up to 100-year floods.

The residual damages after completion of the diking system along the Cagayan river are assumed to be 20 % of the existing damages.

According to the procedures mentioned above, annual benefit under the constant property condition was estimated as follows including the bank protection benefit:

- Flood reduction benefit: ₱ 1,564 mil/yr.
- Bank protection benefit: ₱ 73 mil/yr.
- Total benefit : ₱ 1,637 mil/yr.

(2) Benefit under Variable Property Condition

Under the variable property condition, hydrological conditions are assumed to be the same as for the constant property condition. However, the damageable values and subsequent flood control benefits are assumed to vary year by year depending upon the accumulation of properties or economic enhancement in the basin.

Damages with and without project were estimated in the similar manner as in the constant property condition for six return periods of floods and for respective points of years.

As the result, the average annual benefits of the long-term plan were estimated under the variable property condition as summarized below.

- ₱1,637 x 10^6/yr. in 1985
- ₱2,723 x 10^6/yr. in 1995
- ₱3,834 x 10^6/yr. in 2005
- ₱7,781 x 10^6/yr. in 2020
- ₱14,728 x 10^6/yr. in 2040

(3) Economic Evaluation

For the cost-benefit analysis, the following assumptions were applied;

1) The main works will be carried out over 15 years from 1991 to 2005, the target year for the Master Plan.
2) Engineering and administration for the project will continue from the year 1990 until 2005.
3) Compensation will be carried out one year earlier than the main works, i.e., from 1990 to 2004.
4) Project costs are assumed to be disbursed uniformly throughout the work periods.
5) Project life is assumed to be 50 years from the beginning of works in 1991 to the year 2040.
6) The benefit to be derived by the project is assumed to be propotional to the cumulative investment disbursed by the year.
7) As an annual operation and maintenance cost, 0.5 percent of cumulative investment disbursed by the year under consideration is assumed.
8) Base year for the cost-benefit analysis is taken at the end of 1985.

Economic viability of the long-term plan is evaluated in terms of the internal rate of return for the both constant and variable property conditions as shown below.

- Constant property condition : 4.8%
- Variable property condition : 14.2%

(4) Principal Features of Long-Term Plan

The principal features of the long-term plan are summarized in Table 5.13.

5.4.3 Priority Ranking of Sub-Projects

Execution of the long-term plan would require a considerable amount of funds and is deemed difficult to complete by the target year of the Master Plan, 2005. Therefore, several sub-projects included in the long-term plan are selected for the Master Plan on the basis of their economic viability as follows;

1) Dike schemes: The following two dikes are segregated from the proposed dike system through the screening works in consideration of properties to be protected by dikes.

   - Tuguegarao dike
   - Cabagan dike

2) Revetment scheme: Revetment works to strengthen the dikes are included in the candidate dike schemes mentioned above.

3) Narrows excavation scheme: The selected Nassiping site is divided into three work sites, i.e., excavation works of left side bank of lower portion (Site-NLL), right side bank of lower portion (Site-NLR), and upper portion (Site-NUP) of Nassiping section. These three sites are proposed as candidate schemes for the Master Plan. The work quantities are summarized below.

   - Site-N(whole): 43,194 x 10^3 m^3
   - Site-NLL : 5,828 x 10^3 m^3
   - Site-NLR : 17,624 x 10^3 m^3
   - Site-NUP : 19,869 x 10^3 m^3

These schemes are expected to reduce the water level at Sta. 65 km by 3.08 m, 1.19 m, 2.1 m and 0.52 m respectively. The respective reductions per unit excavation volume are estimated to be 7.1, 20.4, 11.9 and 2.6 $cm/10^6m^3$.

4) Flood control dam schemes: All the dams included in the long-term plan are to be encompassed in the candidate schemes as follows;

- Cagayan No. 1 dam
- Magat/Alimit dam
- Ilagan No. 1 dam
- Siffu No. 1 dam
- Mallig No. 2 dam

5) Bank protection schemes: All the bank protection schemes included in the long-term plan are taken up.

Priority rank is given to each candidate scheme as the criteria for the selection to the master plan on the basis of economic viability. The economic viability is examined according to the following assumptions:

1) Project cost including main works, engineering and administration, and compensation is assumed to be disbursed uniformly for 5 years from the 1991 to 1995 years.

2) Benefit is assessed independently for each candidate scheme comparing with the conditions with and without project. The benefit is estimated under the constant and variable property conditions of the basin.

3) Benefit derived from the dam works is assumed to be realized next year of the completion of the works, while the benefit of the channel workes is assumed to be propotional to the progress of the works.

4) Same criteria adopted in the evaluation of the long-term plan are applied in the study for other conditons in this evaluation.

Result of study on the priority ranking of these candidate schemes is shown in Table 5.14, which is summarized below.

Rank	Candidate Scheme	IRR. CPC/1	IRR. VPC/2
No. 1	Tuguegarao dike	11.6%	23.1%
2	Narrow imp.(Site-NLL)	8.9	18.9
3	Bank protection	7.3	13.7
4	Cabagan dike	5.3	13.6
5	Narrow imp.(Site-NLR)	5.2	13.5
6	Magat/Alimit dam	5.1	13.1
7	Siffu No.1(A) dam	5.1	12.8
8	Cagayan No.1 dam	3.8	11.6
9	Mallig No.2 dam	2.2	9.3
10	Ilagan No.1 dam	-	5.4
11	Narrow imp.(Site-NUP)	-	-

Note; /1: IRR under constant property condition
/2: IRR under variable property condition

VI SECTORAL STUDY ON THE AGRICULTURAL DEVELOPMENT

6.1 Present Agricultural Land Use

The agricultural area of the Cagayan river basin is estimated to be 5,339 km^2 in total. Paddy field amount to about 46% or 2,470 km^2 of the agricultural area. Diversified crops occupy the next largest area of 1,303 km^2 which is equivalent to 24.4%. Other land uses are pasture land for cattle grazing, permanent crops area and fish ponds of 1,269 km^2, 270 km^2 and 27 km^2 respectively.

Temporary crops are cultivated on the alluvial terraces which extend along the Cagayan river, and occupy about 70% of the total agricultural land. The cattle ranches have been rapidly expanding in recent years. They extend over the undulating to rolling hilly areas. Permanent crops include banana, citrus, coconuts and coffee. These tree crops are sporadically observed over the hilly and mountainous areas. Present agricultural land use is demarcated in Fig. 6.1.

The potentially cultivable area in terms of topography is limited to lands of less than 18% slope. Comparison between the present agricultural land use map (Fig. 6.1) and slope map (Fig. 2.2) indicates that the existing agricultural lands nearly coincide with the area with less than 3% slope. Lands with the slopes between 3-8% having smaller areas, compared with other slope categories, have been also partly utilized for agricultural production. This means that the most suitable lands for agriculture have already been fully developed and only undulating lands are left for further expansion of agricultural land.

6.2 Present Agriculture Production

6.2.1 General Overview

Agriculture in the Cagayan river basin is characterized by (i) a high rural population, (ii) a high contribution of agriculture to GRDP, (iii) limited agricultural land use, (iv) significantly high proportion of idle grassland, (v) heavy reliance on temporary crops like rice and corn and (vi) low productivity. Comparison between the country and the river basin (or Region II) is given in Table 6.1. Comparison in production is made as illustrated on Fig. 6.2. Crop yields per ha are also compared with the country average as given in Fig. 6.3. All these comparisons indicate that in spite of extreme importance of agriculture in the basin area, its productivity is generally low.

6.2.2 Cropping Pattern and Farming Practices

The present cropping pattern for the areas utilized for annual crops cultivation is given in Fig. 6.4. The commonest cropping pattern in irrigated paddy fields is paddy-paddy. The cropping intensity is about 180% due to insufficient supply of irrigation water during the dry season. Advanced rice cultivation techniques are widely applied in this area. High yielding varieties are adopted and use of fertilizers and agro-chemicals is common. In the rainfed paddy fields of about 100,300 ha, paddy is grown only once in the wet season. About 20% of the rainfed paddy fields is cultivated for corn during the dry months from January to May. The remaining 80% of the fields is left unutilized in the dry season due to lack of water. The use of improved varieties, fertilizer and agro-chemicals is limited in this area.

The primary crop in the diversified crops area of about 130,300 ha is corn. Corn is grown twice a year under rainfed condition. More than 90% of corn grown in the basin is native white varieties and hybrid yellow corn is not popular yet. As can be seen in Table 6.1, corn yield is generally very low due to limited use of fertilizers and agro-chemicals. Sugar cane is grown in Piat area of Cagayan province. Sugar cane yield is very low due to unstable rainfall condition. Sugar cane is exclusively sent to the sugar factory at Piat to process. Peanuts are usually intercropped with dry season corn. A major root crop is sweet potato which is grown in undulating upland area. Tobacco is mostly grown in the river terraces in Isabela province. Major tree crops in the basin are banana, coconut, citrus and coffee. No significant activity in tree crop plantation is observed.

6.2.3 Marketing and Prices

Only rice and corn have a country-wide marketing channel. Other minor crops are generally consumed locally. Most of the livestock and fishery products are also consumed within the basin. Average paddy production in recent years amounts to about 840 x 10^3 tons. The basin consumes about 350 x 10^3 tons of paddy. After meeting the basin's consumption, about 490 x 10^3 tons are available for appropriating to other regions. Most of the surplus corn (about 55% of the basin's production or about 145 x 10^3 tons) are transported to Manila. A number of local dealers (about 1,700) are handling about 90% of the marketable surplus of rice and most of the surplus of corn. The National Food Authority (NFA) functions as a marketing leader for rice, handling about 10% of the marketable surplus.

The farmgate price of paddy is remarkably fluctuating by season. Fluctuation of farmgate price of paddy directly influences the farmers' livelihood because paddy is grown by most of farmers and constitutes a major source of farm income.

6.2.4 Agro-Processing Industry

The basin has a total milling capacity of about 800 x 10^3 tons per annum. The capacity of modern rice mills which produce a better quality of milled rice, is about 295 x 10^3 tons per annum which corresponds to only about 60% of the marketable surplus. The quality of rice produced by other local rice mills is considered rather poor and unsuitable for marketing. The rest of the surplus (about 195 x 10^3 tons) is therefore moved to Central Luzon for milling. The total quantity of paddy processed within the basin is about 551 x 10^3 tons inclusive of the basin's consumption of 256 x 10^3 tons, which corresponds to about 70% of total milling capacity.

Agro-processing facilities other than rice mills are represented by CASUCO and CAVADECO. The former is a sugar mill with a capacity of 4,000 tons per day and the latter is processing feeds for livestock with a capacity of 6 tons per hour. Neither of them have realized the full operation of their design capacity due to difficulties involved in procurement of raw materials.

6.2.5 Agricultural Support System

DAF plays a leading role in the agricultural support system. DAF has its regional office at Tuguegarao and provincial offices at each provincial capital. It provides the farmers with the following services through its various channels:

Research: DAF has an agricultural experimental station at Ilagan. The station specializes in rainfed upland crop experiments and trials. Cagayan Valley Experiment Station is located within the Magat Irrigation Project area and specializes in irrigated rice trials. Agricultural research and trials are also carried out by other institutions which include (i) Cagayan State University, (ii) Cagayan Integrated Agricultural Development Project (CIADP), and (iii) Isabela State University. All the research works are coordinated under DAF regional office.

Seed Multiplication: The seed multiplication has been carried out by three institutions i.e.; (i) Luna-Abulug Seed Farm Complex, (ii) Ilagan Experiment Station, and (iii) Cagatan Valley Experiment Station. These institutions mainly work on rice under BPI/Seed Board, Manila. These institutions are responsible for technical guidance to the seed growers, processing of multiplied seeds, storage and distribution. These institutions however are not capable of supplying enough registered seeds to the seed growers and also of certified seeds to the farmers due to their limited facilities and equipment.

Cooperative Movement: A total of 934 farmers' associations (Samahang Nayon) are registered in Region II, among which only 144 associations (15%) are actually operating. Organization is not so strong.

Extension: The government rice programs (Masagana 99 and Intensified Rice Production Program - IRPP) cover about 84×10^3 ha or 34% of the total paddy fields. About 34×10^3 farmers participate in the programs. The government corn program called "Expanded Corn Program (ECP)", which is a modified program of Maisagana, covers about 10,600 ha or 10% of the total corn fields. These production programs have credit services.

6.2.6 Agricultural Production

(1) Crop Production

Major crops grown in the basin are rice and corn, followed by peanuts, tobacco, sugar cane, sweet potato, beans and vegetables. Production of these crops in 1985 is estimated as shown in Table 6.2. Rice and corn are extremely important in the Cagayan area. However, the planted/harvested area and production of these crops are largely fluctuating year by year as shown from Fig. 6.5 through Fig. 6.8.

(2) Livestock Production

Most of livestock animals in the basin are raised by small farmers or backyard raisers. Large scale commercial production is still under-developed. The number of livestock and poultry in the basin is estimated as shown in Table 6.3.

The present livestock industry is characterized by its low productivity which is evidenced by (i) low slaughter live weight, (ii) low percentage of carcass dressing, (iii) high mortality rate and long breeding interval. The present low productivity of livestock industry is attributable to (i) the high rate of backyard production, (ii) the high rate of native breeds (very low introduction rate of improved breeds), (iii) the high probability of diseases occurrence (No serious diseases have been observed in this area. Dominant diseases are hemorrhagic septicemia and blackleg which can be prevented by vaccination), (iv) low utilization of hay, silage and high energy feeds, and (v) lack of technical guidelines for the pasture land development.

(3) Fish Production and Forestry Production

Aquaculture is still underdeveloped in the basin. Natural swamps and river scars are generally utilized as fish ponds. Major species are milkfish, mudfish and tilapia. Large scale fish ponds are observed in the northern coastal areas of the Cagayan province. There are about 1,600 fish ponds in the basin, with a total area of 2,700 ha. Annual fish production is estimated at about 1,500 tons in total, or 0.57 ton per ha.

Logwood production in 1985 is estimated to be 715,000 m^3 on the basis of forestry statistics provided by BFD.

(4) Agricultural Production Value

Agricultural production in term of Gross Value Added (GVA) for the year 1985 is estimated to be ₱862 x 10^6 at 1972 constant price. Paddy shares 50% of total agricultural GVA in 1985. Forestry following paddy produces ₱147 x 10^6 or 17%. Corn and other crops share 11 % and 12 %. The contributions of livestock and fisheries are as low as 9 % and 1 %, respectively.

6.2.7 Present Conditions of Irrigation and Drainage

(1) Existing Irrigation Systems

The existing irrigation systems inclusive of on-going projects cover a total irrigation service area of about 224,000 ha, which comprises 150,800 ha commanded by the NISs, 58,300 ha by the CISs, 2,800 ha by the PISs and 12,100 ha by the private pump irrigation systems. Since the irrigation service area of the private gravity irrigation systems is insignificant and the data on these systems are not available, their service areas are excluded from the above. The irrigation service areas in the Basin are shown schematically in Fig. 6.9.

