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REPUBLIC OF THE PHILIPPINES

FINAL REPORT
FOR
THE MASTER PLAN STUDY
ON
THE CAGAYAN RIVER BASIN WATER RESOURCES DEVELOPMENT

EXECUTIVE SUMMARY

AUGUST 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

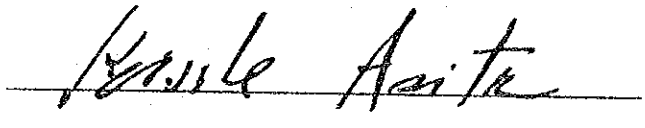
P R E F A C E

In response to the request of the Government of the Republic of the Philippines, the Japanese Government has decided to conduct a Master Plan Study on the Cagayan River Basin Water Resources Development Project and entrusted the study to the Japan International Cooperation Agency. JICA sent to the Philippines a survey team headed by Mr. Hideki Sato of Nippon Koei Co., Ltd. from October 1985 to March 1987. The team exchanged views with the officials concerned of the Government of the Philippines and conducted a field survey. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

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

August, 1987



Keisuke Arita
President
Japan International Cooperation Agency

THE MASTER PLAN STUDY
ON
THE CAGAYAN RIVER BASIN WATER RESOURCES DEVELOPMENT

August 1987

Mr. Keisuke Arita
President
Japan International
Cooperation Agency
Tokyo

Dear Sir,

LETTER OF TRANSMITTAL

We are pleased to submit to you the Final Report for the MASTER PLAN STUDY ON THE CAGAYAN RIVER BASIN WATER RESOURCES DEVELOPMENT, prepared for consideration by the Government of the Philippines in implementing water resources development in the specified region, in line with nation's socio-economic development objective.

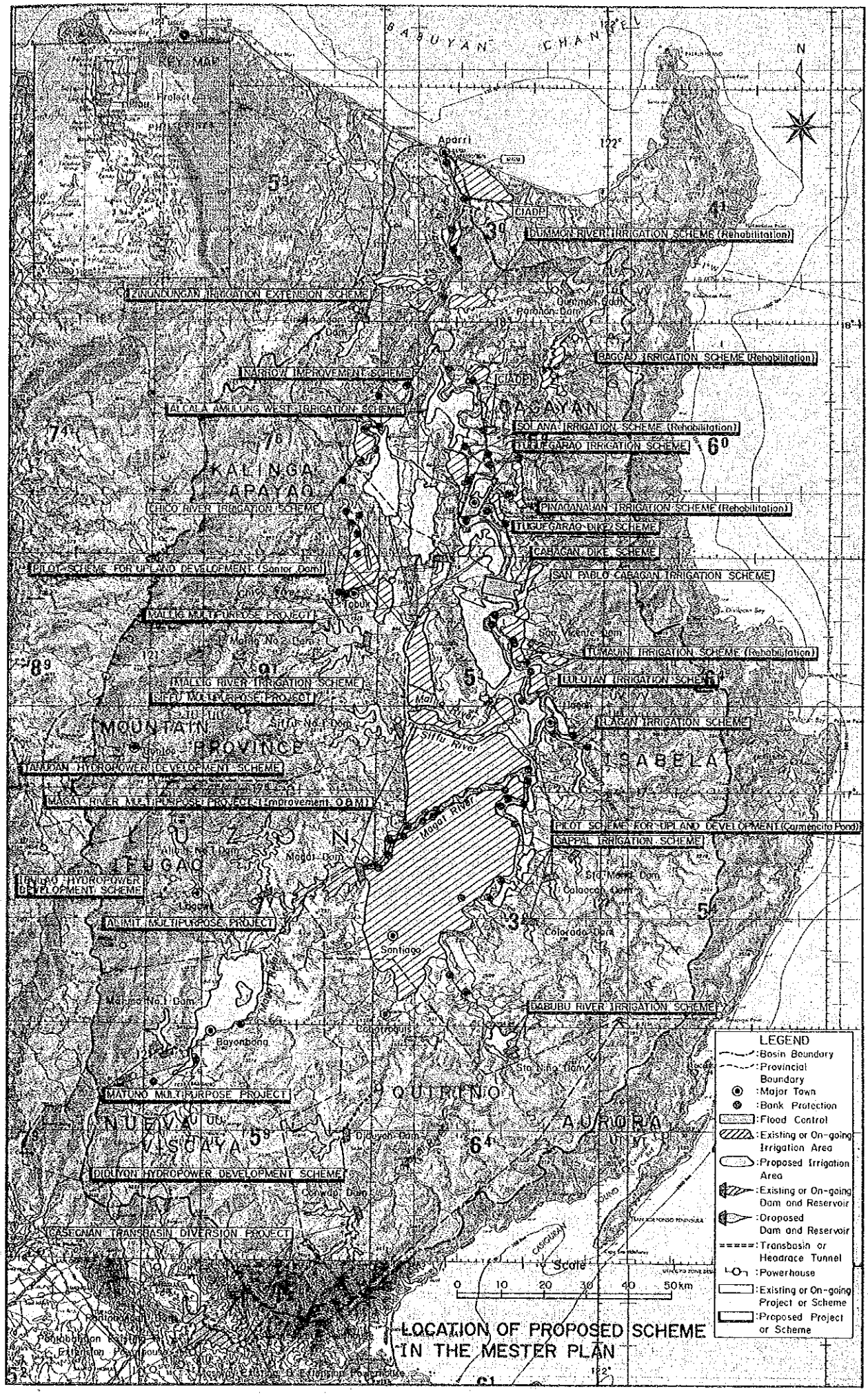
The report presents a master plan comprising various proposed schemes for flood control, agricultural development and hydropower development. The several multipurpose dams and single purpose dams are also proposed in the Master Plan in order to meet the anticipated water demands incurred by the proposed developments.

The Report consists of the Executive Summary, Main Report and Supporting Report. The Executive Summary briefs the summaries of the findings and the Master Plan proposed. The Main Report contains background and conditions, flood control plan, agricultural development plan, dam and hydropower development plan, conclusions and recommendations. Supporting Report contains supporting data and technical details.

All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, Ministry of Agriculture, Forestry and Fisheries and Embassy of Japan to the Philippines as well as officials and individuals of the Philippines for their assistance extended to the Study Team. The Study Team sincerely hopes that the study results would contribute to socio-economic development and well-being in the Cagayan river basin.

Yours sincerely,

Hideki Sato
Team Leader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I INTRODUCTION

1. The Study is performed in conformity with the stipulations of the IMPLEMENTING ARRANGEMENT on the Study agreed by both the Governments of Japan and the Philippines on August 1, 1985.

2. Thereby, the objectives of the Study is specified to formulate a Master Plan for the water resources development in the Cagayan river basin covering an area of 27,300 km^2. The target period of the plan is defined as about 20 years from 1985.

3. JICA organized the Study team with the selected consultants in order to carry out the Study. The team conducted the Study with a close and effective cooperation extended by the Government of the Philippines through the Counterpart Officers. JICA also established an Advisory Committee formed by staff of the Ministry of Construction and the Ministry of Agriculture, Forestry and Fisheries, Japan in order to guide the Study team and review the findings thereby. A Steering Committee formed by staff from the various related agencies with advisory members and a Technical Working Group established by the Government of the Philippines also guided the Study in various aspects.

4. The Study established the regional socio-economic development framework in terms of population, GRDP and GVAs. With due respect of the stipulations of the IMPLEMENTING ARRANGEMENT, the Study duly envisaged the development of flood control works, irrigation systems and hydropower generating facilities which will sustain the development framework plan. The Study projected future water deficits to be incurred by increasing water demands corresponding to the socio-economic developments mentioned above. Accordingly the Study proposes the construction of several impounding dams in the Cagayan river basin as preferred water resources developments which will remedy the water deficits projected. In addition, a flood control capacity is provided in the proposed impounding reservoir if it is judged to be effective.

5. The Study Team prepared and submitted a Draft Final Report to JICA at the end of March, 1987. This was duly distributed to the relevant committees by JICA. Meetings of the Advisory Committee in Japan and the Technical Working Group in the Philippines were held to discuss the comments received on the Report. Finally a joint meeting of JICA Advisory Committee, the Steering Committee of the Government of the Philippines and the Study Team was held on June 15, 1987 in Quezon City. All the conclusions of the meeting were incorporated in the Report from which this Final Report has been prepared.

II PROFILE OF THE CAGAYAN RIVER BASIN

1. The Cagayan river basin lies between $15^{o}52'$ and $18^{o}25'$ north in latitude and between $120^{o}51'$ and $122^{o}18'$ east in longitude. The basin is bordered as follows;

   - East : Sierra Madre mountain range
   - West : Cordillera Central mountain range
   - South : Caraballo-Maparang mountain range
   - North : Babuyan channel

2. The basin administratively comprises 8 provinces belonging to Regions I, II and IV as follows;

   - Region I : Mountain Province
   - Region II: Cagayan, Ifugao, Isabela, Kalinga-Apayao, Nueva Vizcaya and Quirino
   - Region IV: Aurora

   In total, 107 municipalities are included in the Cagayan river basin. The locations of provinces and municipalities are shown in Fig. 1.

3. According to the results of a census carried out by NEDA, the total population in the Cagayan river basin was 1,885,000 in 1980. The urban population was estimated to be 316,000 and the rural population 1,569,000. The most urbanized municipality is Tuguegarao which has an urban population of 30,000 or 41% of total population. The average population density is 69 person/km^2. The figure appears extremely low as compared with the national average of 160 person/km^2.

4. The gross regional domestic production (GRDP) in the Cagayan river basin was ₱1,825 x 10^6 in 1985 at 1972 constant prices. The compositions of the gross value added (GVA) by sector was as follows;

Item	GVA (₱10^6)	Ratio (%)
GRDP	1,825	100
Agriculture	862	47.2
Industry	272	14.9
Services	691	37.9

(At 1972 constant prices)

The per capita GRDP of ₱854 is extremely low as compared with the national average of ₱1,654 at 1972 constant prices.

5. The topography of the basin is generally sloping. The lowlands which have a slope less than 8% cover only 6,800 km^2 or 25% of the total land area. The upland areas with slopes between 8% and 18% cover 9,000 km^2 and the mountainous area with slopes of more than 18% cover 11,500 km^2. The land use may be summarised as follows;

(Unit: km^2)

Land Use		Area
Lowland	Paddy	2,470
	Corn and others	1,300
	(Sub total)	(3,770)
Upland	Permanent crops	270
	Pasture	1,270
	(Sub total)	(1,540)
Mountain	Forest	11,500
	(Sub total)	(11,500)
Idle land, Bare land and others		(10,490)
Total		27,300

Noteworthy land resources to be developed is around 3,000 km^2 of potential arable land in the lowland and 7,000 km^2 of mainly potential pasture land in the upland areas.

6. Meteoro-hydrologic features of the basin may be judged from the following data;

1) Average annual rainfall:

- Maximum: more than 4,000 mm in the mountainous area.
- Minimum: less than 2,000 mm in the northern lowland.
- Average: 2,600 mm

2) Seasons:

- Dry season: From December to May (NE monsoon period)
- Wet season: From June to November (SW monsoon period with frequent typhoon)

3) Average annual runoff:

River	Catchment area (km^2)	Runoff (m^3/s)	Specific discharge ($m^3/s/km^2$)
Magat	5,113	263	0.051
Upper Cagayan	6,633	291	0.044
Whole basin	27,300	1,343	0.049

4) 100-year flood peak discharge:

River	Catchment area (km^2)	Discharge (m^3/s)	Specific discharge ($m^3/s/km^2$)
Magat	5,113	10,600	2.1
Chico	4,551	8,700	1.9
Cagayan/1	11,993	23,900	2.0
Whole basin	27,300	21,600	0.8

Note: /1; Just upstream from the junction of Ilagan river.

These figures indicate the abundance of water resources with a biased distribution over the year.

7. The riverbed slope and flood water surface slope of the Cagayan river are estimated and presented as below;

River stretch	Length (km)	Riverbed slope	Water surface slope
Ilagan-Tuguegarao	70	1/5,620	1/5,670
Tuguegarao-Alcara	75	1/8,680	1/12,080
Alcara-River mouth	65	1/8,680	1/3,450

The differences in slopes of the riverbed and the water surface demonstrate the possibility of a bottle-neck around Alcara.

8. The flow capacities of the existing river channels are small in the aluvial plain and inundation is rather frequent. The capacity of the Cagayan river between Alcara (Catchment area: 21,400 km^2) and Tuguegarao (Catchment area: 19,500 km^2) is estimated to be only 0.23 $m^3/s/km^2$ in terms of specific discharge, which is no more than the equivalent peak discharge of a 2-year flood.