(2) National Irrigation Systems

As of December 1986, there exist eight (8) NISs consisting of six (6) locally funded and two (2) foreign assisted NISs, while three (3) national irrigation projects (NIP) are under construction. The aggregate irrigation service areas of the NISs and the on-going NIPs comprise 131,480 ha and 19,317 ha, respectively. Fig. 6.10 shows location of these systems/-projects. The name and each service area of the systems/projects are given in Table 6.4.

Among the eight (8) NISs, the service areas of the Magat river integrated irrigation system are located widely in the provinces of Isabela and Ifugao. These of Chico RIS are distributed in the Provinces of Isabela, Kalinga Apayao and Cagayan. The Tumauini River Irrigation System (RIS) is located in the province of Isabela, meanwhile the other five (5) existing NISs concentrate in the province of Cagayan.

The Magat River Integrated Irrigation System and the Chico River Irrigation System are foreign assisted projects. Meanwhile, the remaining six irrigation systems are locally funded. The Solana-Tuguegarao Irrigation System (IS) taps water from the Cagayan river through pumps. The other five locally funded NISs are depending on unregulated flow from the tributaries of the Cagayan river for their water source. Neither storage dam nor diversion dam is provided for in any of the systems even though the catchment areas of the tributaries at each intake site are relatively small. Therefore the intake discharge is directly affected by fluctuation of river runoff especially during the dry season.

All canals are unlined regardless of soil texture and erosion; siltation and deterioration are rather common. Canal embankments are generally insufficient in their width and height for their commanding area, which limits the extent of areas to be irrigated. The number of turnouts and structures is sufficient to divert irrigation water from a main, lateral or sublateral canal to a rotation area, and adequately located in the systems. However, their functions may be limited because most of them consist only of a precast concrete pipe with an inlet box and are not equipped with any control gate or measuring device. Farm ditches are provided for in all the systems, but their density varies from system to system ranging from 10 to 60 m/ha. No significant drainage problem is noted among any of the systems except the general lack of farm drainage.

The actual irrigation area of each system is always smaller than their irrigation service areas not only during the dry season cropping but also the wet season cropping as shown in Table 6.5. Table 6.6 shows the average actual irrigation area and the average ratio of actually irrigated area to the service area for the recent five (5) years or after completion of the system.

The Chico River Irrigation System Stage I with a total irrigation service area of 20,108 ha, extends over Tabuk and Pinukpuk municipalities in the province of Kalinga Apayao, Tuao municipality in the province of Cagayan, and Quezon and Mallig municipalities in the province of Isabela.

The project has been implemented since March 1976 with the financial assistance of IBRD. As of December 1986, irrigation and drainage facilities have been provided for 99 % of the service area. Partial operations were commenced in November 1983 for an area of 4,700 ha and were reportedly extended in 1985 for an area of 7,000 ha for wet season cropping and 11,200 ha for dry season cropping.

The Magat River Integrated Irrigation System (MRIIS), which is the irrigation component of the Magat River Multipurpose Project (MRMP), which commands 97,400 ha of rice lands, extending over alluvial terraces in the flood plain of the Cagayan, Magat and Siffu rivers. The MRMP was implemented with the co-financing of IBRD and ADB during the period from 1976 to 1987. At the initial stage of implementation of the MRMP, irrigation by the existing systems was limited to 40,000 ha in the wet season and 19,000 ha in the dry season. After completion of the Magat dam in 1982, however, the irrigation area increased drastically. In 1984/85, irrigated area reached about 70,000 ha for the dry season crop and 75,000 ha for the wet season crop, respectively. In addition to this, two (2) locally funded and one (1) foreign assisted irrigation projects are now under construction. The locally funded projects are the San Pablo-Cabagan Irrigation Project and the Mallig River Irrigation Project. The foreign assisted one is the Cagayan Integrated Agricultural Development Project.

(3) Communal Irrigation systems

Irrigation development by the CIS in the basin was initiated by the farmers in Spanish times and continued until 1960. In 1950's, the Government agencies started the construction of the CISs. As of December 1985, there were 1,156 CISs with an aggregate service area of 58,290 ha. The CISs and their respective aggregate areas for each province in 1985 are summarized in Table 6.7.

Generally, a CIS is served by the unregulated flow of small rivers or streams. An intake without diversion weir is the most common diversion system. The canal system consists of main and lateral canals. Provision of farm ditches is limited to those constructed recently by the NIA.

Irrigation intensity, the ratio of irrigated area to service area, varies year to year depending upon fluctuation of river discharges and other reasons. The annual irrigation intensity of all CISs in the basin in 1985 was estimated to be 1.36 comprising 0.73 for the wet season crops and 0.63 for the dry season crops. It also widely varies among the provinces from 1.89 in the province of Cagayan to 0.58 in the province of Quirino as shown in Table 6.7. The difference between the actual irrigation area and its service area of most CISs, occur for the following reasons;

1) The service area is excessively dependent on available river discharge.
2) Part of the service area is left undeveloped after establishment of the canal system.
3) Once part of the system deteriorates, the area being served by it is abandoned due to insufficiency of funds for rehabilitation

which should be borne by the water users association.

(4) Pump Irrigation System

PISs have been constructed since the middle 1970's by the FSDC. As of end 1985, 40 PISs have been completed and one (1) PIS is under construction. The aggregate irrigation service area of these PISs is 2,800 ha in the whole basin. Due to the high cost of operation and maintenance, however, these areas are not always served. The composition and total area of the PISs in each province is shown in Table 6.8.

(5) Private Irrigation System

A small number of gravity type private irrigation systems have been constructed and operated by individuals in the basin. Since the data on those systems are not available, their locations and irrigation service areas could not be identified.

Pump units issued to individual farmers by the NIA from 1973 to 1979 reached 3,365 units, whose aggregate irrigation service area tallied 30,872 ha. As of December 1985, however, operational pump units were reduced to 1,825 due to deterioration, loss, diversion of pump units, etc., thereby resulting in the reduction of irrigation service areas to about 12,000 ha. Distribution of these pump units serving the irrigation areas in each province is shown Table 6.9.

(6) Present Irrigation Practice

Operation and maintenance of the NIS are conducted by the system office (O & M Office) under the NIA from headworks to turnouts on sub-lateral canals. Operation and maintenance of farm ditches are carried out by farmers with the technical assistance of the system office. One gate keeper is assigned for gate operation, and water masters are appointed for gate operation of turnouts on main to sublateral canals. One water master is responsible for an irrigation area of 500-700 ha. Generally, simultaneous irrigation is applied to the whole irrigation area, and rotational irrigation is occasionally conducted when water shortage take place during the dry season. Present water supply which is limited to rice cultivation, is practised in accordance with the water requirement calculated on the monthly basis.

Operation and maintenance of both the CISs and the PISs are carried out by the water users association. Only the peak unit diversion water requirement has a standard figure of 1.5 - 2.5 l/sec/ha, and all the irrigation practices are dependent on farmer's experience.

Each system office (O & M Office) of the NIS keeps a daily intake discharge record. However, the records are fragmentary and unreliable in the absence of measuring devices. As for the CIS, PIS and Private Irrigation System, no intake discharge records are available.

6.3 Potential and Strategy of Agricultural Development

6.3.1 Potential of Agricultural Development

The potential area for agricultural development is estimated to be 1,080 x 10^3 ha on the basis of the land area with slope less than 18% excluding built-up area and bareland of 500 x 10^3 ha. It comprises low land with slope less than 8% of 476 x 10^3 ha and upland of 604 x 10^3 ha.

On the other hand the soil and land classification studies were made on the basis of the physiographic landform map (Fig. 6.11) and several soil maps which were collected from DAF/BS and NIA. The results of soil study are summarized in Table 6.10. Land capability both for the rice and the upland crops was also studied for each soil series on the basis of a modified form of the USBR standard. The land capability classifications for paddy and diversified crops are delineated as shown on Fig. 6.12 and Fig. 6.13 respectively. According to the land capability classification map developed, 476 x 10^3 ha of lowland is suitable for paddy cultivation including highly suitable land of 306 x 10^3 ha. The map also indicates that the land of 1,080 x 10^3 ha with slope less than 18% is arable for diversified crops. Non arable lands for paddy and diversified crops are

$2,254 \times 10^3$ ha and $1,650 \times 10^3$ ha, respectively.

The total land utilized for paddy, corn and the other diversified crops is estimated to be 377×10^3 ha out of arable lowland of 476×10^3 ha. The consequent idle grass land is estimated to be 99×10^3 ha. Likewise, lands of 154×10^3 ha are utilized for permanent crops and pasture land out of the arable upland of 604×10^3 ha in 1985. The idle grass land is estimated to be 450×10^3 ha, which is expected to be able to develop in the future.

The possible maximum land use was studied assuming the full developments of the paddy field up to 306×10^3 ha, corn field up to 142×10^3 ha and the other diversified cropland to remain 28×10^3 ha as it is. In this case idle grassland of 99×10^3 ha would be developed and be fully utilized.

In the upland area, permanent cropland and pasture land are assumed to be increased up to 200×10^3 ha and 300×10^3 ha. Consequently idle grass land will decrease from 450×10^3 ha to 104×10^3 ha.

It is assumed on the basis of the present agricultural productivity and the agricultural experimental data that if all the necessary measures are be taken up in the fields of flood control, irrigation and other agricultural development, the area will attain double productivity in terms of GVA per ha at 1972 constant price. Potential maximum GVA to be produced from the potentially maximum agricultural land is estimated at ₱$2,408 \times 10^6$ in the basin as shown in Table 6.11.

6.3.2 Basic Concept of Agricultural Development

The major constraints which hamper the agricultural production are considered as follows:

a) rainfall with wide range of fluctuation and its uneven seasonal distribution;

b) flood damages caused by occasional typhoons; and

c) insufficient provision of agricultural support services.

Other constraints such as limited use of fertilizers, insufficient practices of crop protection, wide use of unnamed native varieties, etc. are also not to be neglected.

In addition to the present situation, the agricultural development policy of the Government is one of the key factors for establishing the development concept. The new Government has given the highest priority for the economic development to the agricultural sector. Based on the new policy, DAF has prepared "A Short-Term Recovery Plan for the Rural Sector". The specific objectives of the Plan are as follows:

a) create jobs for landless workers;
b) redistribute land rental income to the poorest farmers;
c) raise output prices at the farmgate level;
d) lower input prices; and
e) increase productivity.

Along these line, the following strategy is established to the extent of the available resources:

1) Improvement of land productivity on existing agricultural land through irrigation development and flood protection works;

   - Major crops in the lowland are rice and corn. These crops, however, give the farmers only unstable and low results of yields due to occasional floods and irregular availability of water.

   - For irrigation development, priority will be given to existing paddy fields. Drastic change in the prevailing paddy-paddy cropping pattern will not be considered, because of the projected future shortage of paddy rice as shown in Fig. 6.14. In the diversified crop areas, corn will continue to be the primary crop. The planted area of yellow corn will, however, be increased, instead of white corn, due to the mushrooming demand for feeds (see Fig. 6.14).

2) Expansion of agricultural land through development of undulating uplands and hillslopes; and

- Large areas of undulating uplands and hillslopes still remain unutilized. Development of the idle grassland will be a key determinant in the regional economy of the basin. These lands could be utilized for tree crops plantation and cattle grazing.

- In particular, cattle grazing will have a great potential considering the increasing demand for beef (see Fig. 6.14) and the extensive suitable land for pasture.

3) Amplification of agricultural support services, particularly to the small farmers who form the majority of rural society.

6.3.3 Target of Development by the Year 2005

As mentioned in the previous chapter for regional economic development, it is proposed that per capita GRDP should be raised to the national average by the year 2005. GRDP in the basin would be ₱6,028 x 10^6 at 1972 constant prices, which is about 3.7 times that in 1985 of ₱1,650 x 10^6.

Since present GRDP depends about 50% on the agricultural GVA, the agricultural sector should respond to the expectations over the sector. In this connection, it is assumed that around 70% of the inherent regional agricultural potential is to be developed by the year 2005 except for the forestry production. Consequently the target of the agricultural GVA is set at ₱1,837 x 10^6 in 2005 at 1972 constant price including the GVA of ₱147 x 10^6 by forestry. The target is around twice agricultural GVA of ₱862 x 10^6 in 1985.

6.3.4 Strategy for Agricultural Development

In view of the present agricultural situation mentioned above, following strategies have been applied in order to achieve the development target.

1) The potential paddy fields of 306 x 10^3 ha will fully be irrigated, through realization of the following measures:

   - Immediate construction of on-going projects;
   - Rehabilitation/improvement of existing NIS and CIS schemes; and
   - Development of new irrigation schemes

2) Productivity of rice production will be increased by extension of improved farming practices under irrigation.

3) The potential diversified cropland of 170 x 10^3 ha will be fully developed, and the increased cropland will be allocated mainly to corn production.

4) Productivity in the diversified cropland will be increased by improved farming practices under rainfed condition.

5) Upland areas will be utilized mainly for production of permanent crops and cattle grazing.

6) Recommended permanent crops will be cashew nuts, mango and citrus fruits.

7) Cattle will be grazed in the pasture and be fattened in the feedlot.

8) Fresh water aquaculture will be the main source of fishery products. The increase in production of fishery products will be set at 4.5% per annum based on "The Medium-Term Plan of BFAR".

9) Forestry production will be maintained at the present selected logging level in due consideration of the government policy on environmental conservation.

On the basis of the strategies mentioned above, the agricultural land use plan for the year 2005 is made as follows:

Unit: 10^3 ha

Lowland	(1985)	(2005)	(Max.)	(2005)/(Max.)
1) Paddy field	247	306	306	100
2) Diversified - Corn field	102	142	142	100
cropland - Others	28	28	28	100
3) Grassland (idle)	99	-	-	-
Upland				
1) Permanent cropland	27	57	200	29
2) Pasture	127	210	300	70
3) Grassland (idle)	450	337	104	-

6.4 Candidate Schemes for Irrigation Development

6.4.1 Objective Area of Preliminary Study

Lands suitable for irrigation are estimated to be 476,000 ha, which are divided into the existing irrigation service areas of 224,000 ha in total and potential irrigable areas of 252,000 ha in total.

Of the potential irrigable areas, those areas with slopes less than 3% and with land areas of more than 100 ha are selected as promising irrigable areas. The total area of those selected amounts 82,400 ha. They are further classified into two (2) categories taking the area and location of each into account, i.e., an aggregate area of 53,800 ha to be developed under National Irrigation Projects (NIP) and a total area of 28,600 ha to be developed under Communal Irrigation Projects (CIP).

On the other hand, a total of existing irrigation service area of 224,000 ha consists of 150,800 ha commanded by the NISs, 58,300 ha by the CISs, 2,800 ha by the PISs and 12,100 ha by Private Irrigation Systems.

Out of the total existing/on-going NISs area of 150,800 ha, an area of 12,200 ha commanded by five (5) NISs is in need of rehabilitation/ improvement since the actual irrigation area is very small as compared with its service area.

Communal irrigation areas of 11,500 ha out of a total area of 58,300 ha are enclosed by or adjacent to the promising irrigable areas to be developed under NIP. It is, therefore, considered that those areas should be integrated into the NIPs when the NIPs are realized. As for the remaining communal irrigation area of 46,800 ha, the CIS areas where the actual irrigation area is much smaller than its service area call for rehabilitation so as to restore the shrunk irrigation area.

In due consideration of the above mentioned land resources and the present condition of the existing systems, it was decided in formulating a framework plan that irrigation development by the year 2005 should cover the following areas (See Fig. 6.15).

- Development of new area under NIP	:	65,300 ha (including CISs area of 11,500 ha)
- Development of new area under CIP	:	28,600 ha
- Rehabilitation/improvement of NISs	:	12,200 ha
- Rehabilitation/improvement of CISs	:	part of 46,800 ha

In addition to the above, improvement of the O & M of the Magat River Integrated Irrigation System (97,400 ha) also is included in the framwork plan.

In this water resources master plan study, the objective areas or projects for preliminarily study are new NIP of 65,300 ha and rehabilitation of NIS of 12,200 ha.

6.4.2 Present Condition of Objective Area

(1) New Irrigation Schemes

Nine (9) schemes with a total area of about 65,300 ha have been taken up as new development schemes (See Table 6.12 and Fig. 6.16). The area comprises paddy fields of 45,100 ha (69%), diversified croplands of 14,200 ha (22%) and idle grasslands of 6,000 ha (9%). In the area, 16 soil series are identified and grouped into six textural classes:

1)	Clay Loam	34,100 ha
2)	Sandy Clay Loam	17,200 ha
3)	Silty Loam	5,000 ha
4)	Silty Clay Loam	4,600 ha
5)	Clay	2,700 ha
6)	Sandy Loam	1,700 ha
	Total	65,300 ha

These soil conditions are suitable for irrigated paddy cultivation and all kinds of upland crops. Most of these soils are graded as "A" in DAF land capability classification. Soil and land use conditions are summarized in Table 6.13.

The total population in the new development areas is estimated at about 269,400. Households total 47,700, of which farm households accounts for 74% or 35,100 in number. Demographic information is given in Table 6.14.

The present cropping pattern is shown in Fig. 6.17. The present cropping intensity is estimated at 129% on average as shown in Table 6.15.

(2) Rehabilitation/Improvement Schemes

Five (5) existing irrigation schemes will be put under the rehabilitation/improvement program. The irrigation service area totals about 12,200 ha (See Table 6.12 and Fig. 6.16). The actually irrigated area, however, is only 3,815 ha (32%) in the wet season and 2,965 ha (25%) in the dry season as shown in Table 6.16. Unit yield of paddy ranges from 3.1 tons/ha to 3.8 tons/ha with an average of 3.4 tons/ha for the wet season paddy and 3.5 tons/ha for the dry season paddy.

A total of 5,950 farmers participates in irrigated agriculture at present. This corresponds to about 57% of the total number of farm households in the service areas. The scheme will also benefit about 4,600 non-irrigated farmers. Demographic feature of the area is given in Table 6.17. Present cropping pattern is illustrated on Fig. 6.18.

6.4.3 Proposed Farming Development

(1) Future Land Use and Proposed Cropping Pattern

After the implementation of the irrigation and rehabilitation/improvement schemes, the present rainfed paddy fields will become irrigated and existing irrigated paddy fields will be improved. Present grasslands will be also opened as the irrigated paddy fields. Diversified croplands under rainfed condition will be developed as irrigated diversified croplands because drastic change in land use is difficult.

Three types of the cropping patterns are proposed as shown in Fig. 6.19 through Fig. 6.21. Pattern A and B are proposed for paddy fields and Pattern C is proposed for the diversified cropland. Pattern A is a paddy-paddy-beans type and designed so as to get the maximum benefits and the stable production. Pattern B is a paddy-paddy type and designed to reduce the total irrigation water requirement and construction costs for dams and irrigation facilities. Two types of cropping pattern are applied to the economic evaluation of each scheme.

Early-maturing varieties of paddy like IR36, IR56, IR58 and IR60 will be adopted to Pattern A and B. These varieties mature within 110 days after seeding. The wet season paddy in Pattern B will be delayed from that in Pattern A by a half month for seeding, tranpslanting and harvesting. A half of the harvesting paddy in Pattern B would be exposed to typhoons in October. The dry season paddy in Pattern B will be ahead of Pattern A by a half month. The period between the two crops of paddy in Pattern A will span 3 months from September to November. Mungo beans or other legumes will be grown in this period as a third crop in Pattern A. Irrigation will be shut down during the month of April in Pattern A and April/May in Pattern B for maintenance of irrigation facilities.

Pattern C is designed for irrigated diversified croplands. Principal crops will be corn, vegetables, Mungo beans and tobacco. Open-pollinated corn will be adopted because of its lower production costs as compared with hybrid corn. Pattern C will be introduced to areas with sandy soils and/or the existing diversified croplands.

Future land use and harvested areas under with project thus estimated are as shown in Table 6.18 for new irrigation schemes and rehabilitation/improvement schemes.

(2) Proposed Farming Practices

Proper farming practice is one of the essential factors for realizing full exploitation of the agricultural potential in the project area. The proposed farming practices and farm inputs in the future with project condition are designed with reference to data collected from Ilagan Experiment Station, Cagayan Valley Experiment Station, Agricultural Pilot Center under CIADP and PCARRD. With regard to the future without project condition, no substantial changes in farming practices are forecast.

Production costs, and labor, animal power and mechanical power requirements under with and without project are shown in Table 6.19.

(3) Anticipated Yield and Production

Present crop yields in the basin are lower than the national average and fluctuate year by year under the rainfed and unstable irrigated conditions. After completion of the irrigation projects, the crop yields will be stabilized and increased through supply of sufficient irrigation water, improved farming practices, and strengthened and expanded agricultural support services.

Anticipated crop yields under with project and without flood conditions are conservatively estimated with reference to the data from the experimental stations in the basin. The crop yield per hectare will gradually increase from the present level and reach the target yield in the 5th year after completion of each irrigation scheme.

		Without Project	With Project
1. Paddy			
Irrigated	- wet season	3.40	4.50
	- dry season	3.50	5.00
Rainfed	- wet season	2.23	-
	- dry season	-	-
2. Corn		0.90	3.75
3. Tobacco		0.60	2.00
4. Vegetables		4.02	13.00
5. Beans		0.34	1.50

The yield of the wet season paddy will be 4.1 ton/ha in the case of with project of cropping Pattern B.

Future crop productions for each scheme under without project are estimated on the basis of the present cropping patterns, harvested areas and crop yields. Future crop productions under with project are estimated on the basis of the proposed harvesting areas and the anticipated crop yields in each case of the proposed cropping patterns A, B and C.

The crop productions under without and with project are as shown in Table 6.20 for the new irrigation schemes and the rehabilitation/improvement schemes.

6.4.4 Criteria Adopted

To establish development priorities for candidate schemes, unified methodologies and criteria have been employed for formulating the development plans of these schemes so that all the schemes could be evaluated on the same basis:

(1) Irrigation water requirement:

Based on the proposed cropping pattern, irrigation water requirements are estimated on a monthly basis by an empirical method. The gist of the calculation methodology and assumptions employed are discussed in ANNEX IR.

(2) Canal network

Facilities required for irrigation development are broadly divided into; irrigation systems, drainage systems, and operation and maintenance (O & M) facilities.

The irrigation system consists of an intake, main and lateral/sub-lateral canals, main and supplementary farm ditches and structures related to those canals. A gravity irrigation system is the first consideration. A pump irrigation system is taken into account only when a gravity type intake is not economically feasible. A service area is subdivided into rotation blocks with a standard area of 50 ha. The rotation block is generally rectangular in shape, 1,000 m in length and 500 m in width. Main and supplementary farm ditches are provided within the rotation block. The standard density of the main and supplementary farm ditches is assumed to be 20 m/ha and 50 m/ha, respectively. Structures related to irrigation canals are those for conveyance, regulation and measurement of irrigation water, and for protection of the canals.

The drainage system comprises farm drains, collector drains, main drains and related structures. The farm drains are provided in the rotation area. The standard density of the farm drains is assumed to be 16 m/ha for the main farm drain and 50 m/ha for the supplementary drains. Related structures of the drains are mainly conveyance structures such as siphons and culverts.

O & M facilities considered in the preliminary study are O & M roads and their related structures. As a rule, O & M roads are provided along whole reaches of the irrigation canals. O & M roads for the main and lateral/sub-lateral canals are all-weather roads and wide enough for passage of vehicles and equipment for maintenance works.

(3) Design discharge

Unit design discharge for the main, lateral/sub-lateral irrigation canals and related structures is determined to be the peak unit irrigation diversion requirement corresponding to one with a 5-year return period. The unit design discharge of each candidate scheme is shown in Table 6.21. The unit design discharge for the main and supplementary farm ditches is determined so as to meet land soaking requirement including farm application loss.

Unit drainage discharge in paddy field is determined to remove excess water caused by a 3-day probable rainfall with a 10-year return period during a 3-day drainage period. Unit design drainage discharge in diversified crops field is determined to remove excess water caused by a 4-hour rainfall with a 10-year return period during a 4-hour drainage period.

(4) Preliminary design

Preliminary design of the facilities is based on the Manning's formula with the following conditions:

Description	Irrigation facilities	Drainage facilities
- Canal type	trapezoidal earth canal	trapezoidal earth canal
- Roughness Coefficient	0.025	0.03
- Permissible velocity	0.3 - 0.8 m/s	0.4-0.9 m/s
- Inside slope	1.5 : 1	1.5 : 1
- Structures	Concrete	Concrete

6.4.5 Candidate Schemes for Irrigation Development

The general layout and the salient features of nine (9) new candidate schemes are shown in Fig. 6.22 to 6.31 and Table 6.22, respectively. And the outline of each scheme is presented as belows;

(1) Chico Mallig Irrigation Project

The Chico Mallig Irrigation Project is located near the provincial boundaries of Isabela, Cagayan and Kalinga-Apayao. The existing Chico RIS had a plan to extend its service areas as the Chico RIS Stage 2. The water conveyance syphon already has sufficient capacity for the Second Stage. However the plan was suspended because the provision of Chico No. 4 dam was cancelled due for social reasons. This Chico Mallig Irrigation Project is planned to cover the Chico RIS Stage 2 areas. The net project area is 31,200 ha, which comprises four (4) separate areas; Chico East area of 8,100 ha, Liwan Gadu area of 9,000 ha, Enrile area of 4,100 ha and Magsaysay area of 10,000 ha.

The proposed water source for the project is dependable water to be exploited by the proposed Mallig No. 2 dam. Since the dam alone cannot afford the sufficient water for the project, water of the Chico river which is preferentially allocated for the Chico River Irrigation System Stage I (Chico RIS), would be diverted to the Mallig river basin through a transbasin water-way with a total length of 5.6 km consisting of an open channel of 1.6 km long and a tunnel of 4.0 km long.

The required storage volume for irrigation purposes with a 80% dependability is worked out through water balance calculation. This would amount to 421 x 10^6m^3 for cropping pattern-A and 334 x 10^6m^3 for pattern-B. In order to supplement the irrigation water for the Chico RIS additional storage of 116 x 10^6m^3 and 146 x 10^6m^3 are required for the cropping patterns A and B.

The irrigation water released from the Mallig No. 2 dam would be conveyed to four (4) irrigation areas through a diversion canal system with a total length of 34.7 km, which is schematically shown in Fig.6.32. The total lengths of the proposed main and lateral/sublateral canals are 135 km and 416 km, respectively.

The design discharge of the diversion canal is estimated to be 59.3 m^3/s at its head, which consists of 51.8 m^3/s for the project and 7.5 m^3/s for supplemental supply to the Chico RIS, and 28.4 m^3/s at its end.

(2) Matuno River Irrigation Project

The Matuno River Irrigation Project with a net irrigation area of 12,680 ha, is located in the northern part of the province of Nueva Vizcaya, extending over the alluvial plain along the left side of the Magat river.

The water source of the project is the unregulated flow of the Sta Cruz and Sta Fe rivers and release from the proposed Matuno No. 1 dam on the Matuno river at about 17 km upstream from its confluence with the Sta Fe river.

The required storage volume for irrigation with a 80% dependability is estimated to be 66.7 x 10^6m^3 for the cropping pattern-A and 45.5 x 10^6m^3 for the cropping pattern-B

In order to tap the water, three (3) run-of-the river diversion weirs; Manamtam, Bayombong and Lanog diversion weirs, are newly proposed. The

Manamtam diversion weir, which would serve a relatively high altitude area of 1,090 ha, is located on the Matuno river at about 7 km upstream from its confluence with the Sta Fe river. The Bayombong diversion weir is proposed on the Magat river near Bayombong, and would serve most (about 11,200 ha) of the project area. The Lanog diversion weir, a kind of catch dam is to be constructed on the Lanog river.

The existing canals are mostly integrated in the proposed system. The main canals of 90.4 km in total comprise 58.0 km of new canals and 32.4 km of existing ones. The lateral canals reach 174.4 km in total, of which about 98.6 km are of existing ones.

(3) Dabubu River Irrigation Project

The Dabubu River Irrigation Project is located at about 40 km southeast of Santiago, the commercial center in Isabela province. A net irrigation area of 1,000 ha extends over the right bank of the lower reaches of the Dabubu river, one of the tributaries of the upper Cagayan river.

A run-of-the river diversion weir would be constructed on the Dabubu river at about 14.5 km upstream of its confluence with the Cagayan river. The irrigation water is diverted through an intake to be constructed on the right side of the Dabubu river at the said diversion weir and conveyed to the project area through a main canal of 13.6 km long and lateral canals with a total length of 19.0 km. A small impounding dam is proposed near Santo Niño to ensure a year-round irrigation. Neither main nor collector drains are proposed because natural drains such as small streams and creeks are located conveniently to discharge excess water from the project area. Design discharge at the intake is 1.22 m^3/s in case of the cropping pattern-A and 1.15 m^3/s in case of the cropping pattern-B, respectively.

(4) Zinundungan Irrigation Extension Project

The Zinundungan Irrigation Extension Project is located on the northern rim of the existing Zinundungan RIS, which extends over the left bank of the lower reaches of the Zinundungan river. The net irrigation area of the Zinundungan IEP is 1,750 ha, while the irrigation service area of the existing Zinundungan RIS is 1,760 ha.