The floods of 1973 and 1980 are noted for the overwhelming havoc they caused. The former accompanied typhoon Openg and submerged a land area of 1,860 km^2. The latter was brought about by typhoon Aling and flooded an area of about 1,740 km^2. Flooded areas caused by typhoons Openg and Aling are shown in Fig. 2.

The average annual cost of flood damage is estimated to be ₱3,793 x 10^6 in the basin at 1985 current prices under existing situations.

9. Agricultural production in the Cagayan river basin tends to be extensive rather than intensive because intensive agriculture is considered to be risky due to frequent flood damage. Agricultural production in the basin at 1972 constant prices is estimated to be as follows;

- Paddy : ₱ 439 x 10^6
- Corn : ₱ 120 x 10^6
- Other crops: ₱ 72 x 10^6
- Fisheries : ₱ 7 x 10^6
- Live stock : ₱ 77 x 10^6
- Forest : ₱ 147 x 10^6

10. The electrification rate was estimated to be 40% in the Cagayan river basin in 1984. The energy demand was 83 GWh and the peak load is 33 MW in 1984 against the installed capacity of 365 MW. The daily load factor is estimated to be 87.5% according to the daily demand curve. The power plants located in the basin are as follows;

- Magat	(Hydropower) :	Installed capacity	360 MW
- Ramon	(") :	"	1,440 kW
- Tumauini	(") :	"	760 kW
- Ilagan	(Dendro thermal):	"	3,100 kW

11. LWUA and DPWH are substantial authorities which supply most of the municipal water to the more urbanized areas, while the Rural Waterworks Development Corporation and Barangay Water Program take care of water supply to the rural areas. 27,000 households were served in 1985 making the service factor about 59%. Half of these households are served only by a public well (Level I). 25% have public faucets (Level II) and 25% enjoy a piped system (Level III). The total water supply amounted to about 141 x 10^3 m^3/day in 1985.

III SOCIO-ECONOMIC PROJECTION AND TARGET

In line with the Government's policy of equitable development, the economic development target is to enhance the economy and per capita GRDP of the Cagayan river basin to the equivalent of the national average by 2005. In this comparison, NCR and Region IV are excluded from the estimate of the national average because these regions are extremely industrialized and their economic structures are of a different category. The socio-economic projections and targets envisioned on the basis of MEDIUM-TERM PHILIPPINE DEVELOPMENT PLAN assessed on this basis may be summarized as follows;

	1985	1990	1995	2000	2005
Population (10^3)	2,136	2,413	2,702	2,989	3,259
GRDP (₱10^6) /1	1,825	2,689	4,014	5,536	7,080
Agriculture /1	862	1,062	1,383	1,631	1,837*
Industry /1	272	444	743	1,568	2,544
Service /1	691	1,183	1,888	2,337	2,699

Note /1; At 1972 constant price

*; 70% of maximum development (₱2,408 x 10^6) of agriculture excluding forest (₱147 x 10^6).

The per capita GRDP is accordingly set at ₱2,172 in the year 2005.

IV FLOOD CONTROL PLAN

1. Structural and non-structural measures are contemplated to mitigate flood damage. In this study, priority has been given to structural measures because these are expected to become effective within the short time target of 20 years. Nevertheless, the non-structural measures such as watershed management, afforestation and reforestation, flood warning and evacuation will also play important roles in flood control in future and should also be incorporated into the flood control plan for the Cagayan river basin.

2. In establishing an overall water resources development Master Plan, two plans were formulated a flood control framework plan and a long-term plan.

3. The flood control plan was framed in line with the following principles which were established through studies on present river conditions.

   1) Flood control dams should be provided in the upper watershed areas to reduce peak flood discharge over the 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.

   3) For the middle and lower reaches of the Cagayan river, a diking system should be provided as well as bank protection works so as to protect lowlying lands from flooding. Channel normalization to accelerate smooth and swift drainage of flood water should also be undertaken. Improvement of the Magapit narrows could be a key to the flood control in these reaches.

4. The framework plan was formulated after comparative studies of the following 6 alternative plans consisting of flood control dams, diking systems, and improvement of Magapit narrows:

1) Alt. OD: With diking system, but without dam and narrows improvement. The estimated project cost: ₱35,688,000,000

2) Alt. 5D: With 5 dams and diking systems but without narrow improvement.
The estimated project cost: ₱36,466,000,000

3) Alt. 9D: With 9 dams and diking systems but without narrow improvement.
The estimated project cost: ₱45,796,000,000

4) Alt.0DM: With narrows improvement and diking system but without dams. The estimated project cost: ₱38,278,000,000

5) Alt.5DM: With 5 dams, narrows improvement and diking systems. The estimated project cost: ₱34,394,000,000

6) Alt.9DM: With 9 dams, narrows improvement and diking systems. The estimated project cost: ₱45,603,000,000

The locations of these alternative plans are shown in Fig. 3.

The combination of 5 dams and the narrows improvement with diking system (Alt. 5DM) was selected as the framework plan on the least cost basis.

The plan contemplates alleviating flooding by flood control dams in the upstream reaches and lowering the flood water levels in the downstream reaches by improvement of the Magapit narrows. The areas along the middle reaches of the river will be protected from flooding by diking systems. Dams encompassed in the framework plan are Cagayan No. 1, Ilagan No. 1, Siffu No. 1, Mallig No. 2 and Magat dams. A 100-

year flood is adopted as the design discharge of the framework plan.

5. Following this, a long-term plan was formulated on the basis of the framework plan. The design discharge, however, was reduced to the 25-year flood. The principal features of the long-term plan are as follows:

1) Project cost (economic): ₱27,543,000,000

- Channel work including dike embankment, revetment, drainage sluices, narrows excavation, cut-off channels, bank protection and appurtenant facilities amounting ₱21,345,000,000.
- Dam works for Cagayan No. 1, Alimit No. 1, Ilagan No. 1, Siffu No. 1 and Mallig No. 2 amounting ₱6,198,000,000.

2) Economic evaluation

- Benefit (₱mil./yr)	3,834.1 (at 1985 curent price)
Flood damage reduction	3,698.6
Bank protection	135.5
- IRR (%)	14.2

6. The economic viability of each element in the Long Term Plan was examined in terms of EIRR. The results are shown in Table 1 and summarized below:

Rank	Scheme	EIRR
1	Tuguegarao dike	23.1 %
2	Narrow imp. (Site-NLL)	18.9 %
3	Bank protection	13.7 %
4	Cabagan dike	13.6 %
5	Narrow imp. (Site-NLR)	13.5 %
6	Magat/Alimit No. 1 dam	13.1 %
7	Siffu No. 1 dam	12.8 %
8	Cagayan No. 1 dam	11.6 %
9	Mallig No. 2 dam	9.3 %
10	Ilagan No. 1 dam	5.4 %
11	Narrow imp. (Site-NUP)	-

V AGRICULTURAL DEVELOPMENT PLAN

1. Agricultural development is based the following concepts;

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

      - Completion of on-going projects
      - Rehabilitation/improvement of existing NIS and CIS schemes
      - 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 conditions.

   5) The upland area will be utilized mainly for production of permanent crops and cattle grazing.

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

   7) Cattle will be grazed in pastures and fattened in feedlots.

   8) Fresh water aquaculture will be the main source of fishery products. The production increase of fisheries 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 selective logging level in due consideration of government policy on environmental conservation.

10) In view of the development policy of the Government of the Philippines, the maximum possible development of agriculture is envisioned by the year 2005. In this connection, 70% of the potential is assumed to be the practicable maximum development.

2. Along these lines, the following land use plan in the cultivable land is contemplated:

(Unit: 10^3 ha)

Land Use	Present Land Use (1985)	Future Land Use (2005) (1)	Land Use Plan in P.M.A.* (2)	Ratio of Attainment in 2005 (%) (1)/(2)
I. Lowland				
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	-	-	-
Sub-total	476	476	476	-
II. Upland				
1. Permanent cropland	27	57	200	29
2. Pasture	127	210	300	70
3. Grassland (idle)	450	337	104	-
Sub-total	604	604	604	-

* Potential maximum area.

3. Irrigation is considered as the principal scheme for lowland development. The locations of the proposed schemes are shown on Fig. 4 and the major features thereof are summarized in Table 2. The proposed irrigation schemes are listed below.

Irrigation Scheme	Service area (ha)
I. New Irrigation Scheme	65,330
1. Chico Mallig Irrigation Project	31,200
2. Matuno River Development Project	12,680
3. Dabubu River Irrigation Project	1,000
4. Zinundungan Irrigation Extension Project	1,750
5. Alcala Amulung West Irrigation Project	6,750
6. Tuguegarao Irrigation Project	1,400
7. Lulutan Irrigation Project	2,950
8. Ilagan Irrigation Project	3,200
9. Gappal Irrigation Project	4,400
II. Rehabilitation/Improvement Scheme	12,212
1. Dummon River Irrigation System	2,070
2. Baggao Irrigation System	1,812
3. Solana - Tuguegarao Irrigation System	3,143
4. Pinacanauan Irrigation System	1,200
5. Tumauini Irrigation System	3,987

Lowlands which will not be irrigated will be developed as rainfed diversified crops fields.

4. At present, only 127 x 10^3 ha or 20% of the total cultivable land of 604 x 10^3 ha is utilized for cattle grazing in the uplands. This area is to be extended to 210 x 10^3 ha, and permanent crops land of 27 x 10^3 ha is to be enlarged to 57 x 10^3 ha by the year 2005. The recommended crops are cashew nuts, mango and citrus fruits.

5. Fresh water fisheries are recommended for development of inland water ponds. New reservoirs and ponds proposed may be available for the purposes.

6. Economic internal rates of return (EIRRs) were estimated for each proposed irrigation scheme for two different cropping patterns as follows;

(Unit; %)

Proposed Scheme	Proposed Cropping Pattern A & C	B & C
I. New Irrigation Scheme		
1. Chico Mallig IP	15.7	12.9
2. Matuno RIP	12.4	10.1
3. Dabubu RIP	19.5	17.2
4. Zinundungan IEP	13.4	12.5
5. Alcala Amulung West IP	17.3	14.9
6. Tuguegarao IP	19.4	18.7
7. Lulutan IP	22.8	18.0
8. Ilagan IP	28.0	27.7
9. Gappal IP - Pump	20.2	16.2
- Dam	13.5	11.4
II. Rehabilitation/Improvement Scheme		
1. Dummon RIS	8.0	5.7
2. Baggao IS	7.3	5.7
3. Solana IS	39.0	28.5
4. Pinacanauan IS	75.7	56.0
5. Tumauini IS	12.6	11.7

The applied cropping patterns A, B and C are illustrated and shown in Fig. 5.

7. The priority of each irrigation scheme was determined through the following procedures: (i) the proposed schemes were classified into two categories; schemes with EIRR of more than 15% and schemes with EIRR of less than 15%, (ii) the priority of each proposed scheme within each category was given in accordance with the net firm income per hectare to be derived thereby; higher priority was given to schemes with higher net firm income per hectare and (iii) if the proposed two schemes yield same net firm income, higher priority was given to the scheme with larger number of beneficiaries per hectare. The results of

ranking are summarized as below;

Scheme	Net firm income (₱10^3/ha)	Rank-ings	Beneficiaries (Person/ha)	Rank-ings	Overall rank-ings
Above 15% of EIRRs (1st Class)					
Pinacanauan IS	33	1	8.3	2	1
Chico Mallig IP	32	2	3.1	8	2
Dabubu RIS	30	3	5.1	5	3
Lulutan IP	29	4	4.4	7	4
Solana IS	28	5	8.1	3	5
Gappal/IP (Pump)	28	5	4.8	6	6
Ilagan IP	26	6	8.4	1	7
Tuguegarao IP	24	7	6.1	4	8
Alcala Amulung West IP	24	7	1.9	9	9
Under 15% of EIRRs (2nd Class)					
Baggao IS	33	1	4.8	3	10
Dummon RIS	32	2	3.2	4	11
Matuno RIS	30	3	6.3	1	12
Tumauini IS	27	4	6.0	2	13
Zinundungan IES	27	4	2.9	5	14

8. The agricultural developments proposed as above entail the following water demand;

Irrigation Water (Monthly)

(Unit: m^3/s)

Year	J	F	M	A	M	J	J	A	S	O	N	D
1985	130	158	94	69	139	124	156	93	48	19	67	73
1990	220	251	202	94	173	232	287	183	109	50	63	161
1995	264	302	254	101	218	281	338	217	124	59	65	195
2000	281	323	278	106	235	298	360	232	133	63	67	207
2005	295	338	296	105	255	317	379	244	134	66	66	222

Livestock Water (Annual)

	1985	1990	1995	2000	2005
($10^6 m^3/y$)	3.74	4.84	5.94	7.04	8.15
(m^3/s)	(0.12)	(0.15)	(0.19)	(0.22)	(0.26)

VI HYDROPOWER DEVELOPMENT PLAN

1. The demands of electric power in Luzon island have been projected up to the year 2005. The projected demands are compared with the existing power supply capacities in 1990. The projected demands in the years of 1990, 1995, 2000 and 2005 are 2,927, 3,813, 4,953 and 6,428 MW. Meanwhile, the installed capacity in 1990 is to be 4,101 MW which is expected to yield an output of 3,280 MW. If the installed capacity is not increased, a certain deficit in electric supply will be entailed. A deficit of some 3,000 MW is projected in the year 2005.