The Zinundungan RIS is dependent for its water source on the unregulated flow from the Zinundungan river, from which the whole the service area is reportedly irrigated throughout a year. According to the results of the water balance calculation, however, it seems that the unregulated flow is inadequate to irrigate entire service area especially during the dry season. Maximum irrigation areas of 1,060 ha in wet season and 810 ha in dry season are expected if cropping pattern-A is adopted, and 1,760 ha and 780 ha if pattern-B.

In order to ensure perennial irrigation to both the existing service area and the extension area, a storage dam is proposed on the Zinundungan river at about 1 km upstream from the existing intake on the Zinundangan river. Required storage volume with a 80% dependability is estimated to be $53.1 \times 10^6 m^3$ for the cropping pattern-A and $34.7 \times 10^6 m^3$ for the cropping pattern-B.

The irrigation water released from the dam would be tapped at the existing intake and conveyed to the extension area through the existing main canal and a new lateral canal with a length of 37.0 km. A new headgate would be provided on the existing main canal at 8 km downstream from its head to divert irrigation water to the new lateral canal.

No enlargement of the existing main canal is needed because it has a discharge capacity of 5.89 m^3/s, which is sufficiently big compared with the integrated design discharge of 5.41 m^3/s in case of the cropping pattern-A and 5.60 m^3/s in case of the cropping pattern-B. The maximum design discharge of the new lateral canal is 1.84 m^3/s for both cropping patterns.

(5) Alcala Amulung West irrigation Project

The Alcala Amulung West Irrigation Project is located about 25 km northwest of Tuguegarao, extending over the left bank of the Cagayan river.

Irrigation water for the net irrigation area of 6,750 ha would be tapped from the Cagayan river by a proposed pumping station with a total pump head of 29 m, which would be located on the left bank of the Cagayan river about 1.5 km upstream from the Buntun bridge.

The design discharge at the head of the main canal is 9.38 m^3/s in case of the cropping pattern-A and 9.19 m^3/s in case of cropping pattern-B. The irrigation water tapped would be conveyed to the project area through a main canal 27.8 km long.

(6) Tuguegarao Irrigation Project

The Tuguegarao Irrigation Project, having a net irrigation area of 1,400 ha, is located on the northern fringe of Tuguegarao.

A pumping station with a total pump head of 23 m would be constructed on the right bank of the Pinacanauan de Tuguegarao river at about 6 km upstream from its confluence with the Cagayan river. Proposed main and lateral canals are 9.5 km and 14.9 km in total, respectively. The design discharge at the head of the main canal is 1.54 m^3/s in case of the cropping pattern-A and 1.43 m^3/s in case of the cropping pattern-B.

(7) Lulutan Irrigation Project

Lulutan Irrigation Project is located about 25 km north of Cauyan, extending over the left bank of the Cagayan river.

The project area of 2,950 ha would be irrigated by a pumped irrigation system. A pumping station is proposed on the left bank of the Cagayan river about 10.5 km upstream of the confluence of the Cagayan and the Ilagan rivers. The required total head of the pumping station is 26 m, and its design discharge is 4.19 m^3/s in case of the cropping pattern-A and 4.10 m^3/s in case of the cropping pattern-B, respectively. Starting at the pumping station, a main canal of 13.5 km would run to the north along the hills and terminate near the confluence of the Cagayan and the Siffu river.

(8) Ilagan Irrigation Project

The Ilagan Irrigation Project area slenderly extends along the lower reaches of the Ilagan river. A pumping station with a total head of 19 m is proposed to tap irrigation water from the Ilagan river near Benito Solven about 36 km upstream of its confluence with the Cagayan river. Irrigation water tapped at the pumping station would be conveyed to the project area of 3,200 ha by a main canal of 16.9 km. The canal would cross the Ilagan river by syphon to serve irrigation areas located on the right bank because no alternative water source is conceivable. The proposed pumping station and the main canal would jointly be used for the Tumauini RIS as well. The integrated design discharge of the main canal at its head is 7.18 m^3/s and 6.63 m^3/s for cropping patterns A and B, respectively.

(9) Gappal Irrigation Project

The Gappal Irrigation Project having a net irrigation area of 4,400 ha, lies along the Cagayan river in the right bank at the opposite side of the service area of the Magat River Irrigation System.

Since two (2) alternative water sources, the Cagayan river and the creeks traversing the project area, are conceivable for the project, a preliminary study on the project was conducted regarding each water source.

Case - I (Water source; the Cagayan river)

A pumping station with a total pump head of 33 m is proposed on the right bank of the Cagayan river near Anggadanan. The irrigation water tapped at the pumping station would be conveyed to the project area of 4,400 ha net through a main canal 40.3 km long. The design discharge of the main canal at its head is 5.98 m^3/s and 5.86 m^3/s for croppings patterns-A and -B, respectively.

Case - II (Water source; Sinalugan river, tributary of Madalan river, and Caunayan creek)

The project relies on dependable water exploited by three (3) storage dams to be constructed on the Sinalugan river, a tributary of the Madalan river and the Caunayan creek. Colorado dam on the Sinalugan river is proposed to have a storage capacities of 58.4×10^6 m^3 and 42.1×10^6 m^3 for cropping patterns-A and -B respectively. The required storages of Calaocan dam and Sta. Maria dam are 41×10^6 m^3 and 18.1×10^6 m^3 for cropping pattern A. The required storages are somewhat lower for pattern B, namely 28.6×10^6 m^3 and 16.2×10^6 m^3.

Irrigation water would be taken just downstream of each dams through one (1) outlet each and conveyed to the project area by three (3) headreaches with a total length of 29.4 km.

6.4.6 Candidate Schemes for Rehabilitation/Improvement

The general layout and the salient features of five (5) candidate schemes for rehabilitation/improvement are shown in Fig. 6.33 to 6.37 and Table 6.23 respectively.

The Solana - Tuguegarao IS is presently served through two (2) pumping stations by the unregulated flow of the Cagayan river, while the Dummun RIS, Baggao IS, Pinacanauan RIS and Tumauni IS are fed by the unregulated flow of the tributaries of the Cagayan river through their respective gravity irrigation systems. Actual irrigation areas of these five (5) NISs are much lesser than their respective service areas even during the wet season. The most common problems are deterioration of canals and structures and insufficiency of on-farm facilities.

In the Dummon RIS, Paranan area of the Baggao IS and Tumauini IS, actual irrigation area is definitely affected by the capricious river runoff not only in the dry season but in the wet season. In the

Pinacanauan IS, Pared area of the Baggao IS and Solana - Tuguegarao IS, on the other hand, their actual irrigation area is depressed considerably despite sufficient water being available throughout the year. This might suggest that deterioration and/or inadequacy of existing facilities might be the cause of shrinkage of the actual irrigation area. Generally however the existing intake works have sufficient design capacity for the respective service areas and are located properly. As for the Solana - Tugnegarao IS, however, the pumping capacity has been constricted seriously and is now limiting the potential irrigation area.

Table 6.24, showing possibly maximum annual areas irrigable by river runoff with a 80% dependability, indicates that:

1) In the Pared area of the Baggao IS and the Pinacanauan RIS, a year-round irrigation would be attainable for the whole irrigation service area with a cropping intensity of more than 1.90 if the existing facilities are rehabilitated/improved properly;

2) In the Dummon RIS, the Paranan area of the Baggao IS and the Tumauini IS, the cropping intensity would remain 0.6 to 1.2 even after the existing facilities are rehabilitated/improved, if water resources is not exploited; and

3) In Solana - Tuguegarao IS, the cropping intensity would be increased only to 1.3 even if decreased pump capacity is restored to its nominal capacity.

To cope with the constraints and problems mentioned above, rehabilitation works are proposed for each system as shown in Table 6.23 and summarized below.

- Dummon RIS
  - a. rehabilitation of existing system
  - b. construction of a storage dam at Dummon

- Baggao IS		
Pared area	a.	rehabilitation of existing system
Paranan area	b.	rehabilitation of existing system
	c.	construction of a storage dam at Paranan
- Solana - Tuguegarao IS		
Solana area	a.	rehabilitation of existing system and existing pumping station
	b.	construction of additional pumping station
Tuguegarao area	c.	abandoned
- Pinacanauan RIS	a.	rehabilitation of existing system
- Tumauini IS	a.	rehabilitation of existing system
	b.	construction of a storage dam near San Vicente
	c.	use of new water source (Ilagan R.).

6.5 Priority Ranking of Irrigation Schemes

6.5.1 Cost Estimate

Estimation of the construction cost for the candidate schemes is made in terms of project cost and economic cost. The project cost comprises i) direct construction cost, ii) compensation cost, iii) cost for O&M facilities, iv) engineering cost, v) administration cost, and vi) physical contingency.

The direct construction cost is estimated based on the preliminary facility plan and the standardized unit costs. The unit costs were determined by referring to those used for on-going projects in the basin as well as those employed in feasibility studies of similar irrigation projects in the Philippines. The principal standard unit costs employed for the study are shown in Table 6.25. The cost of O&M facilities is assumed to be

₱1,000/ha for new schemes and ₱500/ha for the rehabilitation/improvement schemes. Engineering and administration costs are assumed to be 8% of the direct construction cost and 7% of the same, respectively. Physical contingency is assumed to be 15% of the sum of the above items i) to v).

All of these costs are expressed in Peso currency at the price levels as of December 1985. The conversion rates between Philippine Peso, U.S. Dollar and Japanese Yen are assumed to be ₱19.0 = US$1.0 = ¥200 referring to the current exchange rate in December 1985.

The project cost for each of the candidate schemes is estimated for both cases of the cropping pattern -A and -B based on the above conditions and assumptions. The project cost for each scheme is shown in Table 6.26. The unit project cost of ₱211 x 10^3/ha incurred by Baggao rehabilitation project with the cropping pattern-A is the highest among 14 candidates. The lowest is Pinacanauan rehabilitation project of ₱19 x 10^3/ha. The lowest among the proposed new irrigation schemes is Ilagan scheme of ₱51 x 10^3/ha if the cropping pattern-B is adopted. A project which requires a dam in general incurs high cost.

The project cost is converted into economic cost by multiplying the standard conversion factor of 0.82 by the local currency component of the project cost except for the compensation cost. In general production foregone is applied in place of compensation cost. Thus estimated the economic cost for each alternative scheme is shown in Table 6.27. The highest and lowest economic unit costs are Baggao project and Pinacanauan project of ₱195 x 10^3 and ₱17 x 10^3 respectively similar to project costs.

In addition to the initial investment cost estimated earlier, operation, maintenance and replacement costs (OMR cost) are needed to maintain the function of the facilities properly over the anticipated project life.

The annual operation and maintenance cost for the irrigation system, apart from the running cost of the pumps is assumed to be ₱400/ha. The running cost of the pumps is estimated based on the average diversion water requirement and a electric charge of ₱2.11/kWh on a monthly basis. Replacement costs of the irrigation systems are based on the estimated economic life of mechanical and electrical works.

6.5.2 Benefit Estimate

The economic price for trade goods such as paddy, corn, beans, peanuts, tobacco, sugar cane and fertilizer is estimated on the basis of the projected world market prices of the World Bank in the long term range for the period of 1985 to 1995. Non-trade goods such as sweet potatoes, vegetables and animal power, etc. are valued at their financial prices. Financial and economic prices of all outputs and inputs are summarized in Table 6.28.

Incremental irrigation benefits of each scheme are estimated as the differences in the net production value between the future with and without project. The net production values under with and without project are calculated on the basis of gross production value and production cost. Annual incremental benefits of each scheme are summarized in Table 6.29. The highest unit annual incremental benefit among the candidate schemes is ₱24,946/ha by Chico Mallig irrigation scheme.

Crop damage by flood and production foregone by the construction of irrigation facilities and dams are taken as negative benefits in this study.

Flood damages in each scheme are estimated according to "the Engineering of River and Sabo Projects", Ministry of Construction of Japan. The gross production value under with project is considered as the damage-able value by floods in the each irrigation scheme. Annual equivalent damages up to 100-year design flood are summarized in Table 6.30.

The annual production foregone is defined as the annual net return accruing from the agricultural production in the cropland occupied by the dam reservoirs and irrigation facilities under the future without project. Annual production foregone in the rehabilitation/improvement scheme is disregarded in this study because the reservoir area is mostly occupied by non-farmland such as forest land, grassland, etc., and the irrigation facilities are already constructed in the service area. Estimations of the production foregone are summarized in Table 6.31.

6.5.3 Project Evaluation and Priority Rankings

The project evaluation is performed by applying the following assumptions:

1) The project life is set at 50 years from the initial year of project implementation;

2) Only direct benefits are counted in the economic evaluation, and any indirect and intangible benefits are not taken into account,

3) Where a multipurpose dam is conceived as the alternative water source facility, the allocated cost is used for estimating cost of a irrigation scheme;

4) Constant prices at 1985 level are used in the economic evaluation; and

5) Cropping pattern-A is to be utilized because it yields a higher EIRR in any candidate scheme.

The project benefits comprise irrigation benefits and negative benefits which are flood damages and production foregone. The project costs consist of construction costs for dams and irrigation facilities, replacement costs, and operation and maintenance costs (O&M cost).

Working out the annual economic cost and benefit flows for each scheme according to the construction schedule for dam and irrigation facilities, the Economic Internal Rate of Returns (EIRRs) for each scheme are calculated and summarized in Table 6.32.

The highest EIRR of 28.4% would resulted from the Ilagan Irrigation Project among the candidates of new irrigation schemes. Meanwhile of the rehabilitation/improvement Schemes the Pinacanauan River Irrigation Project would result in the extraordinarily high EIRR of 75.7%.

The net farm income per hectare derived from the financial farm budget analysis is another index of project evaluation. In general, a gravity type irrigation project shows high unit net farm income. The Pinacanauan and the Chico Mallig projects present high net farm income of ₱33 x 10^3/ha and ₱31 x 10^3/ha respectively. Tuguegarao Irrigation Project would result in a low net farm income of ₱22 x 10^3 in spite of a high EIRR of 19.5%. The net farm income of the Baggao Irrigation Project is estimated to be as high as ₱33 x 10^3/ha although the EIRR would be as low as 7.3%. Estimated net farm incomes are summarized in Table 6.33.

It is considered that the project beneficiaries are not only farmers but also the other inhabitants who are employed by other industries and the unemployed in the area. The number of beneficiaries per ha in the irrigation service area is one of the parameters for judging the efficiency of the socio-economic impacts. The number of beneficiaries per ha of each scheme are summarized in Table 6.34. High unit beneficiaries of more than 8 person/ha would occur on the Pinacanauan, Ilagan and Solana projects.

The priority of each project was then evaluated as follows;

1) Projects are classified into two groups according to EIRR. Higher priority is given to a project with EIRR more than 15%;

2) In each group, projects are ordered according to net farm income; and

3) If the same net farm income would result from more than one project, the numbers of beneficiaries are examined and priorities given accordingly.

As a result, the order of priority becomes: Pinacanauan, Chico Mallig, Dabubu, Lulutan, Solana, Gappal, Ilagan, Tuguegarao, Alcala Amulung

West, Baggao, Dumun, Matuno, Tumauini and Zinundungan as shown in Table 6.35.

6.6 Irrigation Water Demand

The implementation schedule of each candidate project is assumed on the basis of the designated priority. Pinacanauan rehabilitation project and Dabubu new irrigation project would be started in 1989. The former will be completed in 1990 and the diversion water increased to serve for the project. Likewise water demand is projected to swell year by year corresponding to the implementation of the proposed projects.

Water demands are estimated on a monthly basis by applying monthly effective rainfall estimated during the 22 years from 1963 to 1984. Irrigation water demand is calculated by aggregated CISs area and aggregated CIPs area in each subbasin and each NIS/NIP as shown in Table 6.36. For making a water balance study of the basin, the Cagayan river basin is divided into 43 subbasins as shown in Fig. 6.38 with due consideration to major existing and proposed intake sites and 14 proposed dams.

The estimated mean monthly water demands are presented in Tables 6.37 and 6.38. These tables show the difference between the demands in 1985 and 2005. The maximum demand of 158 m^3/s would occur in February and the second maximum of 156 m^3/s in July in 1985. While in 2005, 379 m^3/s in July is the maximum and 338 m^3/s in February the second. The differences in the demands between the two years become above 200 m^3/s in July and March.

6.7 Proposed Development of Diversified Crops

The rainfed diversified crop area will be expanded up to 170 x 10^3ha. The main crop will be corn and the area increased will be developed as corn fields. The other recommendable crops are vegetables, beans and tobacco.

Corn cultivation will be needed to avoid typhoon damages. Cultivation of hybrid corn varieties would require high cost and be very risky because of frequent typhoons and floods. Short maturing and open pollinated corn is recommended to avoid the risks of damage and to cultivate by low inputs.

6.8 Proposed Development of the Uplands

Uplands will be developed up to 267 x 10^3 ha for cattle grazing with pasture land development and tree crop development. The principal activities would be cattle grazing and tree crops.

The dairy/beef cattle development plan in the basin is outlined as follows:

(1) Cattle Breeds

The crossbred production of dairy/beef cattle is recommended in the basin. First crosses of Brahman, Holstein and Sahiwal will be used for the foundation stock. Cow-calf production will be done by three-way-cross or back-cross breeding.

(2) Cattle Farm Management

Cattle farm management system will consist of grazing and fattening. The cattle will be rotationally grazed and feeder stock will be produced in the pasture land. The steers will be fattened in the feedlots which will be newly established in the basin. Beef cattle fattened in the feedlots, cow and milk maybe the main income sources of cattle farming.

(3) Selection of Pasture and Forage Crops

The natural grassland will be improved to grazing pasture by sowing pasture seeds. Pasture will be established by mixed-seeding of Guinea grass, Para grass, Centro, Stylo, etc. Ipil-ipil will also be used for fencing. Forage crops like Napier grass, Guinea grass, Para grass, Centro, Stylo, Ipil-ipil, etc. will be introduced to the meadows for production of beef cattle feeds.

(4) Unit Yield of Forage

Average yields of forage are estimated at 47.5 tons/ha in the pasture and 80 tons/ha in the meadows, as shown in Table 6.39. Possible feed intake ratio is estimated at 55% for pasture and 85% for meadow.

(5) Cattle Herd Composition

Cattle herd composition on the averaged size farm of 280 ha is estimated as shown in Table 6.40. The ratio of feeder stock will be 26% of the total.

(6) Cow-Calf Production and Feedlot Management

The existing continuous grazing system will be changed to the rotational system. Grazing intensity will be increased from 0.4 head/ha at present to 1.3 head/ha in the future. An outline of the pasture management and calf production is summarized in Table 6.41.

Beef cattle will be fattened primarily in the feedlots. The live weight target of fattening cattle will be 400 kg/head or more. For attainment of this target, a meadow of 2.8 ha will be required for the fattening 41 head of beef cattle on the average size farm of 280 ha. The proposed feedlot management method is outlined in Table 6.42.

(7) Disease Control

Dominant diseases in the basin are hemorrhagic septicemia and blackleg. No serious diseases have been observed in this area. These diseases can be prevented by vaccination. However, the expansion and establishment of disease control facilities and the increase in the number of veterinarians are required because the present facilities and staff are insufficient. Artificial insemination centers will also be needed to improve the existing beef cattle industry and to set up new type beef-dairy cattle production.

(8) Utilization and Development of Existing Grassland

Most of the present grassland is leased to private investors as pasture lease where beef cattle grazing is practiced. The pasture lease will be expanded to the maximum extent with possible assistances from the Government. The small farmers will also be involved in the future cattle industry through the organization of farmers' cooperatives.

Permanent cropland will be expanded up to 57 x 10^3 ha. The recommendable crops will be cashew nuts, mango and citrus fruits. For the expansion of the permanent crops in the upland area, the following measures will be required.

a) Selection of the most suitable varieties to the climatic conditions and consumers' taste,
b) Experimentation on cropping pattern and farming practices taking typhoon damages into consideration,
c) Construction of seedling production and distribution centers,
d) Construction of collection and processing facilities,
e) Credit services for the cultivation of permanent crops, and
f) Preparation of a development plan for permanent crop production in the uplands for successful implementation.

In this respect, a master plan study on the uplands development is recommended to achieve comprehensive and effective land use in the areas.

6.9 Fishery and Forestry

(1) Fishery

For the future development of fishery in the basin, brackish water aquaculture development could be neglected in this study for of the following reasons:

1) The potential development area of about 3,800 ha for brackish water aquaculture which is delineated by BFAR's study is out of the basin; and
2) Diversion of water from the Cagayan river to the potential development area above mentioned will not be required because extensive fish farming is suited to the area and high input-high output culture will not be profitable due to acid-sulphate soils, low-lying and low drained land, and occasional floods.

Fish farming in the dam reservoirs and fishponds are underdeveloped in the basin although the potential is quite promising. The following measures are required for fresh water aquaculture development.

1) Strengthening of experimentation in the fresh water aquaculture,
2) Increase in the number of extension personnel and intensive extension services,
3) Careful management on the water quality, especially against the water pollution by agro-chemicals,
4) Construction of the necessary facilities for experimentation, cold storage and processing, and
5) Preparation of a development plan for freshwater aquaculture in the basin for successful implementation.

(2) Forestry

Another JICA study team for forestry delineates the land with slopes over 18 %, as a forest reserve. The delineation is observed in this Study.

6.10 Improvement of Agricultural Support System

Improvement of the present agricultural support system is essential for the achievement of the agricultural development target. The following measures are recommended:

(1) Irrigated lowland

1) Extension of short maturing varieties and new cropping patterns for the decrease of typhoon damage, especially on paddy and corn,
2) Extension of intensive farming to get high yields,
3) Expansion of seed multiplication facilities and increase in production of registered and certified paddy seeds,
4) Research on irrigated diversified crops, such as corn, vegetables, beans and tobacco, and their seed/seedling multiplications and distribution,
5) Strengthening and expansion of the seed growers association,
6) New credit service programs for the production of vegetables, beans and tobacco,
7) Activation of Samahang Nayon, especially for the raising of farmers' bargaining power in the market, and
8) Propagation of marketing information to the farmers.

(2) Rainfed lowland

1) Research on rainfed diversified crops, such as corn, vegetables, beans, peanuts, tobacco and sugar cane to get sufficient yields by low inputs under rainfed condition, and their seed/seedling multiplication and distribution,
2) New credit service programs for the production of rainfed diversified crops, and
3) Activation of Samahang Nayon and diffusion of marketing information.

(3) Upland

1) Establishment of an integrated upland agricultural development center for research on dairy/beef cattle and tree crops,
2) Improvement of the existing DAF facilities for beef cattle development, and
3) Establishment of more artificial insemination and vaccination units.

6.11 Agricultural Development Plan

The target for agricultural production in 2005 mentioned in the previous chapter is expected to be achieved through the agricultural land use plan mentioned before together with the development plans for crops, livestock, fishery and forestry. Improvement of the agricultural support system will contribute much to agricultural development.

The GVAs of paddy and corn will increase from ₱524 x 10^6 and in 1985 to ₱1,148 x 10^6 in 2005 at 1972 constant price. Other crops in the lowlands will grow from ₱70 x 10^6 to ₱113 x 10^6. In the uplands, GVA of permanent crops will grow to 4.2 times ₱37 x 10^6 in 2005. That of livestock will increase from ₱77 x 10^6 to ₱256 x 10^6. The total GVA from upland will become ₱412 x 10^6, which is about 3.6 times of that in 1985.

The GVA of fishery is estimated to be ₱17 x 10^6. And the total of agriculture and fishery will tally ₱1,690 x 10^6, which is about 70% of the maximum potential of ₱2,408 x 10^6.

Forestry production (being examined separately) is assumed to maintain the present level of ₱147 x 10^6. Subsequently the total GVA of agriculture, fisheries and forestry becomes ₱1,837 x 10^6 in the year 2005 at 1972 constant prices.

Labour requirements are also studied in relation to the proposed agricultural development. The requirements present a peak of 10 x 10^6 man-days for the three months of April to June. It is estimated to be 8 x 10^6 man-day in October. The potential of the area is estimated to be 12 x 10^6 man-day per month. Accordingly these requirements should be well covered by the local labour force.

VII SECTORAL STUDY ON THE HYDROPOWER DEVELOPMENT

7.1 Present Power Supply

In 1985, the total installed power generating capacity of National Power Corporation (NAPOCOR) in the entire country was 5,550 MW and the total annual power generation was 18,757 GWh.

In addition to NAPOCOR, utilities and private bodies have operated their own generating facilities as follows;

- electric cooperatives : about 230 MW
- private utilities : about 480 MW
- captive power (own generation): about 950 MW

The total power output is estimated to be about 7,200 MW of which NAPOCOR has about 75% of total generating capacity. NAPOCOR provides power transmission services to utilities which provide distribution services to the consumer. The utilities consist of electric cooperatives owned by provincial member and private utilities owned by private firms.

In Luzon island, 8 utilities out of 70 have been generating in addition to NAPOCOR. Utilities generating power are listed in Table 7.1. However, NAPOCOR is the principal power generator with an installed capacity of 4,101 MW or about 99% of total generating capacity in the island. The capacity of NAPOCOR is equivalent to an energy output of 14,449 GWh.

The power plants of NAPOCOR located in Luzon island are listed in Table 7.2. The total installed capacity of oil-based plant is 1,925 MW or 47% of total capacity. Malaya 2 power plant with capacity of 350 MW is the largest among 10 oil-based thermal plants. Hydropower of 1,216 MW or 30% shares next to oil-based thermal plants. The Magat power plant with a capacity of 360 MW is the largest of 24 power plants of NAPOCOR in the island. Geothermal and coal-based thermal plants share 16% and 7%

respectively.

The power plants of the utilities are dendro-thermal, mini-hydro and other plant. There are 6 mini-hydro plants and other thermal generating plants in the island. These plants generated 21 MW of power in 1984.

The Magat power plant described above is located in the Cagayan river basin. Besides the NAPOCOR plant, ISELCO I operates a mini-hydroplant at Ramon and ISELCO II operates a mini-hydro plant at Tumauini and a dendro-thermal plant at Ilagan. The total output is about 5,300 kW in 1984. The other 7 utilities located in the Cagayan river basin did not generate power. No captive power is recorded.

In Luzon island including the Cagayan river basin, the entire transmission line grid is provided and owned NAPOCOR, while the distribution networks are owned by the electric cooperatives and private utilities. Fig. 7.1 shows the electric supply system in the Luzon island.

There are no isolated public power systems located in the Luzon main island. The total energy generated in 1984 was 14,733 GWh. NAPOCOR contributed 14,655 GWh and the remaining 78 GWh was generated by Cooperatives. The total energy consumed in 1984 was 11,408 GWh.

7.2 Present Power Consumption

In 1984 MERALCO consumed the major part, 8,428 GWh or 74%. Demand and supply (1984) are summarized in Table 7.3.

The electrification ratio in the Luzon island was estimated to be 74% on the basis of the actual connected house of 3,270,985 and assumed potential houses of 4,406,388 in 1984. A breakdown of the figures is presented in Table 7.4.

Power consumption is distributed quite evenly between residential, commercial and industrial uses. The record of MERALCO in 1985 is shown in Table 7.5.

All in all, there are 9 cooperatives located in the basin but no private utilities. The cooperatives connect 154,378 houses in total with Isabela I having the largest number, 38,864. A breakdown of the connections and potential connections is summarized in Table 7.6.

The electrification ratio is estimated to be 40% in the basin. The figure is very low level as compared with the average electrification ratio of 62 percent in the whole cooperative franchise area and 74 percent for whole Luzon island.

In 1984, energy consumption in Cagayan basin was only 83 GWh for 154,378 households or 537 kWh per household, though the average power consumption of 50 cooperatives was 675 kWh per household throughout Luzon.

In 1984, the peak load in the area was only 33 MW while the installed capacity was 365 MW, and the generated energy 1,122 GWh compared to a power requirement of only 119 GWh. Thus the Cagayan basin area is clearly power export area.

The type of consumer in the Cagayan river basin may be judged on the basis of the energy sales of ISELCO I. According to the data, residential consumption shares about 43% of the total energy sold, industrial consumption 38%, and commercial and others 15% and 4% respectively.

NAPOCOR hourly load record for Luzon Grid on a typical weekday in the dry season is shown on Fig. 7.2. Hence, the typical daily load duration curve is shown on Fig. 7.3.

The daily load factor is calculated to be 87.5% based on this typical load curve.

7.3 Hydropower Potential

7.3.1 Single Purpose Hydropower Potential Study

The hydropower potential in Luzon island is being studied by JICA's Luzon Hydropower Potential Study. The main objective of the study is to formulate a hydropower development plan for orderly development in Luzon, in line with the energy policy of the Government of Philippines toward:

- Reduction of dependency on imported energy, particularly crude oil energy,
- Conservation of energy use and demand to an adequate level,
- Diversification of supply sources, and
- Acceleration of shift to alternative domestic energy sources, particularly to geothermal, coal-fired and hydro sources.

The JICA study team identified 145 potential sites for hydropower development in Luzon island. Among the potential sites, 65 were selected as technically possible sites. The sites identified were evaluated in terms of power potential and energy potential.

In addition to the 65 sites selected, there are 12 hydropower development projects which are already committed, or detailed designs or feasibility studies therefor have been completed. Their total power and energy thereof are estimated to be 7,260 MW and 20,600 GWh respectively.