2. In order to meet the deficit, the following hydropower schemes are envisaged within the Cagayan river basin as the candidate schemes;

Scheme	MW	GWh	Q (m^3/s)	Gross H. (m)	Turbine	Unit
(Casecnan)	(268)	(1,379)	(110.0)	(208.5)	(Francis)	(3)
Matuno	180	528	110.0	220.0	Francis	2
Ibulao	17	85	7.8	274.0	Francis	3
Tanudan	25	130	11.9	270.0	Francis	2
Diduyon	352	957	85.2	486.0	Francis	2
Chico IV	360	955	355.0	151.0	Francis	4

Casecnan scheme is regarded as an on-going project.

3. The project costs thereof are estimated as follows:

(Time basis 1985 December)

- (Casecnan) (445.8×10^6)
- Matuno 267.0×10^6
- Ibulao 29×10^6
- Tanudan 34×10^6
- Diduyon 469.2×10^6
- Chico IV 534.9×10^6

VII MUNICIPAL WATER DEMAND PROJECTION

1. Municipal water demand is projected with assumptions presented hereunder;

Item	1985	1990	1995	2000	2005
Unit water consumption					
Domestic water (lit/capita/day)					
Level 1	30	30	30	30	30
2	60	60	60	60	60
3	100	105	110	115	120
Service (m^3/establishment/day)	1.0	1.25	1.5	1.75	2.0
Public					
School (m^3/unit/day)	1.0	1.25	1.5	1.75	2.0
Hospital (m^3/unit/day)	3.0	3.25	3.5	3.75	4.0
Others (m^3/unit/day)	2.0	2.25	2.5	2.75	3.0
Construction					
(m^3/day/GVA (₱10^6 at 1972 prices))	31	31	31	31	31
Other Industries					
(m^3/day/GVA (₱10^6 at 1972 prices))	763	743	723	703	684
Service factor of domestic water supply (%)					
Rural Level 1	44	47	50	53	50
2	16	28	30	32	35
No service	40	25	20	15	15
Urban Level 1	50	25	0	0	0
2	25	25	25	0	0
3	25	50	75	100	100
Existing supply capacity					
(10^3 m^3/day)	52.4	58.1	58.1	58.1	58.1
Loss rate (%)	35	32.5	30	27.5	25

2. The treated water demands are projected assuming that the socio-economic developments envisioned are to be realized as follows;

(Unit: m^3/day)

Year	Domestic use	Service and Public use	Manufacturing use	Total
1985	82,465	17,258	41,538	141,261
1990	111,495	23,722	47,023	182,240
1995	143,504	30,308	77,220	252,032
2000	179,761	39,872	204,881	424,514
2005	211,343	91,182	431,672	692,197

3. The source water demands are projected on the basis of the treated water demands projected as mentioned above. The projected are allocated to the assumed 20 waterworks over the Cagayan river basin. The projected and allocated water demands are presented as follows;

(Unit: m^3/day)

Assumed Waterworks	1985	1990	1995	2000	2005
Block 1	11,236	14,639	20,483	34,891	57,111
Block 2	6,977	8,713	11,306	17,472	26,918
Block 3	21,951	28,174	40,017	70,948	118,574
Block 4	9,550	11,519	14,590	22,291	33,851
Block 5	14,901	18,792	25,544	42,376	67,597
Block 6	9,143	11,613	15,991	26,932	43,332
Block 7	12,664	15,901	22,034	7,980	62,110
Block 8	13,568	17,107	24,008	42,131	69,598
Block 9	14,465	18,101	24,165	39,124	61,488
Block 10	10,445	12,542	15,387	21,821	30,941
Block 11	6,563	7,616	8,662	10,801	13,665
Block 12	12,911	16,261	22,842	40,209	66,558
Block 13	6,159	7,569	9,436	13,569	19,586
Block 14	4,359	5,440	6,584	8,517	11,147
Block 15	10,947	13,884	19,561	35,062	60,082
Block 16	2,823	3,420	3,833	4,243	4,647
Block 17	12,290	14,780	20,419	35,766	57,778
Block 18	13,075	15,874	19,768	28,419	40,356
Block 19	7,528	9,122	11,201	15,663	21,775
Block 20	15,772	18,916	24,214	37,320	55,814
Total (m^3/day)	217,325	269,985	360,046	585,537	922,930
(m^3/sec)	2.52	3.12	4.17	6.78	10.68

VIII WATER DEMAND AND SUPPLY BALANCE

1. Water demand and supply balances are simulated at various points in the Cagayan river basin. The physical distribution of water is illustrated and shown in Fig. 6. The simulation is performed using the average 10-day runoff estimated for 22 years period from 1963 to 1984 at relevant points.

   In this simulation, the following river maintenance flows are assumed;

   1) River maintenance flow for general use: 0.0046 $m^3/s/km^2$
      N-th minimum among N-year record
   2) At the pump station in Magapit: 140 m^3/s
      80% dependable flow under the condition with present (1985) water demand
   3) At the existing Magat and Siffu intakes: Zero

2. Water deficit of 109 x 10^6 m^3 is projected against the water demand in 1985. The deficit will increase to 1,373 x 10^6 m^3 in 2005 if no water resources are developed. The details are given in Table 3.

3. In order to augment the natural flow and to remedy the projected water deficit, provision of the following dams is proposed:

Dam	Balance Point	Purpose	Required storage (10^6 m^3)
Sto. Niño	6	Dabubu irrigation	2
Santa Maria	8	Gappal irrigation	
Colorado	"	"	118
Calaocan	"	"	
Matuno No. 1	11	Matuno irrigation	61
San Vicente	33	Tumauini irrigation	7
Mallig No. 2	23, 26, 30, 31	Chico Mallig irrigation	545
Paranan	42	Baggao irrigation and hydropower	18
Zinundungan	44	Zinundungan irrigation and hydropower	53
Dummon	46	Dummon irrigation and hydropower	24

The water deficit projected in the Magat project is to be met by the dams of Matuno No. 1, Siffu No. 1 and Alimit No.1 , which are discussed in the next chapter as the Master Plan.

All the water deficits are can be met by the water released from these dams or the return flow thereof. The location of damsites are shown in Fig. 7.

IX MASTER PLAN

1. The least costly alternative to meet the deficit of the Magat project and to allocate a part of the Magat reservoir space to flood control was found to be the optimum combination of the proposed Siffu No. 1, Matuno No. 1 and Alimit No. 1 dams. The results of study are presented *in Fig. 8.*

2. The optimum combination was identified as that providing the maximum Net Present Value (NPV) in comparison with various least costly combinations corresponding to the various flood control capacities discussed above. The maximum NPV is obtained if a storage volume of 139 x 10^6 m^3 is allocate to flood control at Magat dam. The benefit-cost curve developed is shown in Fig. 9.

   The optimum apportionment of flood storage capacity of each dam is listed below;

   - Flood control space of Magat reservoir: 139 x 10^6 m^3
   - Contribution of Matuno No. 1 reservoir: 36 x 10^6 m^3
     (deficit supply of Magat dam)
   - Contribution of Alimit No. 1 reservoir: 156 x 10^6 m^3
     (deficit supply and subrogate of flood control of Magat dam)
   - Contribution of Siffu No. 1 reservoir : 41 x 10^6 m^3
     (deficit supply of Magat dam)

   In addition to this, the implementation order of Siffu No. 1, Matuno No. 1 and Alimit No. 1 turns out to be the optimum.

3. The necessary scales of water supply dams are obtained as discussed in the previous chapter for WATER DEMAND AND SUPPLY BALANCE in terms of the required storage. The said scales are just enough to cope with the projected water demand up to the year 2005, the target year of the Study. Water demand, however, will continue to increase beyond the

target year, but the preferable damsites will be limited. In this respect, further dam development should be designed to take maximum advantage of hydrological and topographic conditions as far as it is economically advantageous. The optimum scale of dam was then examined through NPV analysis by applying the water demands assumed up to the year 2040 and the assumed water supply benefits of ₱1.0/m^3 for municipal and ₱0.38/m^3 for irrigation water supplies. The growth rates of population and GDP projections made by the NEDA were applied to project the water demands for the period from 2006 to 2020. The water demands, for the period from 2021 to 2040 were projected by linear extrapolation of the water demands in 2015 and 2020.

Since the assumed increases in water demands are small, the increases in benefits are negligible as compared with the increases in costs corresponding to the required additional storages. Thus the optimum scales of all dams were found to be the scales previously designated as the required scales. The benefit and cost curves are developed and exhibited in Fig. 10.

4. The flood control capacity is accumulated at the obtained optimum scale of water supply dam if the flood control function is as proposed by the flood control study. The scales of such dams are thus modified as follows;

1) Siffu No. 1 dam

Water supply and hydropower	93×10^6 m^3
(Equivalent to Magat 41 x 10^6 m^3)	
Flood control	115×10^6 m^3
Total	208×10^6 m^3

2) Mallig No. 2 dam

Water supply	545×10^6 m^3
Flood control	112×10^6 m^3
Total	657×10^6 m^3

3) Matuno No. 1 dam

Water supply (Magat) and hydropower	36×10^6 m^3
Irrigation and hydropower	61×10^6 m^3
Total	97×10^6 m^3

5. The cost of a multipurpose dam is allocated to each purpose by applying the Separable Cost and Remaining Benefit method. The priority of each scheme is re-allocated utilizing the allocated costs. The revised priorities are as follows;

Flood Control

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

Irrigation

1	Pinacanauan	Rehabilitation
2	Chico Mallig	Development (Multipurpose)
3	Dabubu	"
4	Lulutan	"
5	Solana	Rehabilitation
6	Gappal	Development
7	Ilagan	"
8	Tuguegarao	"
9	Alcala-Amulung	"
10	Baggao	Rehabilitation (with hydropower)
11	Dummon	" (")
12	Matuno	Development (Multipurpose)
13	Tumauini	Rehabilitation
14	Zinundungan	Development (with hydropower)

Hydropower

1 Matuno (Multipurpose)
2 Ibulao
3 Tanudan
4 Diduyon

6. The multipurpose projects comprising multiple schemes to be connected by multipurpose dams were evaluated in terms of EIRR reflecting whole the costs and benefits as follows;

- Matuno Project: EIRR; 15.3%
- Mallig " : EIRR; 15.2%
- Siffu " : EIRR; 14.5%
- Alimit " : EIRR; 12.1%

7. In order to select schemes for inclusion in the proposed Master Plan, following principles are employed;

1) Although the economic viability of a multipurpose project is of importance, high priority must be given a project which satisfies a deficit in water or hydropower.

2) To achieve the GVA target in 2005, it is assumed that more than 10% of the projected flood damage of ₱8,998 x 10^6 in 2005 at 1985 constant prices should be prevented.

3) To develop the lowlands fully, all the proposed 9 irrigation development and 5 irrigation rehabilitation schemes should be selected.

4) The uplands are to be developed and the present land use area of 154 x 10^3 ha should be extended to 267 x 10^3 ha by 2005.

5) The least costly alternative schemes should be selected to satisfy the hydroelectric demands.

8. In conformity with these principles, the following projects and schemes were selected for inclusion in the proposed Master Plan;

1) Multipurpose projects: Siffu project, Mallig project, Matuno project and Alimit project.

2) Flood control schemes: Tuguegarao dike, Narrows improvement (NLL), Cabagan dike, Narrows improvement (NLR) and Bank protection works.

3) Agricultural development schemes: 9 irrigation development schemes, 5 irrigation rehabilitation schemes, permanent crops development (30,000 ha) and cattle grazing (83,000 ha).

4) Hydropower development schemes: Ibulao, Tanudan and Diduyon scheme Hydropower developments of Dummon, Paranan and Zinundungan are incidental to the relevant irrigation schemes.

The location of the selected projects and schemes are shown in Fig. 11.

Regarding the flood control schemes, non-structural measures such as watershed management, afforestation and reforestation, flood warning and evacuation should also be incorporated as well as the structural measures mentioned above. And as for agricultural development, the improvement project for the operation and maintenance of the Magat River Integrated Irrigation System is considered as proposed.

9. The costs to be incurred by these projects and schemes selected were estimated as follows;

1) Multipurpose projects:

Siffu	₱1,057 x 10^6
Mallig	₱3,715 x 10^6
Matuno	₱5,855 x 10^6
Alimit	₱2,037 x 10^6
Sub total	₱12,665 x 10^6

2) Flood control schemes:

Tuguegarao dike	₱554 x 10^6
Narrows imp. (NLL)	₱978 x 10^6
Bank protection	₱970 x 10^6
Cabagan dike	₱307 x 10^6
Narrows imp. (NLR)	₱2,957 x 10^6
Sub total	₱5,766 x 10^6

3) Irrigation development schemes:

Pinacanauan	₱ 23 x 10^6	
Dabubu	₱ 99 x 10^6	
Lulutan	₱184 x 10^6	
Solana	₱ 73 x 10^6	
Gappal	₱606 x 10^6	
Ilagan	₱166 x 10^6	
Tuguegarao	₱ 99 x 10^6	
Alcara-Amulung	₱434 x 10^6	
Tumauini	₱378 x 10^6	
Dummon	₱449 x 10^6	(Including hydropower)
Baggao	₱451 x 10^6	(")
Zinundungan	₱418 x 10^6	(")
Magat O & M	₱1,060 x 10^6	
Sub total	₱4,441 x 10^6	

4) Hydropower development schemes:

Ibulao	₱551 x 10^6
Tanudan	₱646 x 10^6
Diduyon	₱8,915 x 10^6
Sub total	₱10,112 x 10^6
Grand Total	₱32,983 x 10^6

10. The implementation schedule was considered in accordance with the following concepts:

1) Schemes or projects which ensure safety or security are to be implemented with high priorities.

2) The implementation of schemes should be scheduled so as not to cause any water or power deficits.

3) Schemes or projects with high EIRRs should be realized as soon as possible.

4) The annual increase in irrigation area should be constant as far as possible throughout the period of master planning.

5) The annual investment should be constant as far as possible throughout the period of master planning.

With regard to the supplement to Magat dam and the apportionment of the Magat flood control space, Siffu No. 1 dam is to be implemented first as described earlier. Matuno No. 1 dam will follow and then Alimit No. 1 dam comes next.

Since meeting the estimated water deficit in Magat project is significant, Siffu project should be implemented as soon as possible. Matuno hydropower scheme should also be in operation by 1998 according to the hydropower development plan. Meanwhile, the priority of the flood control scheme by Magat dam is not urgent. Consequently the implementations of these dams are scheduled to commence as follows;

Siffu No. 1	1990
Matuno No. 1	1992
Alimit No. 1	1997

The economic viability of Mallig project is higher than that of Siffu project. And Chico Mallig irrigation scheme has the second highest

priority among the proposed irrigation schemes. Consequently the implementation of Mallig project is scheduled to commence in 1990 following Pinacanauan and Dabubu irrigation schemes.

Since bank protection work sites are located at 75 sites and can be implemented independently, bank protection is considered to be implemented through out the period of master planning.

The implementation schedule proposed is shown in Fig. 12 and the disbursement schedule of estimated project costs is given in Table 4.

11. The value added induction factor of construction works was estimated by applying the Inverse Matrix for Input Output Analysis prepared by NEDA. The factor of 1.01 was yielded by the Study. This implies that implementation of the Master Plan will bring about considerable beneficial impacts on the regional socio-economy.

84,000 families or 462,000 persons are expected to benefit by 2005 from the effects of the proposed flood control schemes included in the proposed Master Plan even against a 2-year flood.

The agricultural, manufacturing and services industries will be developed as programmed if the proposed Master Plan is realized. In this case, the total labour requirement in the year 2005 is estimated to be 880 x 10^3 persons which is about 77% of the potential labour force of 1,140 x 10^3 persons.

In addition to the above, the removal of water deficit problems and the improvement of electrification may contribute substantially to the cultural development of the region.

The effects of the Master Plan may be summarized as follows;

1) Increase of family income and consumption.
2) Increase and stabilizing of job opportunities.
3) Change in quality of job due to the development of manufacturing and services.
4) Land enhancement due to the flood protection.
5) Improvement of sanitary conditions due to the flood control.
6) Improvement of sanitary conditions due to improved municipal water supply.
7) Improvement of cultural situation due to the electrification.
8) Evolution of diversified life styles due to the improvement of electrification.
9) Technical innovation by industrialization.
10) Technical improvement due to the evolved complexity in agricultural management.
11) Evolution of urbanization.
12) Environmental pollution due to industrialization.
13) Environmental pollution due to the development in livestock industry.
14) Environmental pollution due to agricultural chemicals.

X SHORT TERM PLAN

1. Schemes proposed for implementation within 10 years were selected for inclusion in the proposed Short Term Plan. The preparation of project proposals and implementation programs is recommended. Related preparatory work such as topographic surveys, geological investigations and budgetary arrangements are specified and recommended.

2. Selected multipurpose projects are as follows;

   1) Mallig project: Mallig No. 2 multipurpose dam
      Chico Mallig irrigation scheme
      Flood control

   2) Siffu project : Siffu No. 1 multipurpose dam
      Siffu hydropower scheme
      Supplement of deficit in Magat project
      Flood control

   3) Matuno project: Matuno No. 1 multipurpose dam
      Matuno irrigation scheme
      Matuno hydropower scheme
      Municipal water supply
      Supplement of deficit in Magat project

3. The selected flood control schemes are as follows:

1) Tuguegarao dike	:	Dike length	22.1 km
		Embankment	2,340 x 10^3 m^3
2) Narrow improvement (NLL)	:	Channel length	3.8 km
		Excavation	5,830 x 10^3 m^3
3) Bank protection works	:	Numbers of sites	75
		Total length	112.3 km

4. The selected agricultural development schemes are as follows;

1) Rehabilitation of Pinacanauan irrigation scheme: 1,200 ha

2) Dabubu irrigation development scheme : Sto. Niño dam
1,000 ha

3) Model developments in the uplands : Santor dam
Carmencita pond

In parallel with the model developments in the upland, a master plan study on the development of whole uplands is recommended to formulate a comprehensive plan.

Hydropower development schemes are included in the proposed multi-purpose projects.

5. The implementation schedule of the proposed Short Term Plan is shown in Fig. 13.

TABLES

Table 1 Economic Viability of Candidate Schemes for Master Plan

Sub-project	Cost (₱ mil.)		Constant Prop. C.		Variable Prop. C.		Rank
	Const.	Total O & M	Total B (mil.)	IRR (%)	Total B (mil.)	IRR (%)	
Tuguegarao dike	500.6	117.5	2,867.0	11.6	13,718.2	23.1	1
Cabagan dike	276.9	65.1	817.8	5.3	3,865.1	13.6	4
Narrow imp. (Site-NLL)	900.1	211.5	4,065.5	8.9	19,135.6	18.9	2
- do - (Site-NLR)	2,717.4	638.6	7,919.5	5.2	37,453.6	13.5	5
- do - (Site-NUP)	3,072.5	722.0	230.3	-	1,089.8	-	11
Cagayan No.1 dam	1,487.0	334.6	3,616.7	3.8	17,655.8	11.6	8
Magat/Alimit dam	1,852.8	416.9	5,507.6	5.1	26,389.5	13.1	6
Ilagan No.1 dam	1,964.8	442.1	1,760.9	-	8,636.8	5.4	10
Siffu No.1 (A) dam	489.7	110.2	1,452.6	5.1	6,632.0	12.8	7
Mallig No.2 dam	402.2	90.5	752.0	2.2	3,417.3	9.3	9
Bank protection	903.4	212.3	3,431.0	7.3	10,620.5	13.7	3

Note : 1. Constant and variable Prop. C. denote total benefit and IRR under the constant and variable property conditions of basin during project life of 50 years.
2. Regarding dam projects, single purpose for flood control is assumed.

Table 2 Salient Features of Irrigation Schemes

1. New Irrigation Schemes

Name of Project	Service Area (ha)	Proposed Facilities: Storage Dam (10^6m^3)/1	Pump Station (ømmxunit)	Diversion Weir (LmxHm)	Main Canal (km)	Secondary Canal (km)	Main & Sec. Drainage (km)	Project Cost (₱10^6)
1. Chico Mallig IP	31,200	537	-	-	169	416	77	3,327
2. Matuno RIP	12,680	66.7	-	127 x 2.5 305 x 1.6 35 x 1.8	90	193	195	1,361
3. Dabubu RIP	1,000	2.0	-	200 x 2.0	14	19	-	99
4. Zinundungan IEP	1,750	53.1	-	-	-	37	-	293
5. Alcala Amulung West IP	6,750	-	1,000 x 6	-	28	92	9	434
6. Tuguegarao IP	1,400	-	500 x 4	-	10	15	7	99
7. Lulutan IP	2,950	-	800 x 4	-	14	27	19	184
8. Ilagan IP	3,200	-	1,000 x 5	-	17	46	6	166
9. Gappal IP	4,400	117	-	-	62	44	-	606

/1: Required storage volume for irrigation

2. Rehabilitation/Improvement Schemes

Name of Project	Dummun RIS		Baggao IS		Solana IS		Pinacanauan RIS		Tumauini IS	
Service Area	2,070 ha		1,812 ha		2,829 ha		1,200 ha		3,987 ha	
Existing Intake	Intake gate		Intake gate		Pumping station		Intake gate		Intake gate	
Rehab./Improvement Plan										
1) Basic Plan/1	. Rehabilitation . New dam		. Rehabilitation . New dam		. Rehabilitation . Add. P/S		. Rehabilitation		. Rehabilitation . New P/S . New dam	
2) Facility Plan	Rehab.	New	Rehab.	New	Rehab.	New	Rehab.	New	Rehab.	New
- Storage Dam	-	24.1	-	18.1	-	-	-	-	-	6.9
- Pumping Station	-	-	-	-	4 units	1000mmx1	-	-	-	300mmx4units
- Main Canal (km)	18.3	-	9.8	-	11.4	-	8.2	-	9.6	-
- Secondary Canal(km)	22.3	2.7	4.0	-	10.9	-	6.1	-	29.8	10.0
3) Project Cost (₱10^6)	389		382		73		23		378	

/1: Rehabilitation; Rehabilitation of existing facilities
New dam ; Construction of new storage dam
Add. P/S ; Construction of additional pumping station
New P/S ; Construction of new pumping station

Table 3 1/5 Probable Annual Water Deficit at Balance Point

Unit: $x10^6m^3$/year

Balance Point	Annual Deficit 1985 Demand	1990 Demand	1995 Demand	2000 Demand	2005 Demand
1					
2					
3					
4					
5					
6			2 (80)	2 (80)	2 (80)
7			2 (78)	5 (78)	6 (78)
8				75 (82)	75 (82)
9			2 (78)	7 (78)	11 (78)
10					
11					87 (84)
12					
13		27 (75)	27 (75)	53 (75)	146 (75)
14					
15					
16					
17					
18					
19					
20					
21	2 (83)	2 (83)	2 (83)	2 (83)	2 (83)
22	3 (83)	3 (83)	3 (83)	3 (83)	3 (83)
23	40 (80)	139 (80)	139 (80)	139 (80)	139 (80)
24					
25					
26	15 (78)	17 (83)	18 (83)	19 (83)	20 (83)
27	4 (78)	4 (78)	5 (78)	5 (78)	6 (78)
28					
29					
30			650 (75)	650 (75)	650 (75)
31	2 (78)	2 (80)	55 (78)	55 (78)	55 (78)
32			7 (74)	7 (74)	8 (74)
33	7 (78)	7 (78)	7 (78)	7 (78)	5 (78)
34		10 (78)	10 (78)	10 (78)	10 (78)
35					
36					
37					
38					
39					
40					
41					
42	6 (63)	6 (63)	6 (63)	6 (63)	14 (78)
43					
44	14 (78)	13 (78)	13 (78)	13 (78)	38 (69)
45					
46	16 (80)	16 (80)	16 (80)	17 (80)	25 (80)
47			8 (78)	25 (81)	37 (69)
48			7 (78)	23 (78)	34 (69)

Note; Figures in parentheses are the years when 1/5 probable deficits occur.