Of 65 schemes selected, 34 sites are located in the Cagayan river basin. And there are 4 hydropower development projects which are already committed or feasibility study therefor have been completed. Total power and energy thereof are estimated to be 3,420 MW and 9,700 GWh respectively.

7.3.2 Potential as Multipurpose Development

In total, fourteen (14) damsites are selected in the Cagayan river basin for the purpose of flood control, water supply and hydropower in this study.

Of these dams, feasibility study or pre-feasibility study have been completed for five (5) dams. Their proposed installed capacity and annual generated energy are as follows:

- Chico II	;	360 MW	784.5 GWh
- Chico IV	;	360	955
- Diduyon	;	352	957
- Matuno No.1	;	180	528
- Casecnan	;	268	1,379

The hydropower potentials of the other dams have also been estimated simply by applying the proposed effective heads and discharge, and assuming efficiencies.

The firm discharge was defined as 95 % dependable flow applying the storage draft curve method.

The estimated hydropower potential of each dam project is shown in Table 7.7 and summarized below:

- Cagayan No. 2	;	7,300 kW	46 GWh/yr
- Addalam	;	9,600	60
- Alimit No. 1	;	14,300	89
- Ilagan No. 1	;	20,600	129
- Disabungan	;	10,700	70
- Siffu No. 1	;	9,500	59
- Mallig No. 2	;	4,100	26
- Pinukpuk	;	13,300	83

7.4 Demand Projection

A preliminary load forecast of Luzon Grid, together with the corresponding power development program by NAPOCOR, is presented in Fig. 7.4.

The energy demand shows a 'low' of 13 x 10^3 GWh and increases gradually. The demands in 1990 and 1995 are projected to be 17 x 10^3 GWh and 22 x 10^3 GWh respectively. In the year 2005, the conservative scenario projected the demand to be about 37.1 x 10^3 GWh, while the high demand scenario projected 38.7 x 10^3 GWh. Since present supply capacity in Luzon island is estimated to be 14.7 x 10^3 GWh, the demand in 1990 will exceed the supply capacity. The energy demand under the conservative scenario will exceed the existing supply capacity by more than 22 x 10^3 GWh in the year 2005. The daily load factor was assumed to be 87.5%.

7.5 Primary Purpose Development

7.5.1 Selected Project

The Luzon Hydropower Potential Study by JICA conducted a potential study for the hydropower development. This study selected five projects which are to be implemented by the year 2005 in the Cagayan river basin by means of the least costly alternative method to satisfy power and energy demands by that year. They are Casecnan multipurpose project, Diduyon hydropower project, Ibulao hydropower development project, Tanudan hydropower development and Matuno hydropower project.

As of 1985, the design of Casecnan project was on-going. The feasibility studies on Matuno hydropower project and Diduyon hydropower project are completed. Those studies propose the installed capacities of 268 MW, 180 MW and 352 MW respectively. Dependable energy of 1,379 GWh, 528 GWh and 957 GWh respectively was estimated by these studies. The total encompassed energy output of 2.9 x 10^3 GWh is about 13% of the anticipated deficit of 22 x 10^3 GWh in the year 2005.

Newly identified and duly selected are Ibulao and Tanudan hydropower development projects. Their respective dependable energies are 85 GWh and 130 GWh. The total dependable energy amounts to 1 % of the anticipated deficit in 2005.

7.5.2 Principal Features of Scheme

In this Study, Casecnan project is assumed to be implemented as it is scheduled and is classified as an On-going project. Accordingly the hydropower development schemes proposed by this Study are Matuno hydropower project, Diduyon hydropower project, Ibulao hydropower development and Tanudan hydropower development project. The principal features thereof are as follows;

1) Matuno scheme : Matuno multipurpose dam
   - Design discharge ; 110 m^3/s
   - Gross head ; 220 m
   - Installed capacity; 180 MW
   - Energy output ; 528 GWh
   - Turbine ; 2 units of Francis type turbines

2) Diduyon scheme: Diduyon dam
   - Design discharge ; 85.2 m^3/s
   - Gross head ; 486 m
   - Installed capacity; 352 MW
   - Energy output ; 957 GWh
   - Turbine ; 2 units of Francis type turbines

3) Ibulao scheme : Run-of-river type hydropower generation
   - Design discharge ; 7.8 m^3/s
   - Gross head ; 274 m
   - Installed capacity; 17 MW
   - Energy output ; 85 GWh
   - Turbine ; 3 units of Francis type turbine

4) Tanudan scheme: Run-of-river type hydropower generation
   - Design discharge ; 11.9 m^3/s
   - Gross head ; 270 m
   - Installed capacity; 25 MW
   - Energy output ; 130 GWh
   - Turbine ; 2 units of Francis type turbine

7.6 Secondary Purpose Development

7.6.1 Selection of Dams

Dams which have been identified as water supply dams and flood control dams are examined for their incidental hydropower generating potentials. As a consequence, all the dams which have areas to be benefited downstream of the damsites and release water to the river, are attested to be suitable for hydropower generation. However, dams with beneficial areas located close to the damsite, and of not so different elevation and with water are withdrawn directly from the reservoirs, are found to be not suitable for hydropower generation because the available heads are too small. In this connection, Alimit No. 1 dam, Siffu No. 1 dam, Zinundungan dam, Dummon dam and Paranan dam are found to be suitable for hydropower generation.

Since the selected dams are all water supply dams and power is a secondary purpose, the discharge from these dams will be determined by the water demands by irrigation and municipal water supply. The high water levels and the low water levels are also determined by the necessary storage volume to satisfy the water supply demands. The alternative tail water levels have been preliminarily studied and it is concluded that provision of long water ways is not advantageous. Accordingly the diversion tunnels are utilized as substantial parts of penstock tunnels.

7.6.2 Candidate Schemes

(1) Alimit No. 1 Dam

The scale of Alimit dam is determined as the optimum combination of Matuno No. 1 dam, Siffu No. 1 dam to compensate for part of Magat reservoir capacity which is to be utilized for flood control. Accordingly no definite discharge nor head is designated. However the annual energy output of around 81 GWh is conceivable assuming a maximum discharge of 26 m^3/s, net head of 56.3 m and the installed capacity of 12.2 MW. In this case the annual plant factor is estimated to be 0.75 with 95 % dependability according to the results of water demand and supply balance study. 2 units of Francis type turbines are assumed to be installed.

(2) Siffu No. 1 Dam

As for Alimit No. 1, the annual energy output of 41 GWh is conceivable assuming a maximum discharge of about 20 m^3/s, net head of 32 m and the installed capacity of 5.4 MW. The annual plant factor is estimated to be 0.87. 2 units of Francis type turbines are assumed to be installed.

(3) Dummon Dam

Water released from Dummon dam would generate power before it is supplied to Dummon irrigation system according to the optimization study on the dam. The maximum discharge is 4.0 m^3/s and net head 18.9 m assuming cropping pattern A to be adopted. The installed capacity is designated to be 0.6 MW which will generate energy of 4.2 GWh per year with 95 % dependability. The annual plant factor is estimated to be 0.76. Because of the small discharge and low head, 2 units of cross flow type turbines will be installed.

If cropping pattern B is adopted, the maximum discharge would be 4.0 m^3/s and net head 17.6 m. The annual energy output would be 3.7 GWh with the same installed capacity of 0.6 MW, and with an annual plant factor estimated to be 0.72.

(4) Paranan Dam

Water impounded in the Paranan reservoir will generate energy of about 5 GWh per year when it is released to the Baggao irrigation system. The maximum discharge is 2.8 m^3/s and net head is 28.4 m if the cropping pattern A is adopted. The installed capacity of 0.6 MW will entail the annual plant factor of 0.86.

If cropping pattern B is adopted the net head would be reduced to 26.1 m and the annual energy output would be about 4.2 GWh, with an annual plant factor estimated to be 0.79.

As for Paranan dam, 2 units of cross flow type turbines are proposed for a maximum discharge of 2.8 m^3/s and the net head of about 28 m.

(5) Zinundungan Dam

The reservoir water impounded will generate annual energy of 10.2 GWh when it is released for the Zinundungan irrigation system. The maximum discharge is 7.2 m^3/s with a net head of 24.3 m if cropping pattern A is adopted, and with an installed capacity of 1.4 MW and an annual plant factor is estimated to be 0.8.

The net head would be reduced to 22.5 m if cropping pattern B is adopted. In this case, the annual energy output would be reduced to 8.9 GWh with an annual plant factor of 0.75.

Because of the small discharge and low head, 2 units of cross flow type turbines are proposed.

7.6.3 Cost Estimate of Candidate Schemes

The costs of civil works specific to power generation were estimated by applying an assumed unit cost for each civil work. Meanwhile the costs for the generating equipment and other requisite apparatus were estimated by applying the empirical cost based on the statistical data.

The Alimit scheme would entail the maximum financial cost of ₱199.73 x 10^6. The Siffu scheme follows with a cost of ₱112.41 x 10^6. The costs of Dummon, Paranan and Zinundungan schemes are estimated to be ₱24.96 x 10^6, ₱22.01 x 10^6 and ₱41.70 x 10^6 respectively at December 1985 prices. A breakdown of costs is given in Table 7.8.

7.6.4 Benefit Estimate

Both power benefits and energy benefits are estimated by means of the alternative cost method. All the candidate schemes are of small scale as compared with existing thermal plants and it is considered inappropriate to adopt these large scale thermal power plants as the alternative projects. In view of this, a hypothetical diesel plant is assumed and costs are estimated. In this manner, the unit power benefit is estimated to be ₱2,470/kW and the unit energy benefit is estimated to be ₱1.18/kWh.

VIII MUNICIPAL WATER DEMAND

8.1 Present Municipal Water Supply

Waterworks systems are classified into three levels: Level I, a point source system; Level II, Level I plus a communal faucet system; and Level III, a piped system. Table 8.1 shows existing water supply systems and the population served by these systems in Region II excluding Batanes province but including Mt. Province of Region I. There are 274 x 10^3 households served by systems I to III, which constitute about 60% of total households in 1985.

Of the total number of households served by these systems, 230,218 households or 84% are covered by 3,419 systems of Level I. Among the Level I systems, 2,139 systems have been constructed within the last five years. There are 82 systems of Level II, which cover 6,276 households or 2% of total served families. Level III systems cover 37,196 households or 14% by 33 water work systems. The average population served by a system of each Level is as follows: 303 by Level I; 1,037 by Level II; and 3,694 by Level III.

LWUA has constructed and promoted 5 of 33 Level III systems and entrusted these to five Water Districts for the management and operation of the water works systems in the basin in 1985. These are the waterworks systems of Tuguegarao, Cagayan; Aparri, Cagayan; Solana, Cagayan; Ilagan, Isabela; and Santiago, Isabela. Of the 33, eleven systems of Level III by LWUA are at the stage of planning or are non-operational due to failure of pumps and piping systems. Water sources of all existing systems are ground water such as deep wells and springs. The approximate number of connections of each Water District as of the end of 1985 is as follows: 1,500 in Tuguegarao; 650 in Aparri; 230 in Solana; 630 in Ilagan; and 2,400 in Santiago.

The Tuguegarao Water District was established in 1983. As shown in Table 8.2, which presents only limited data from January to September 1985, the average number of connections of 1,112 was distributed as follows: 65% or 719 for residential; 34% or 383 for commercial; 0.3% or 3 for industrial; and 0.6% or 7 for municipal. The average consumption volume is 23,513 m^3/month, which is distributed as follows: 57% or 13,455m^3/month by residential; 40% or 9,535 m^3/month by commercial; 1% or 170 m^3/month by industrial; and 2% or 353 m^3/month by municipal. As a result, the respective consumptions per consumer units are estimated to be 597 l/day by residential, 815 l/day by commercial; 1,859 l/day by industrial and 1,658 l/day by municipal. Since average family size in Tuguegarao is assumed to be 5.5 in 1985, per capita water consumption is calculated as 109 l/day. The average leakage rate from the distribution network was about 35% in 1985.

The unit cost of water was studied on the basis of data furnished by LWUA. The average value of a unit source of water is estimated to be ₱1.10/m^3 and distribution and treatment costs of ₱0.47/m^3. The economic cost of a water source, consequently, is estimated to be ₱1.0/m^3.

8.2 Unit Yield Projection

Present housing conditions are studied through socio-economic data and sample surveys in the basin. Future conditions are assumed to change as living standards rise in proportion to economic growth. Once living standards improve, property ownership will increase and water will be consumed more than before. At the same time, people will require better accessibility to water and a higher quality of potable water. Thus, service levels in the basin should be improved year by year. In this study, service factors have been assumed as shown in Table 8.3 on the basis of the service coverage proposed by "Rural Water Supply and Sanitation Plan" by DOH, MHS and DPWH. Furthermore, the per capita consumption served by a piped system (Level III) will increase in proportion to economic growth. Then, unit consumption by Level III in the future is assumed to increase as shown in the same table, which is estimated by reference to feasibility studies and preliminary-design reports prepared by LWUA. On the other hand, the number of housing units are estimated through population projection and family size which is estimated through past trends. The product of per capita consumption, family size, the number of houses and service factor, gives the total domestic water demand.

The water demand of the trade establishments sector can be assessed from conditions such as inventory stocks, equipment and allotment for population as grasped through socio-economic data. The conditions will be modified as the economy develops. Furthermore, population growth will inevitably increase the number of trade establishments to maintain present service levels. The unit consumption again comes from feasibility study reports by LWUA. The product of the number of establishments and unit consumption provides the total water demand of the trade establishments sector.

The water demand of the social service sector is derived by almost the same procedure as described above for the trade sector applying the basic data shown in Table 8.3.

The industrial sector has to be broken down into two sub-sectors, i.e., manufacturing, and construction. Present conditions in the industrial sector are studied through socio-economic data. Future conditions in terms of number and productivity are derived from future economic growth, that is, GVA growth of the industrial sector in the region. The present proportion of construction sub-sector output as distinct from the manufacturing sub-sector is applied to the early stages of industrial development. As time goes on, the construction share is assumed to increase in accordance with the implementation of the proposed projects. It will later decrease corresponding to the completion of the projects. With regard to the unit consumption rate (m^3/day/GVA), the standard of industrial freshwater demand in Japan is applied to estimation of water consumption by a manufacturing establishment. However, freshwater recycling ratios for manufacturing are assumed to be 50% of the recyclic use in Japan in 1985 and 75% in 2005. Thus, unit daily consumption by a manufacturing establishment was estimated to be 763 m^3/₱10^6(GVA) in 1985 and 684 m^3/₱10^6(GVA) in 2005 as shown in Table 8.3. Distribution of water consumption over each municipality, however, is assumed in proportion to urban population distribution.