Table 4 Assumed Cost Disbursement

(Unit: Mill. Pesos)

Item	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
I. MULTIPURPOSE PROJECT																				
1. Matiag Project				44.87	281.51	748.07	905.79	1,016.20	718.82											3,715.26
2. Siffu Project				31.72	158.58	264.31	338.31	264.31												1,057.23
3. Matuno Project						152.16	507.20	937.26	1,348.04	1,668.00	1,342.41									5,855.07
4. Alimit Project											61.10	306.57	609.28	661.87	509.28					2,037.10
																			Sub-Total	12,664.66
II. FLOOD CONTROL PROJECT																				
1. Tuguegarao Dike				27.60	131.70	131.70	131.70	131.70												554.40
2. Magapit (Nassiping Left,NLL)					49.00	232.30	232.30	232.30	232.30											978.20
3. Bank Protection		53.30	53.90	53.90	53.90	53.90	53.90	53.90	53.90	53.90	53.90	53.90	53.90	53.90	53.90	53.90	53.90	53.90	53.90	969.60
4. Cabagan Dike										15.50	72.80	72.80	72.80	72.80						306.70
5. Magapit (Nassiping Right,NLR)										147.70	312.10	312.10	312.10	312.10	312.10	312.10	312.10	312.10	312.10	2,956.60
																			Sub-Total	5,765.50
III. IRRIGATION PROJECT																				
1. Pinacanauan RIS			1.85	21.16																23.01
2. Dabubu RIP			5.54	46.81	46.72															99.07
3. Lututan IP											7.80	88.29	87.85							183.94
4. Solana IS											2.92	35.10	35.10							73.12
5. Gappal IP											19.79	88.06	259.24	238.96						606.07
6. Bagan IP													7.00	79.75	79.39					166.14
7. Tuguegarao IP													4.15	47.64	47.46					99.25
8. Alcala Amulung West IP														13.59	126.62	186.15	125.41			433.77
9. Bagao IS														21.23	85.97	162.51	161.27			450.98
10. Dummon RIS															20.75	84.38	182.50	161.75		449.38
11. Tumauini IS																	20.74	178.93	178.73	378.40
12. Zinundungan IEP																17.57	73.19	172.55	154.75	418.06
13. Magat O & M Improvement		157.75	352.95	234.71	183.46	131.13														1,060.00
																			Sub-Total	4,441.19
IV. HYDROPOWER																				
1. Ibulao									16.53	82.65	137.75	176.32	137.75							551.00
2. Tanudan												19.38	96.90	161.50	206.72	161.50				646.00
3. Didiyon															1,069.78	1,337.22	2,674.44	2,674.44	1,158.92	8,914.80
																			Sub-Total	10,111.80
Total	0.00	211.05	414.24	460.77	904.87	1,713.57	2,169.20	2,635.67	2,369.59	1,867.75	2,010.57	1,151.64	1,576.07	1,653.34	2,513.97	2,315.33	3,603.55	3,553.67	1,858.40	32,963.15
V. PROJECT COST BY SECTOR																				
1. Flood Control	0.00	53.30	53.90	90.62	291.87	562.21	612.35	618.20	383.32	217.10	468.16	585.53	683.36	751.82	610.56	366.00	366.00	366.00	366.00	7,436.35
2. Irrigation	0.00	157.75	360.34	359.43	559.38	948.74	1,031.64	1,186.66	1,055.94	540.95	477.20	251.96	460.85	484.13	412.86	404.61	489.67	441.94	289.61	9,925.56
3. Hydropower	0.00	0.00	0.00	10.72	53.62	212.62	525.21	828.85	920.33	1,109.70	1,065.22	314.03	431.86	417.39	1,490.55	1,544.72	2,747.88	2,745.73	1,202.79	15,621.22

FIGURES

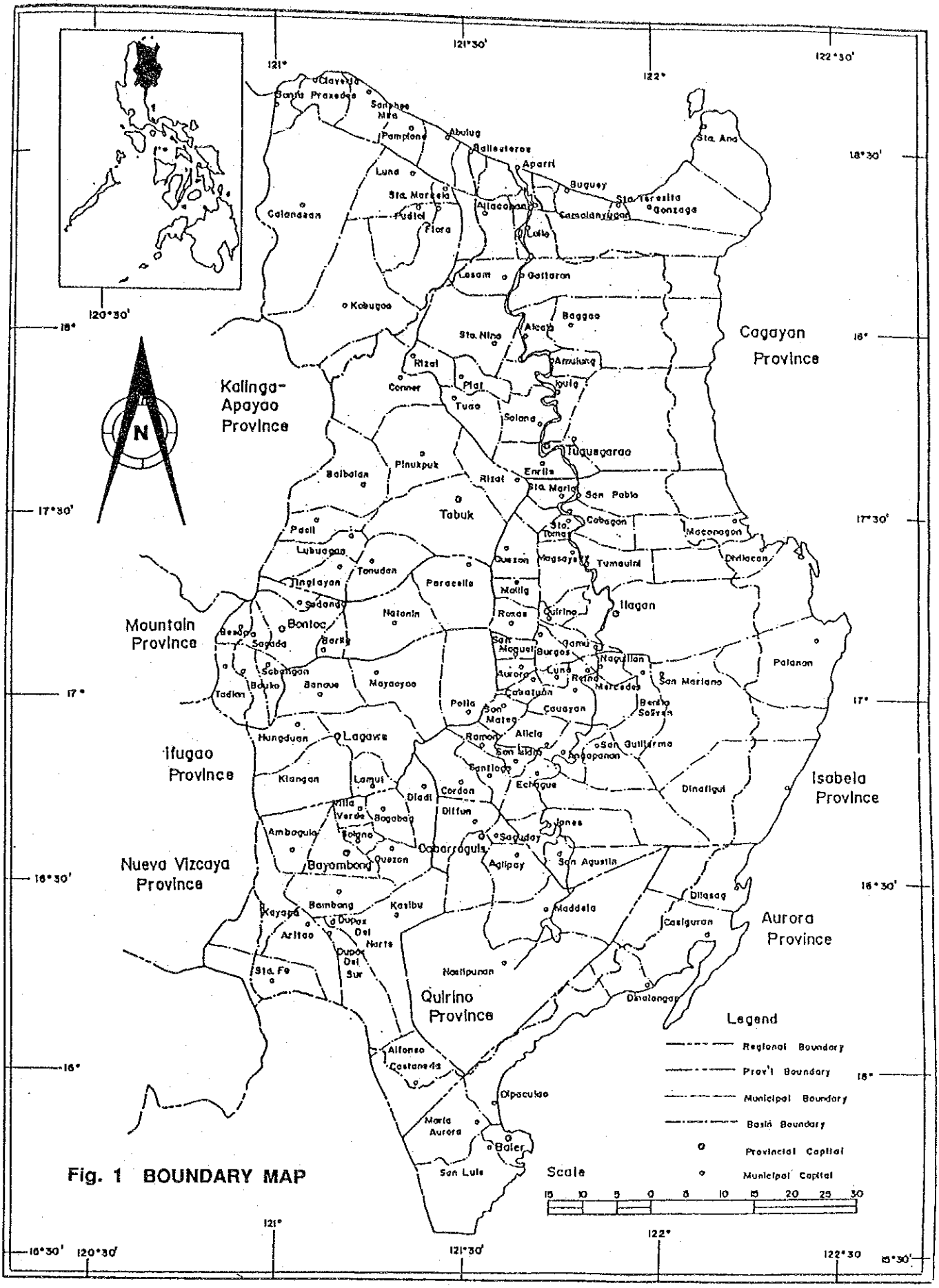


Fig. 1 BOUNDARY MAP

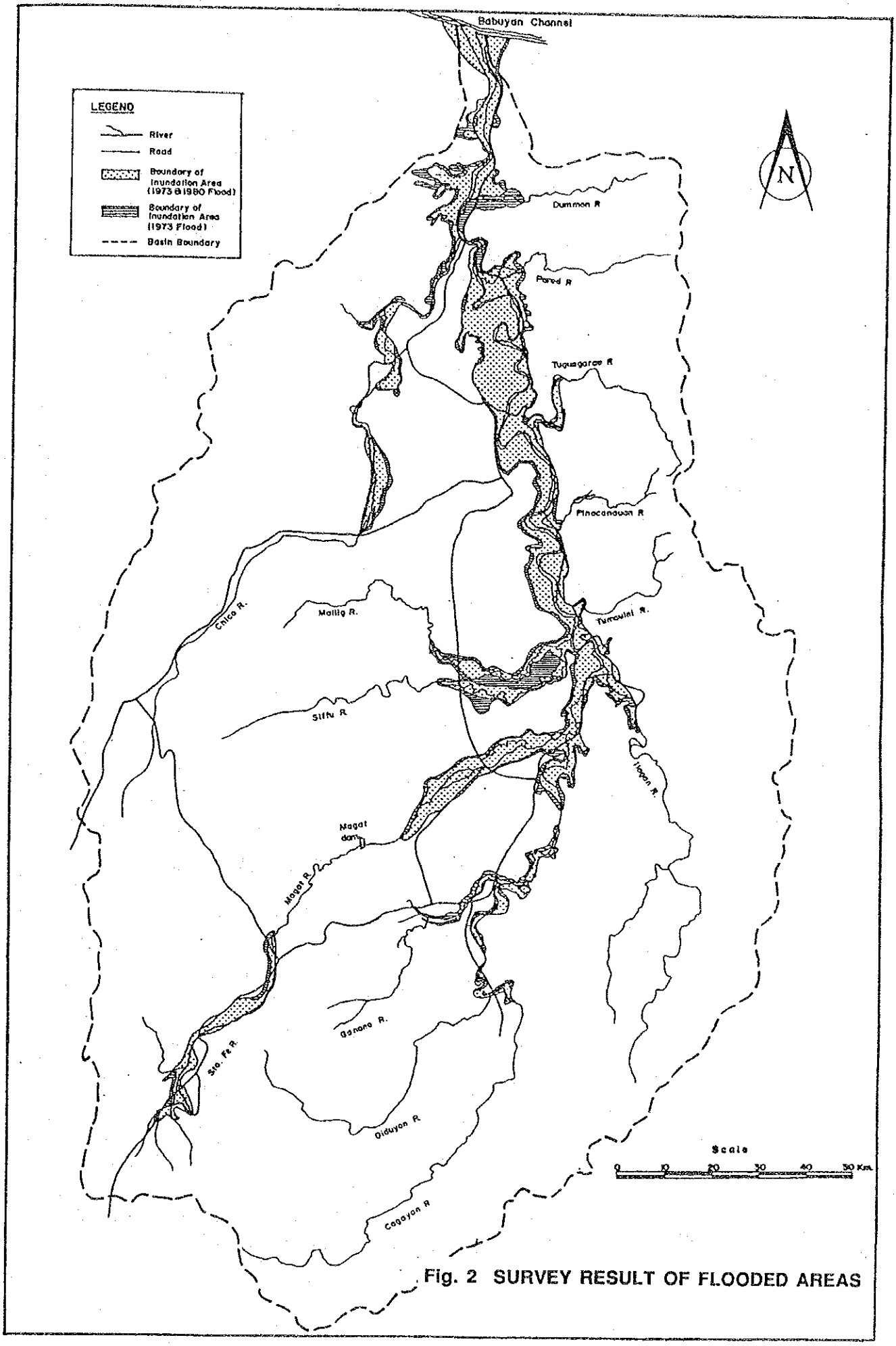


Fig. 2 SURVEY RESULT OF FLOODED AREAS

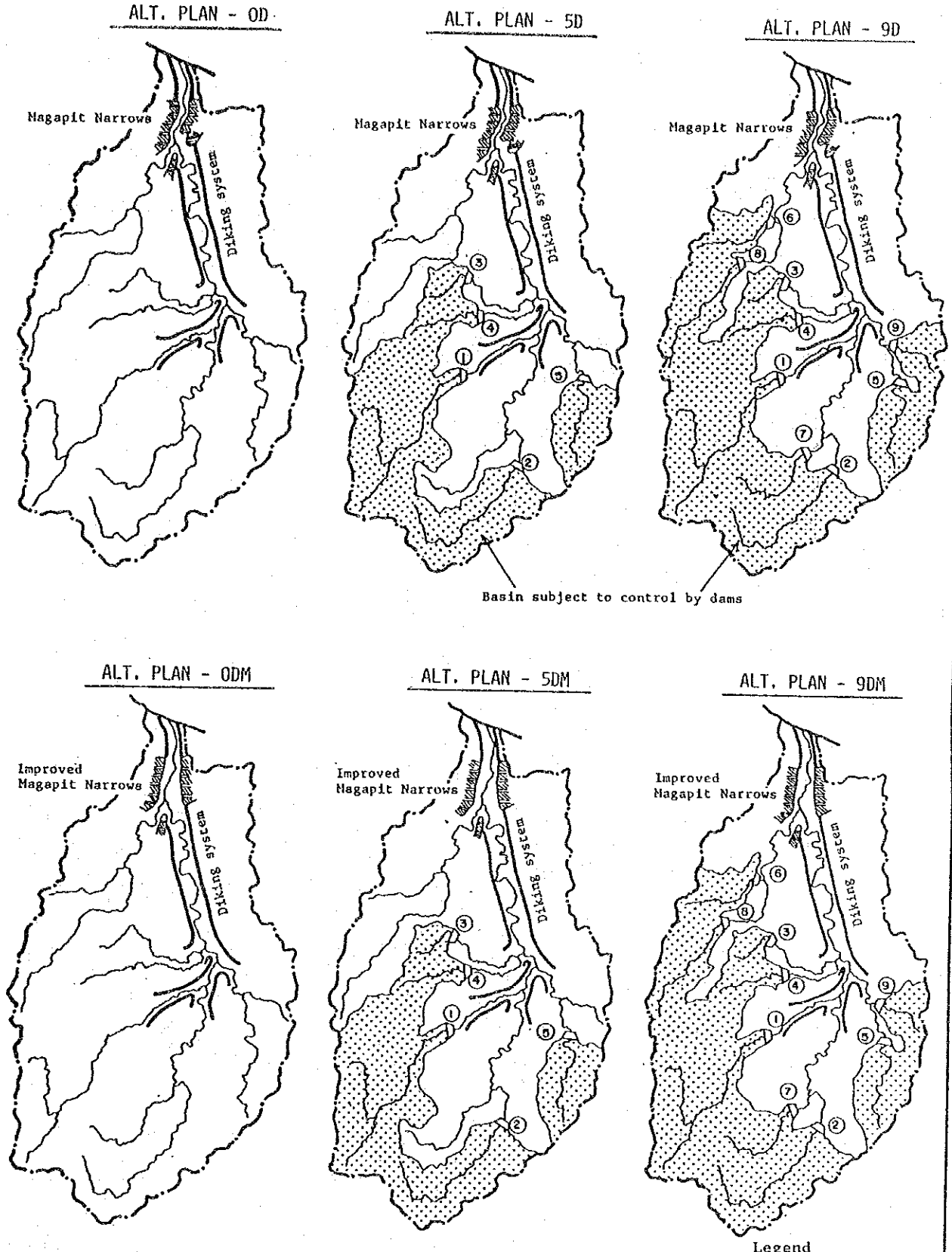


Fig. 3 ALTERNATIVE FLOOD CONTROL FRAMEWORK PLANS

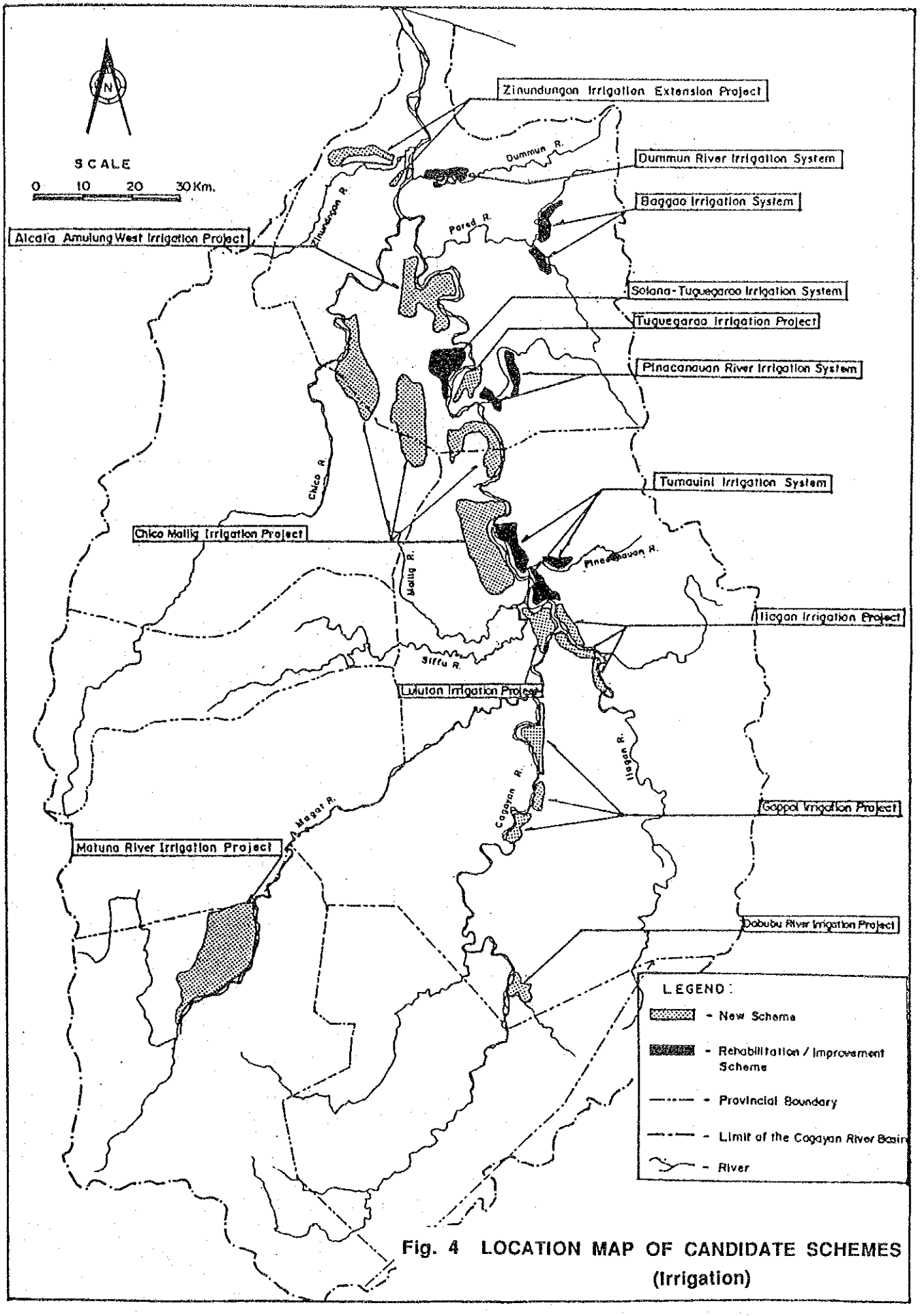
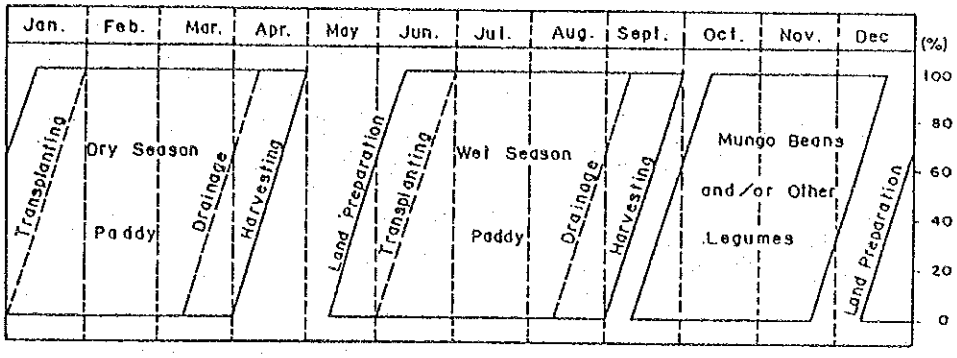
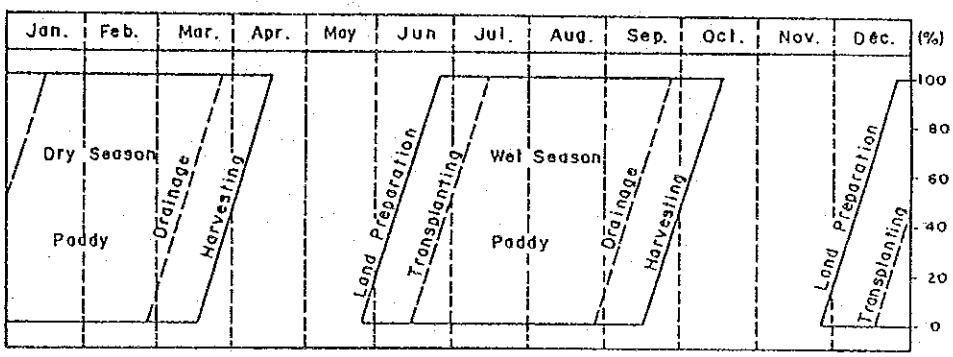


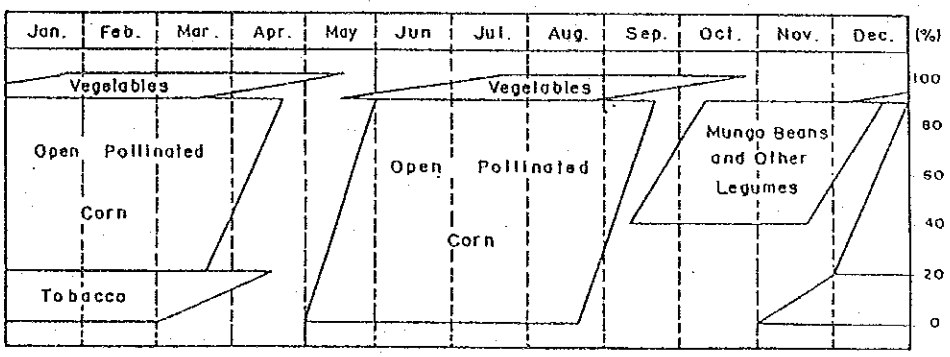
Fig. 4 LOCATION MAP OF CANDIDATE SCHEMES (Irrigation)