8.3 Water Demand Projection

Total water demand excluding the agricultural sector is derived from the sum of the water demands of each sector mentioned above. The upward trend of water demand will continue by attainment of the target. The target in the year 2005 is that the whole urban population and 85% of the rural population shall be covered by water supply systems of Level I to III. The projected water demand by municipality and by sector is shown in Tables 8.4 and 8.5 respectively. From these tables, the projected total water demand in 2005 is 642 x 10^3 m^3/day. The total source water requirement is calculated by applying a loss rate to the total demand. The loss rate used is that quoted in LWUA's studies. Table 8.6 shows the total source water requirement divided into the 20 blocks of the assumed waterworks, each of which has been so determined as to have a population of approximately 100,000 persons in 1980. Table 8.7 shows the same requirement by sector. In 2005, the total requirement reaches 855 x 10^3 m^3/day.

IX POTENTIAL OF DAM DEVELOPMENT

9.1 Potential Damsite

The Cagayan river basin is endowed with a number of potential damsites. NIA and NAPOCOR have undertaken studies on various possible dam development schemes. They have completed feasibility studies on Chico No. 4 Hydropower Development Project, Diduyon Hydropower Development Project, Casecnan Transbasin Project and Matuno Dam Project. DPWH has also studied the Cagayan River Basin Flood Control Project which encompasses forty four (44) dam schemes. At present the Magat dam is the only completed large impounding dam within the objective river basin. In order to formulate a Master Plan for the target period of about 20 years, the candidates for the dam development within the target period are selected with reference to those previously proposed.

The candidate dams will serve some rather large scale irrigation systems, municipal water demand and flood control. The beneficiaries thereof are mostly located in the flat alluvial plain. However, the agricultural development focussed on the intensive land uses in the sloped hilly areas. With this respect, the potential of small scale dam development is also studied.

All the potential damsites are identified on the available topographic maps in scales of 1 to 25,000 and 1 to 50,000. The map study identified 55 potential multipurpose damsites, 56 small scale damsites and 4 potential pond sites. The identified multipurpose damsites are located on Fig 9.1. The locations of the small scale damsites are shown on Fig 9.2 together with the proposed pond sites.

9.2 Screening of Multipurpose Damsite

For the first screening the storage efficiency or the storage volume per unit dam volume, catchment area and possible dam height inherent to each damsite are evaluated. Among these identified, 26 damsites are selected as the candidates for the second screening.

In the second screening irrigation, hydropower and flood control efficiencies are preliminarily evaluated separately for each damsite. Each damsite is categorized into one of three classes with regard to each efficiency.

In addition to the above, the following technical and economic assessments were made:

1) From the point of view of equitable regional development and effective development for flood control which are deemed to be of primary importance in this basin, one dam is selected on one major tributary for the Master Plan.

2) Dams, which would be located in the weathered limestone zone have been basically discarded at this stage since a detailed geologic investigation would be needed and foundation treatment would in general be costly.

3) Land/property compensation and social circumstances generally are most important factors to be considered today. Dams which are not particularly attractive for some purpose yet have anticipated social or compensation problems have been discarded.

Schems were thus 14 dams selected as alternative schemes by the first and second screenings summarized in Tables 9.1 and 9.2.

The selected schemes are:

Siffu No. 1, Mallig No. 2, Ilagan No. 1,
Disabungan, Alimit No. 1, Cagayan No. 1, Pinukpuk,
Cagayan No. 2, Addalam, Chico No. 4, Chico No. 2,
Matuno No. 1, Casecnan and Diduyon dams

9.3 Site Conditions of Selected Dam Schemes

Among the selected 14 dam schemes, Chico No. 4, No. 2, Matuno No. 1, Casecnan and Diduyon dams have been proposed and examined already in the other studies discussed earlier (see Chapter VII).

Site of the existing Magat dam has already been shown to be appropriate for flood control, since it is located at the outlet from the mountainous area covering 81% of the whole Magat river basin. To provide flood control capacity in the existing Magat reservoir Alimit No. 1 dam is proposed in order to complement the capacity of Magat reservoir and to allow an allocation for flood control purposes.

(1) Damsite Geology

Through field investigation in two stages, geological conditions at the selected damsites were confirmed to be suitable for dam constructions. Table 9.3 shows in summary the results of the geological surveys.

From the results of these surveys at the proposed damsites it would appear that Pinukpuk, Siffu No. 1, Mallig No. 2, Disabungan and Addalam damsites would only be suitable for fill type construction due to the foundation conditions of the sites. Meanwhile, the proposed Ilagan No. 1, Alimit No. 1, Cagayan No. 1 and Cagayan No. 2 damsites are suitable for both concrete dams and fill type dams. Potential construction material for each dam was also studied through field surveys as shown in Table 9.4.

The depth of overburden of surface soil or weathered rock layers in the dam foundations of each proposed damsite were assessed from exposures at river banks and the sites of land slides. Thus the required depth of foundation excavation was classified into one of three groups; Class A with 3 meters, Class B with 5 meters, and Class C with 7 meters excavation. The classification assumed for each proposed damsite is as follows;

- Class A : Mallig No. 2, Ilagan No. 1, Alimit No. 1
- Class B : Pinukpuk, Siffu No. 1, Addalam
- Class C : Disabungan, Cagayan No. 1, Cagayan No. 2

(2) Land use and building numbers in the reservoir area

Present land use and numbers of buildings in the proposed reservoir areas were estimated on the basis of available topo-maps and field investigations. The results in respect of each proposed damsite are shown in Table 9.5. The land use area of 5,040 ha in the proposed Cagayan No. 1 reservoir area at HWL of 160 m is the largest. The reservoir area also encompasses 3,458 buildings.

(3) Accessibility

Length of necessary access road from an existing National road or Provincial road to a proposed damsite was measured from existing topo-maps. Estimated length of necessary access road to each proposed damsite vary from zero at Pinukpuk and Cagayan No. 2, to 30 km at Alimit No. 1 dam.

9.4 Screening of Small Dams and Ponds

The storage efficiency of potential small damsite was compared to select preferable damsites. The area of idle grass land located nearby is another criteria for screening because the land would be the target of development with the proposed dam. In this connection, cattle grazing (ranching) is envisaged to utilize the grass-land. Accordingly, available grassland areas situated within 4 km from the proposed reservoir areas were assumed to be target areas and were measured. It is considered that the larger the available land the higher the priority to a given dam. Finally 10 damsites and a pond site were selected as the promissing schemes. Their locations are shown in Fig. 9.2. Principal features and results of the screening are shown in Tables 9.6 and 9.7.

9.4.1 Priority Ranking

Of ten screened, three (3) sites (Sta. Maria, Calaocan and Colorado) are considered as alternative water resources for Gappal irrigation scheme which has been studied in the irrigation sector. Accordingly, these three (3) sites are excluded from those to be studied.

In order to examine the feasibility of these small dams, preliminary economic features were assessed for the seven (7) proposed damsites. In this assessment, two alternative cases are studied. One is the use of impounded water for both cattle grazing (ranching) and paddy irrigation located nearby. The other is to use the impounded water only for cattle grazing. The cost components comprises the costs incurred by dam and related facilities, irrigation facilities if included, cattle farm facilities, compensation and access roads. Overall benefits comprises the benefits derived from irrigation if involved for paddy cultivation and cattle grazing.

The economic evaluation are conducted for each proposed site on the basis of the estimated costs and benefits. In this assessment, a discount rate of 10% per annum was adopted.

Among the seven (7) proposed small damsites, the most economical damsite judged from the economic internal rate of return (EIRR) and benefit cost ratio (B/C) is the proposed Santor dam. EIRR and B/C ratio of this dam are 16.5% and 1.35 respectively if the dam is planned as single purpose dam for cattle grazing. The results of economic evaluation and priority rankings for the proposed sites are summarized in Table 9.8.

In addition to this, an economic evaluations was also made for the proposed Carmencita Pond. Two alternative cases were again evaluated for this scheme. Carmencita scheme is economically more advantageous than the Santor dam scheme if irrigation development is not contemplated. However, the Santor dam scheme appears to be more profitable than the Carmencita Pond scheme in both cases as summarized below;

With irrigation

- EIRR;	Santor dam;	12.6% ,	Carmencita pond;	10.3%
- NPV ;	"	₱13.6 x 10^6,	"	₱0.7 x 10^6
- B/C ;	"	1.17 ,	"	1.02

Without irrigation

- EIRR;	Santor dam;	16.5% ,	Carmencita pond;	18.6%
- NPV ;	"	₱18.7 x 10^6,	"	₱9.9 x 10^6
- B/C ;	"	1.35 ,	"	1.44

The economic indices of each proposed scheme are presented in Table 9.8. The table shows that most of schemes are economically advantageous if they are planned as the single purpose dams for watering cattle. However, there are some which indicate that irrigation purposes may be well contemplated due to their site conditions.

9.5 Preliminary Design of the Selected Dams

9.5.1 Criteria for Dam Design

New aerophoto maps at 25,000 scale were developed by JICA for the proposed damsites and reservoir areas of Siffu No. 1, Mallig No. 2, Ilagan No. 1, Disabungan, Cagayan No. 1 and Cagayan No. 2. These maps were made full use of in the study. Structures were laid out on these maps and work quantities estimated on the basis of the topographic data furnished by the maps.

For dam and related facilities design, the following basic design criteria were applied for each damsite, except for those for which pre-feasibility and feasibility studies are already completed.

(1) Dam and reservoir

1) Sediment level is set at the estimated 100-yr sediment level for a multipurpose dam. For a small dam, 25-yr sediment storage is provided.

2) Surcharge water level (SWL) is set at the elevation required for flood control of a 100-yr probable flood above the normal high water level. The constant-ratio constant-amount outflow method is assumed as the reservoir operation method.

3) Flood water level is set at the estimated level which could discharge the peak discharge of a 200-yr probable inflow flood for the concrete dam, however, 1.2 x 200-yr probable flood is applied for the fill-type dam.

4) Dam type is selected from the following types with due regard to the topography, geology and the availability of construction materials of each damsite.

i) Rockfill dam with an impervious zone
ii) Earthfill dam
iii) Concrete gravity dam

5) Dam slope and crest width are applied for the following value:

	Upstream Slope	Downstream Slope	Crest Width
Rockfill	1:2.9	1:2.0	12m
Earthfill (Multipurpose)	1:3.9	1:2.7	12m
" (Small)	1:4.0	1:3.0	8m
Concrete gravity	1:0.1	1:0.8	8m

(2) Spillway

1) Gated or a side overflow type for fill type dam, and free overflow crest with gated conduit type for concrete dam for multipurpose dam.

2) Non-gated overflow type spillway is provided for a small dam.

3) Stilling basin type is applied for energy dissipator.

(3) Diversion System

1) Tunnel type is adopted for diversion systems during construction for a multipurpose dam.

2) Open channel type or tunnel type are adopted for diversion systems during construction for small dam depending on topographical conditions.

3) The following probable floods are applied for diversion systems:
- Fill dam ------ 25-yr probable flood
- Concrete dam -- 2-yr probable flood

Waterway and Powerhouse are designed such as intake, headrace tunnel, penstock line and power house.

9.5.2 Layout Plan

The dam and the related facilities were laid out with reference to the design criteria. Prior to dam layout, the dam type was decided considering the available construction material, topographical and geological conditions as follows:

- Pinukpuk	Rockfill
- Siffu No.1	Earthfill
- Mallig No.2	Rockfill
- Disabungan	Rockfill
- Ilagan No.1	Concrete gravity
- Alimit No.1	Concrete gravity
- Addalam	Rockfill
- Cagayan No.1	Concrete gravity
- Cagayan No.2	Concrete gravity
- Santor	Earthfill
- Carmencita Pond	Earthfill

9.5.3 Cost Estimate

Unit prices to be used for calculation of construction costs were estimated by referring to the unit prices adopted for Chico IV, Gumain, Panay, Binongan and Casecnan Projects. In order to decide principal figures, such as exchange rates and price indices, December 1985 was adopted as the time basis. Table 9.9 shows unit prices for dam construction.

In addition to the construction costs estimated from the work quantities and unit prices, the following provisions were made:

- Miscellaneous civil works	: 10% of the sum of the estimated cost
- Preparatory works (except access road and bridge)	: 8% of the sum of the estimated cost of civil works including miscellaneous cost
- Engineering services cost	: 10% of the direct construction cost
- Government administration cost	: 5% of the direct construction cost
- Physical contingency	: 15% of the sum of the direct construction cost, engineering services cost, government administration cost and compensation cost.

Applying the conditions described as above, construction costs of civil works for dam, spillway and diversion works were calculated on the basis of the unit prices and work quantities which were estimated through the facility planning. Cost curves of total construction cost of civil works for dam, spillway and diversion works at each dams were developed and are presented in Fig. 9.3.

Compensation costs of dams were estimated from the land use and building numbers in the reservoirs. Estimated compensation cost curves of dams are developed and are shown in Fig. 9.4.

Among the selected fourteen (14) damsites, feasibility study had been completed for four (4) damsites such as Chico IV, Matuno No.1, Diduyon and Casecnan Project. However, these project costs were estimated two to thirteen years before then studies and the prices have changed during the laps of time. Therefore, it was necessary to update the project costs at the price level as of December 1985. These updated project costs were estimated and made available by the JICA Luzon Hydropower Potential Study Team as follows;

- Casecnan 909.8×10^6 US$
- Matuno No. 1 267.0×10^6 US$
- Diduyon 469.2×10^6 US$
- Chico No. 4 534.9×10^6 US$

X WATER DEMAND AND SUPPLY BALANCE STUDY

10.1 Conditions Adopted

The total possible water consumption in the basin up to the year 2005 is estimated as the sum of water demands for irrigation and municipal water demands which are estimated in each sectoral study. In addition, the river maintenance flow is another component of the water demand.

The balance of water demand and supply is examined at each point where the flow regime may be changed by the increasing water demands due to projected economic activities. In this connection, balance points selected are those of the proposed damsites, proposed intake sites of irrigation water and municipal water, confluences of the major tributaries and the estuary. Consequently the water demand and supply balance is examined at 48 points in the Cagayan river basin. The schematic diagram of water balance is illustrated in Fig. 10.1.

In order to carry out water demand and supply balance study, the following criteria and conditions are assumed:

(1) Inflow

The average 10-day naturalized runoff estimated for a 22-year period from 1963 to 1984 is applied for this simulation.

(2) River maintenance flow

1) In determining the maintenance flow of a river, the following aspects have to be considered to maintain the normal functions of the river: (a) navigation, (b) fishing, (c) picturesque scenery, (d) salt water intrusion, (e) clogging of river mouth, (f) riparian structures, (g) groundwater table, (h) flora and fauna, (i) river water quality.

2) Among these, items (a), (e) and (g) are deemed not significant with regard to the Cagayan river basin.

3) In order to maintain the functions in (c), (f), (h) and (i), the maintenance flow at each balance point is assumed to be the specific discharge of 0.0046 $m^3/s/km^2$, which is the average of the n-th lowest discharges during n-years recorded at several stream gauging stations over the basin. The figure is applied to each balance point except for the existing large scale intake sites such as Magat dam and Siffu intake. The river maintenance flow immediately downstream of Magat dam and Siffu intake weir is nil at present. The situations are accepted as they are in this study.