(1) PROPOSED CROPPING PATTERN (A) IN THE PADDY FIELD AREA



(2) PROPOSED CROPPING PATTERN (B) IN THE PADDY FIELD AREA



(3) PROPOSED CROPPING PATTERN (C) IN THE DIVERSIFIED CROP AREA

Fig. 5 PROPOSED CROPPING PATTERN

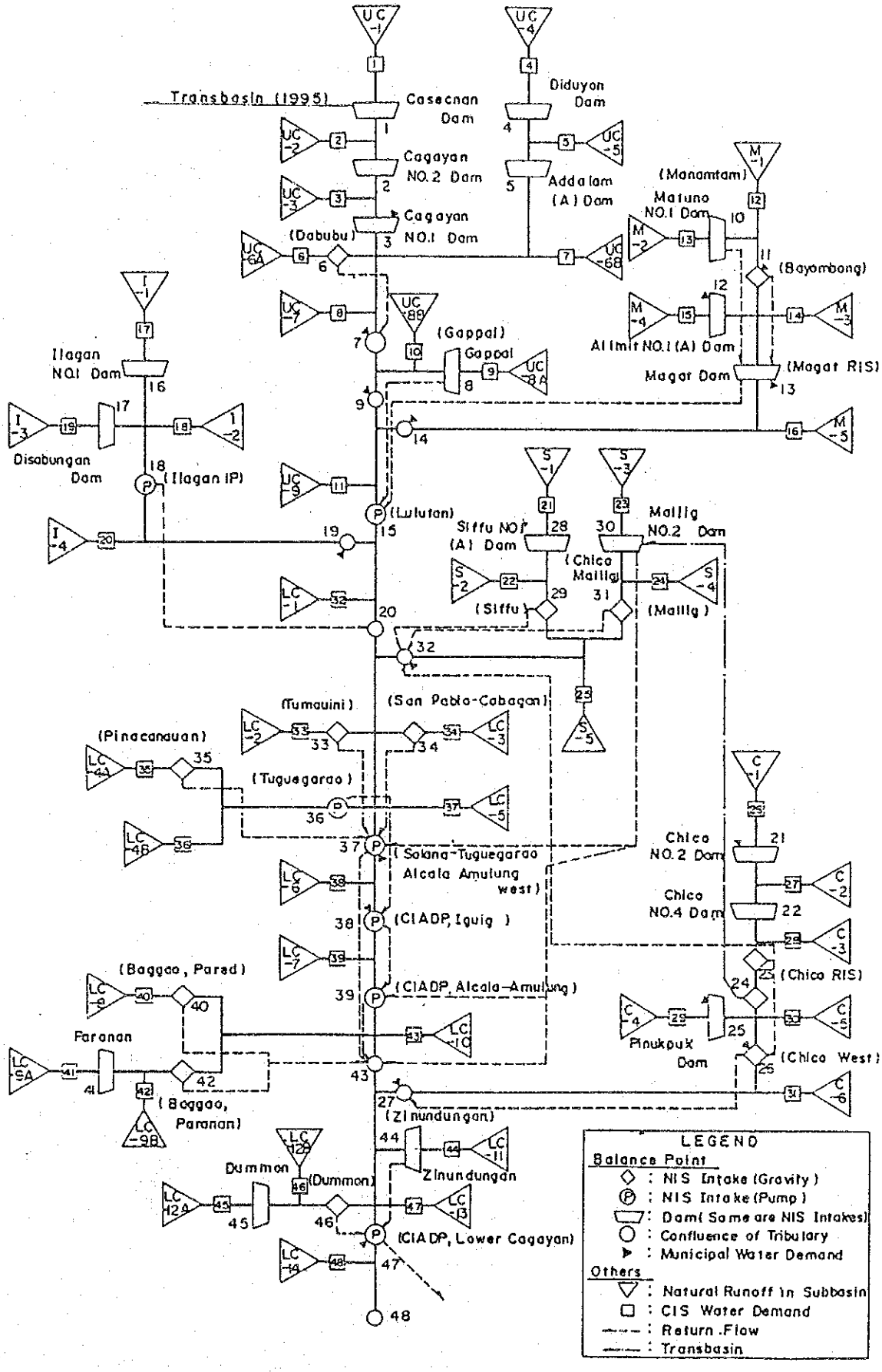


Fig. 6 BASIN MODEL FOR WATER BALANCE STUDY

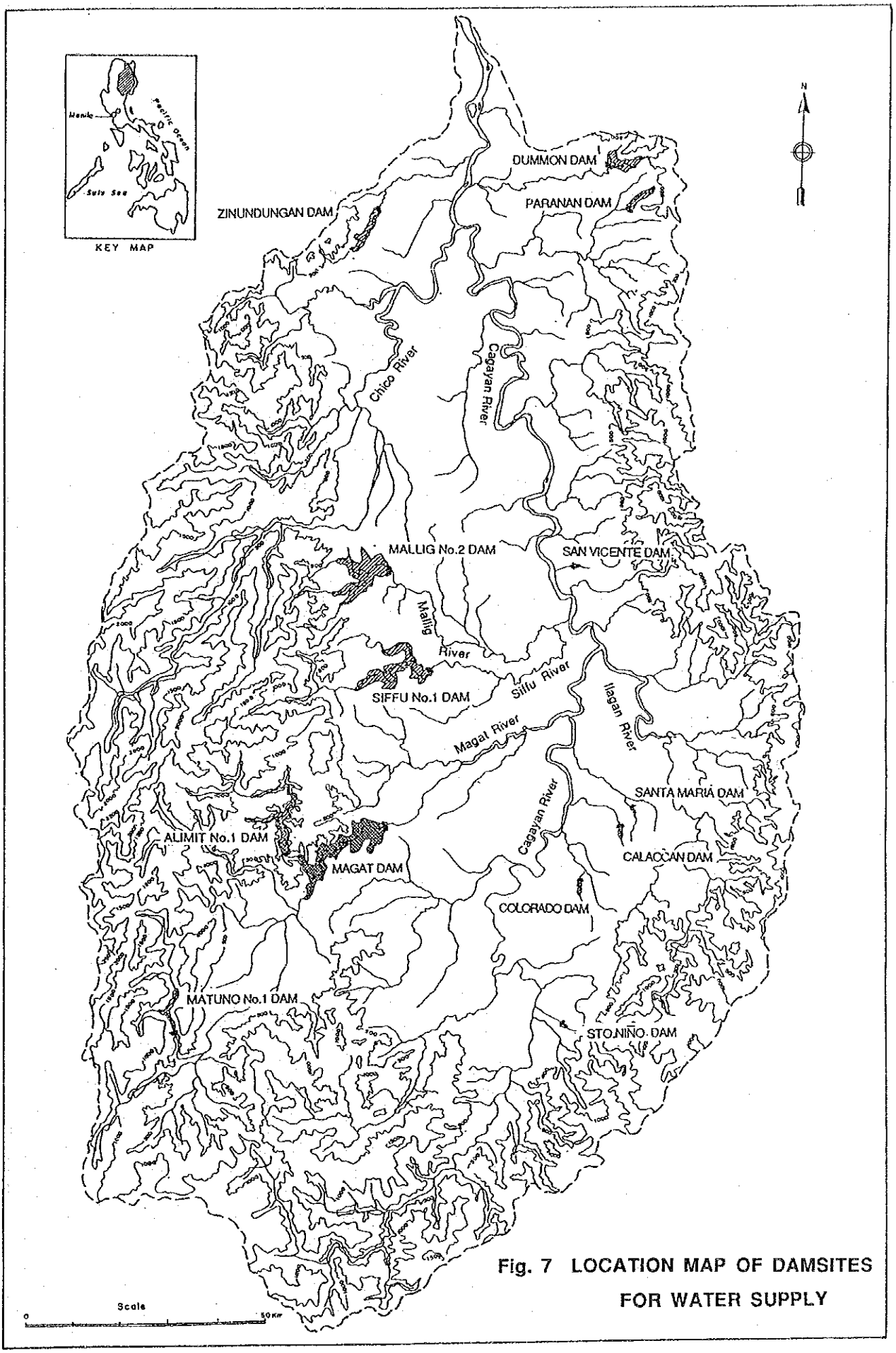


Fig. 7 LOCATION MAP OF DAMSITES FOR WATER SUPPLY

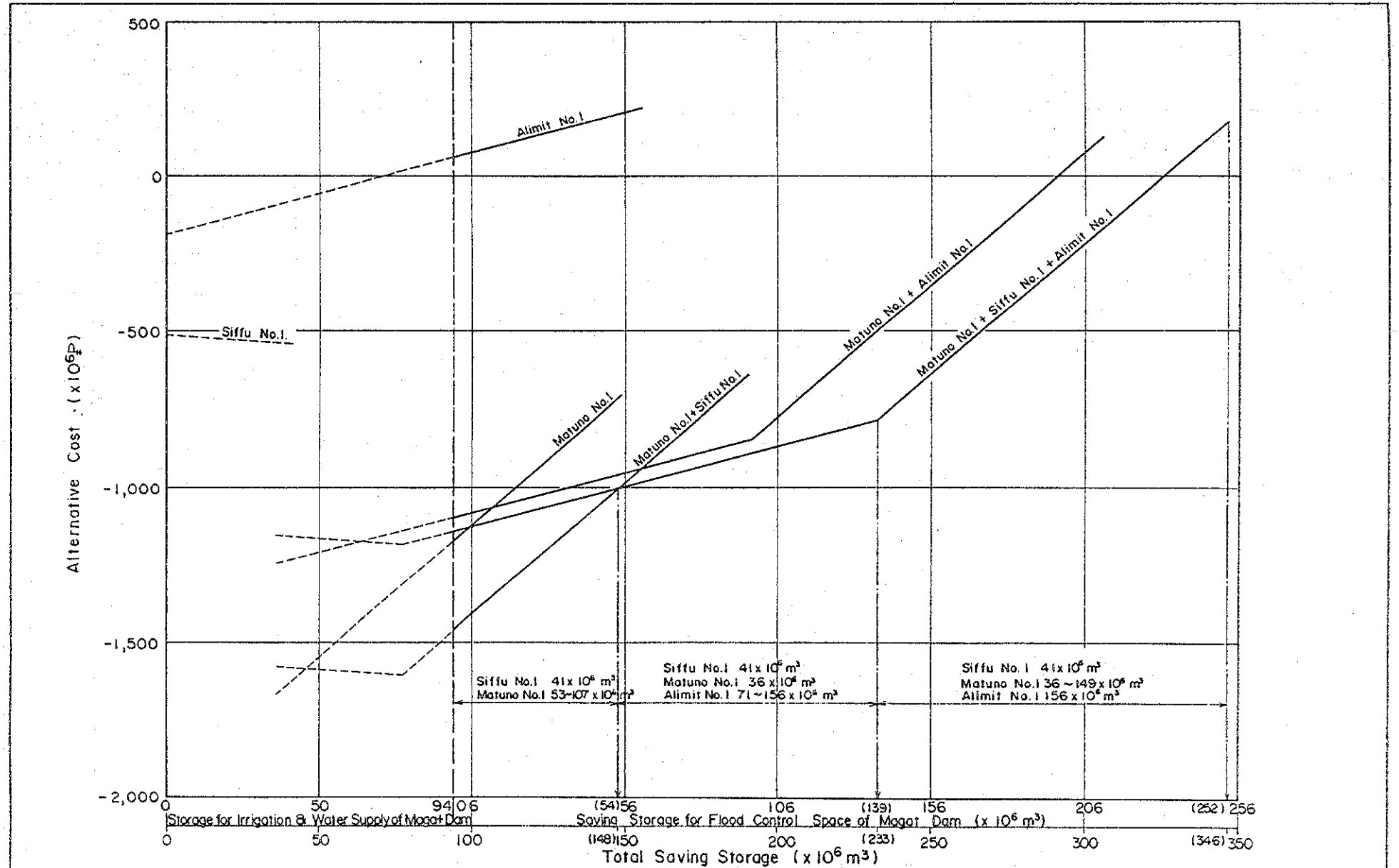
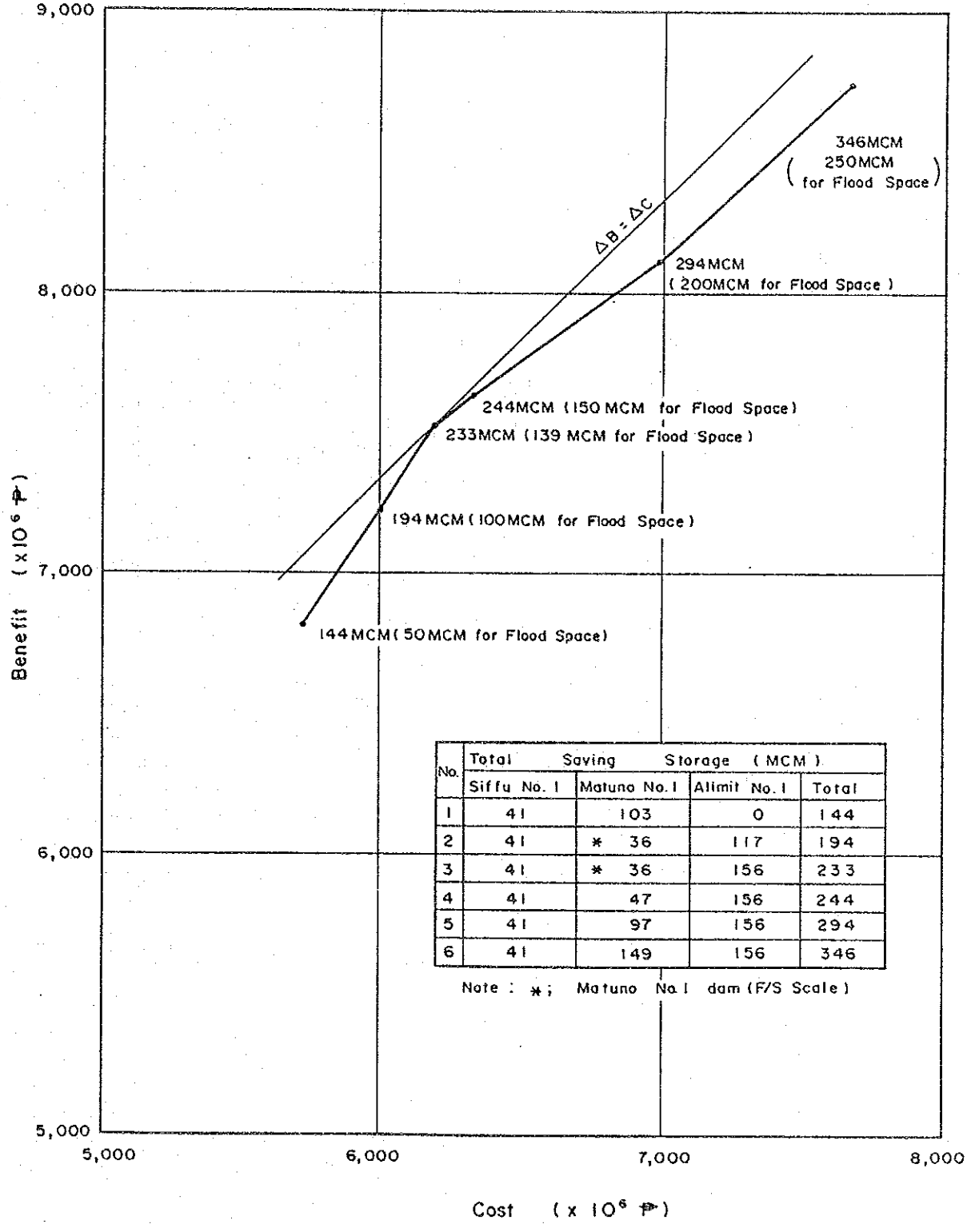