Another critical point in the Cagayan river is the Magapit pumping station site and its lower reach. The maintenance flow at the station was decided to be 140 m^3/s so as to be free from damages due to salt water intrusion. The amount is adopted because it is the 4th minimum discharge against the 22-year flow assuming the water abstractions which correspond to the water demand in 1985. It is supposed that the river section downstream of the site can maintain its present functions if the flow conditions are not worsened.

(3) Dependabilities of design discharges

The dependabilities of design discharges by sectors are set at the following figures:

- Irrigation scheme : 80%
- Hydropower scheme : 95%
- Municipal water supply scheme : 95%
- Fisheries water supply scheme : 90%

(4) Return flow

Return flow from schemes are assumed as follows:

- Irrigation scheme : 30%
- Hydropower scheme : 100%
- Municipal water supply scheme : 40%
- Fisheries water supply scheme : 90%

10.2 Projected Water Deficit

The annual water deficit with a return period of 5 years, assuming no additional water sources facilities are provided, is projected as the 4th largest annual deficit during the simulated 22-year period as presented in Table 10.1. In this projection, a return flow to the lower reach is accounted as the balance of the water abstracted at an intake site and that consumed in the service area. In other words, if no water is abstracted at an intake because of water deficit, no return flow is assumed to flow into the lower reach downstream of the intake site.

The maximum annual deficit is estimated to be 650 x $10^6 m^3$ in 1995 at the proposed Mallig No. 2 dam site (Balance point 30) according to the results of the demand and supply balance study. The applied runoff in 1975 generates this amount of deficit. The deficit is attributable to the water demand of the proposed Chico Mallig irrigation project which will be put into operation by 1995.

Another large deficit is 139 x $10^6 m^3$ in the Chico river (Balance point 23). The water demand of the Chico river irrigation project incurs the deficit from 1990 against the runoff experienced in 1980. Likewise the development of Magat irrigation system and the proposed Matuno irrigation scheme inflates the water demands in accordance with their implementation and subsequent operation. The deficit is projected to be 27 x $10^6 m^3$ in 1990 at the balance point 13 and to increase to 146 x $10^6 m^3$ in 2005. The hydrologic condition in 1975 is the most critical in this case. A considerable deficit of 75 x $10^6 m^3$ is projected in the proposed Gappal irrigation scheme at the balance point 8 after 2000. This deficit is attributable to the water demand of the proposed Gappal irrigation scheme and the drought experienced in 1982. The Matuno irrigation system also brings about a water deficit of 87 x $10^6 m^3$ in the year 2005 at the balance point 11. And this is a major cause of the projected deficit at the point 13 as mentioned before. The runoff in 1984 is considered to be most critical in this river. The proposed Mallig irrigation scheme requires a certain amount of water to be diverted from the Mallig river. An annual deficit of 55 x $10^6 m^3$ is projected in 1995 through 2005 at the balance point 31. The runoff in 1978 is considered to be critical. Some more deficits are projected in the main river and the tributaries. Most of them are attributable to the water demands of the proposed irrigation schemes.

The maximum water demand in the target period of the Study is loaded in the year 2005. The water demand in the year 2005 may entail water deficits at 7 balance points if the hydrologic condition experienced in 1978 recurs. The projected total deficit amounts to 107 x $10^6 m^3$. Against the hydrologic conditions in 1969 and 1980, water deficits are simulated at 3 balance points. The respective total deficits are 109 x $10^6 m^3$ and 166 x $10^6 m^3$.

10.3 Deficit Supply for Tributaries

The 5-year probable water deficit of 75 x $10^6 m^3$ simulated in the proposed Gappal irrigation area is to be complemented by the water released from three dams, Sta. Maria, Colorado and Calaocan. Dams are to be made available by the year 2000 so as to avoid this deficit.

The deficit simulated in the Matuno river is to be fully complemented by the released water from the Matuno No. 1 dam. The dam is scheduled to be operational by the year 1997. This water deficit in the Matuno river is fully made up. At the same time the dam is to be provided so as to supplement water to the Magat river at Magat damsite. But in this case, the proposed Alimit No. 1 dam and Siffu No. 1 dam are also considered as the alternative facilities to complement the deficit.

The proposed Mallig No. 2 dam with the water augmentation from the Chico river through the transbasin waterways will complement the water deficit along the Mallig river. This water once impounded in the reservoir will be supplied to the existing Chico river irrigation system (balance point 23) as well as to the proposed Chico Mallig irrigation project. The simulated water deficit at the balance point 32 becomes zero because of the return flow from the augmented irrigation water.

The generated water deficit of $14 \times 10^6 m^3$ in 2005 in the Pared river due to the proposed Baggao irrigation system is to be amended by the release from the proposed Paranan dam. Likewise the deficits in the Zinundungan, Dummon Dabubu and Tumauini rivers are to be complemented by the releases from the proposed Zinundungan dam, Dummon dam, Santo Niño dam and San Vicente dam.

San-Pablo-Cabagan irrigation is one of the on-going projects without provision of any dam. It is recommended to provide a dam on the upper reach of the Pinacanauan river so that the irrigation system is able to function as it is scheduled.

The Chico river presents a considerable amount of water deficits at balance points 21, 22, 26 and 27. Since no water resources development of the river is included in this Study due to social circumstances, the generated water deficit is not made up. The maximum annual deficit of $20 \times 10^6 m^3$ appears at balance point 26 with a maximum 10-day deficit of $5.9\ m^3/s$. And the longest conspicuous duration is estimated to be 20 days in March against the water demand of $1.8\ m^3/s$. In this case the river maintenance flow secured is as much as $15\ m^3/s$. Accordingly the deficit is considered not serious.

All the water deficits are compensated by the water released from these dams or the return flow thereof. The location of damsites are depicted and shown in Fig. 10.2.

10.4 Deficit Supply for Main Stream

At the balance point 7, an annual deficit of 6 x $10^6 m^3$ is generated with a maximum 10-day deficit of 4.2 m^3/s. The catchment area is estimated to be 5,580 km^2 at this point and the river maintenance flow of 25.7 m^3/s is secured. With this regard, the generated deficit is considered to be insignificant.

The water deficit of 11 x $10^6 m^3$ at the balance point 9 is to be remedied by the return flow from the Gappal irrigation system which is to be supplied from the proposed dams. The water deficits of 37 x $10^6 m^3$ and 34 x $10^6 m^3$ at the balance points 47 and 48 respectively are to be complemented by the augmented return flows from the tributaries in the upstream reaches.

In view of this, no specific dam is proposed to cope with the deficit generated under present condition in the main river.

XI MASTER PLAN

11.1 Optimum Scale of Dam

11.1.1 Required Dams

As discussed in the previous chapter, following dams are proposed in order to augment the natural flow and to complement the water deficit:

a) Dams to compensate and supplement Magat reservoir: Matuno No. 1 dam, Alimit No. 1 dam and Siffu No. 1 dam.

b) Water supply and hydropower dams: Dummon dam, Paranan dam and Zinundungan dam.

c) Water supply dams: Mallig No.2 dam, Santa Maria dam, Calaocan dam, Colorado dam, Santo Niño dam and San Vicente dam.

d) Hydropower generating dams: Casecnan dam, Diduyon dam and Matuno No. 1 dam.

In addition, small dams and ponds are proposed as water sources for the development of hilly areas. The objectives of such facilities are not only economic development but the social impacts in the rural area of generating job opportunities and enhancement of living standards. Furthermore, the water demand in these areas is not quantifiable and not located exactly in this master plan study. In this regard, the optimum scales have not been studied for the identified small dams and a pond.

11.1.2 Optimum Scale of Matuno No. 1, Alimit No. 1 and Siffu No. 1 Dams

These dams are to compensate for reservoir capacity for irrigation and municipal water supply and hydropower generation of the Magat dam allocated to flood control purpose. Meanwhile, the water demand and supply balance study indicates that the existing reservoir may entail a water deficit and that an additional storage of 94 x $10^6 m^3$ is necessary to compensate for the deficit and to suffice the whole water demand for irrigation water supply to 97,400 ha and for local municipal water supply. The dams are also to cover this required storage as well.

The required storage volume which has the function equivalent to the unit storage volume of the Magat dam is estimated for each dam through water demand and supply balance study. The necessary alternative storage is thus estimated for each dam to apportion the water supply space of the Magat dam. The dam cost is estimated corresponding to each storage of the dams. Consequently the necessary dam cost for storage saving or flood control space generation in the Magat reservoir is estimated for each dam as shown in Fig. 11.1.

Each of the dams mentioned above, however, has its own specific purpose and benefits other than the apportionment of water supply functions of the Magat dam. The dam cost less these benefits is considered as the net cost attributable to the generation of the Magat storage to be allocated to flood control and to compensate for the water deficit due to the Magat irrigation and municipal water supply. The results of the study on cost and benefit for each dam prove that the cost of storage saving or generation is proportional to the storage generated for each dam. Accordingly the optimum combination of three dams with optimum scale is obtained for a given generated storage of the Magat dam by the Linear Programming method. In this method, the objective is the minimum of the total generated cost and the variable is the storage to be generated by each dam. The constraints are: i) the sum of storage generated by each dam is equivalent to or more than the given storage in question, ii) the hydrologic or topographic limit of each dam and iii) the minimum storage to be provided to suffice the specific requirements to the dam. The results of the study furnished the least costly alternatives for several given Magat storages to be generated. They are plotted and illustrated in Fig. 11.2. The optimum combinations of dams can be obtained in the figure against a given flood control space. The overall costs and benefits, which include the costs and benefits specific to each dam are estimated against each given flood control space of Magat reservoir. The overall costs and benefits estimated are plotted and the Benefit-Cost curve is developed as shown in Fig. 11.3. It shows that the generated space of 233 x $10^6 m^3$ entails the highest overall NPV of ₱1,336 x 10^6 with a discount rate of 12%. Consequently the scales of these dams are proposed as follows;

- Alimit No. 1 dam; Required storage volume: 156 x $10^6 m^3$, height 89 m
  Generated Magat volume : 156 x $10^6 m^3$
- Matuno No. 1 dam; Required storage volume: 97 x $10^6 m^3$, height 147 m
  Generated Magat volume : 36 x $10^6 m^3$
- Siffu No. 1 dam ; Required storage volume: 93 x $10^6 m^3$, height 58 m
  Generated Magat volume : 41 x $10^6 m^3$
- Magat dam ; Generated flood control space: 139 x $10^6 m^3$
  Generated supplemental volume: 94 x $10^6 m^3$

11.1.3 Optimum Scale of Water Supply and Hydropower Generating Dam

The Dummon, Paranan and Zinundungan dams have functions to generate hydropower as well as to supply water for irrigation purposes. The water supply benefit was estimated by applying the unit source water value of ₱0.38/m^3 for irrigation to the volume to be supplied for the period of project life. Meanwhile, the hydropower generating benefit was estimated in the previous sectoral chapter for several alternative scales. The project cost of each dam is also estimated for each alternative scale. The present worths of total benefit and cost were estimated by applying a discount rate of 12%. The estimated benefits and costs are plotted and shown on Fig. 11.4. The figure indicates the scale which yields the maximum NPV of each dam. The obtained scales of the dams are summarized as follows;

- Dummon dam : Storage volume 24.1 x $10^6 m^3$ height 36.0 m
- Paranan dam : " 18.1 x $10^6 m^3$ " 50.0 m
- Zinundungan dam : " 53.1 x $10^6 m^3$ " 48.0 m

The optimum scales which are defined as the scales with the maximum net present values of schemes are those which satisfy the projected water demand in the year 2005. After this date the rate of water demand increase will become very small and the NPV will decrease with increase in scale of the project.

In addition to the above mentioned purposes, these dams have flood control function because floods are regulated in the flood impounding capacities between the proposed HWLs and FWLs although the functions are incidental. The benefit resulting from this function is not evaluated in this Study.

11.1.4 Optimum Scale of Water Supply Dam

There are some dams which have the function of irrigation and/or municipal water supply. The water supply benefit in this case is estimated applying the unit source water value of ₱1.0/m^3 for municipal water and ₱0.38/m^3 for irrigation water to the volume to be supplied. The benefits to be derived from several scales of dams are thus obtained. The dam cost is estimated in the previous chapter for each corresponding scale. The present worthes of both benefit and cost are estimated applying a discount rate of 12%. The discounted benefit and cost are plotted and shown on Fig. 11.4. The figure enunciates the optimum scales of the dams. They are summarized as follows;

- Mallig No. 2 dam:	Storage volume	$545.0 \times 10^6 m^3$	height	84.0m
- Santa Maria	:	"	$18.1 \times 10^6 m^3$	"	26.5m
- Calaocan	:	"	$41.0 \times 10^6 m^3$	"	30.5m
- Colorado	:	"	$58.4 \times 10^6 m^3$	"	32.5m
- Sto. Niño	:	"	$2.0 \times 10^6 m^3$	"	18.0m
- San Vicente	:	"	$6.9 \times 10^6 m^3$	"	30.0m

The optimum scale turn to be the scale which suffices the projected water demand in the year 2005.

11.2 Cost Allocation of Dam

The cost of multipurpose dam is allocated to each purpose by means of the Separable Cost-Remaining Benefit method. In this respect, the cost excluding a purpose is estimated to assume separable costs for the purpose. The benefit to be derived and the justifiable expenditures are estimated for each dam and for each purpose. The allocated costs are summarized in Table 11.1. The figures of the proposed Siffu No. 1 dam and Mallig No. 2 dam presented in the table include the costs incurred for flood control purpose. The proposed flood control spaces are 115 x $10^6 m^3$ for the Siffu No. 1 dam and 112 x $10^6 m^3$ for the Mallig No. 2 dam. Subsequently the EIRR for the flood control scheme by the proposed Siffu No. 1 dam is improved to 18.6% from 12.8%. The Mallig flood control scheme yields EIRR of 10.3% instead of 9.3%.

11.3 Adjustment of Priority with Allocated Cost

The dam costs are allocated in accordance with the results of the cost allocation studies described in the previous section. The priority of each proposed scheme is reshuffled on the basis of the results of new economic evaluation utilizing the allocated costs. The reshuffled priorities are as follows;

<u>Flood Control Project</u>

Priority No.	1	Tuguegarao dike
	2	Narrow improvement (Nassiping left bank: Site-NLL)
	3	Siffu No. 1 dam
	4	Bank protection works
	5	Cabagan dike
	6	Narrow improvement (Nassiping right bank: Site-NLR)
	7	Magat/Alimit No. 1 dam
	8	Cagayan No. 1 dam
	9	Mallig No. 2 dam
	10	Ilagan No. 1 dam
	11	Narrow improvement (Upstream of Nassiping: Site-NUP)