Fig. 8 LEAST COSTLY ALTERNATIVES



No.	Total Saving Storage (MCM)			
	Siffu No. 1	Matuno No. 1	Alimit No. 1	Total
1	41	103	0	144
2	41	* 36	117	194
3	41	* 36	156	233
4	41	47	156	244
5	41	97	156	294
6	41	149	156	346

Note : *; Matuno No. 1 dam (F/S Scale)

Fig. 9 BENEFITS AND COSTS FOR ALTERNATIVE SPACES OF MAGAT RESERVOIR

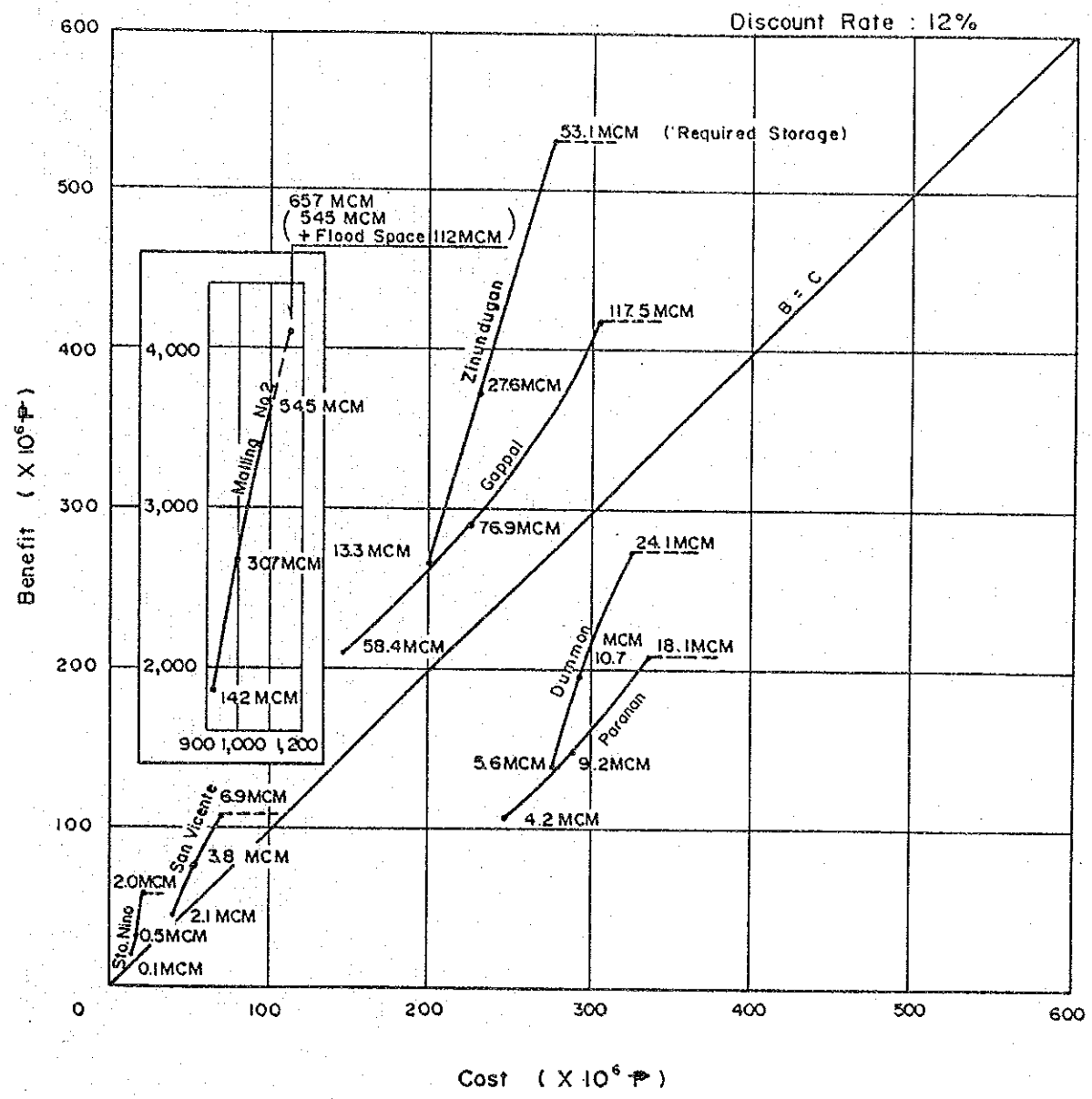


Fig. 10 BENEFITS AND COST FOR ALTERNATIVES

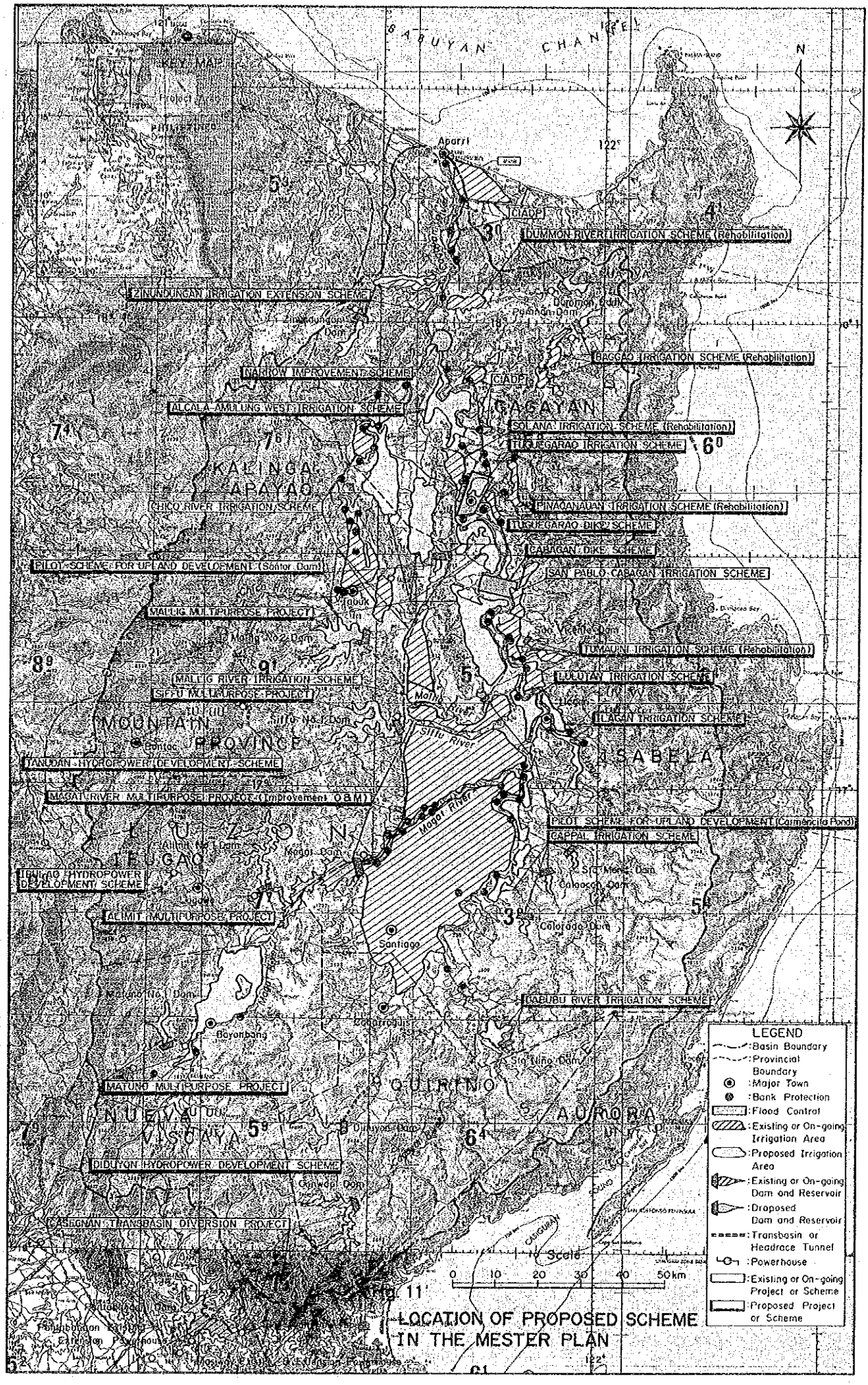


FIG. 11 LOCATION OF PROPOSED SCHEME IN THE MESTER PLAN

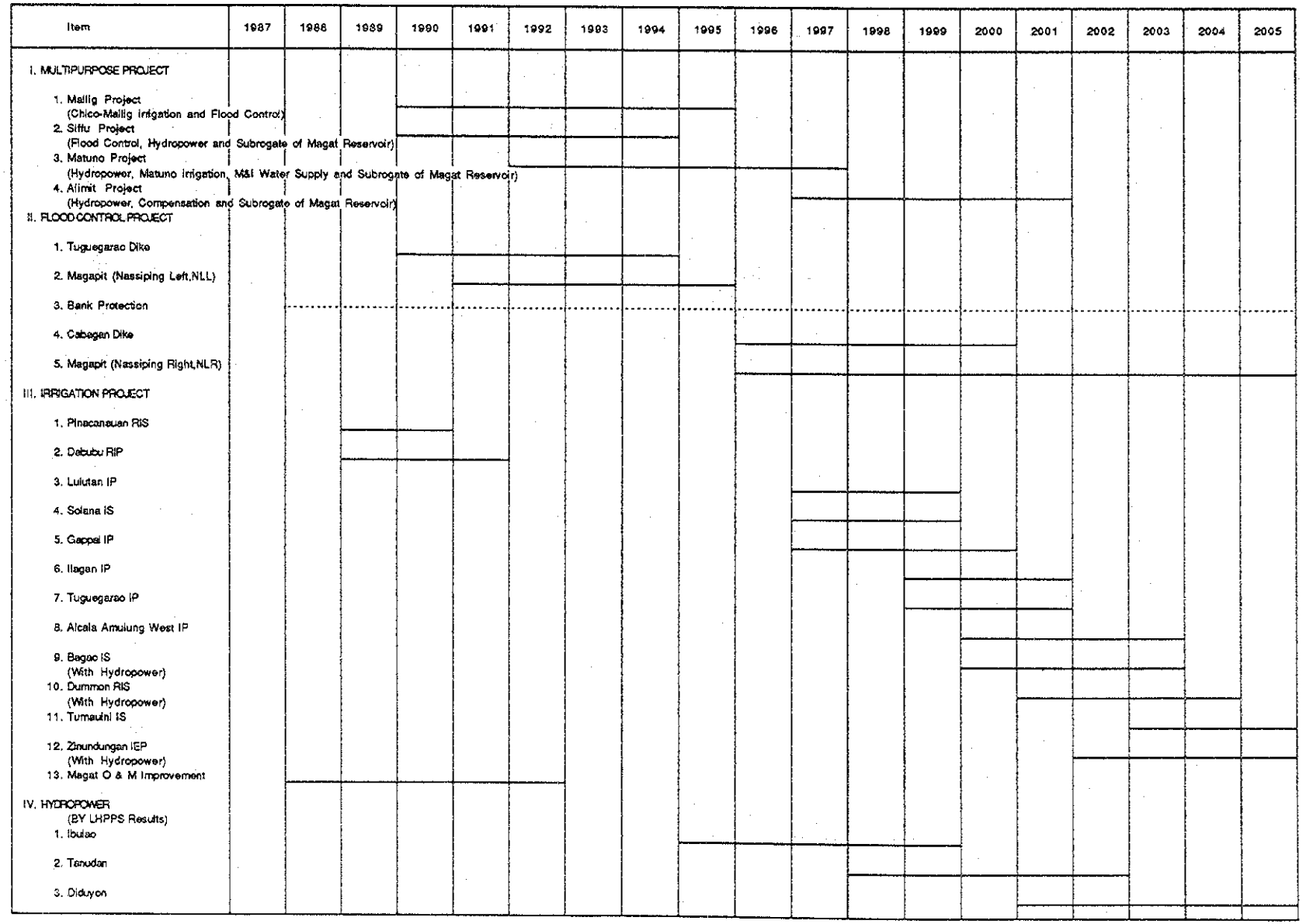


Fig. 12 IMPLEMENTATION SCHEDULE FOR MASTER PLAN

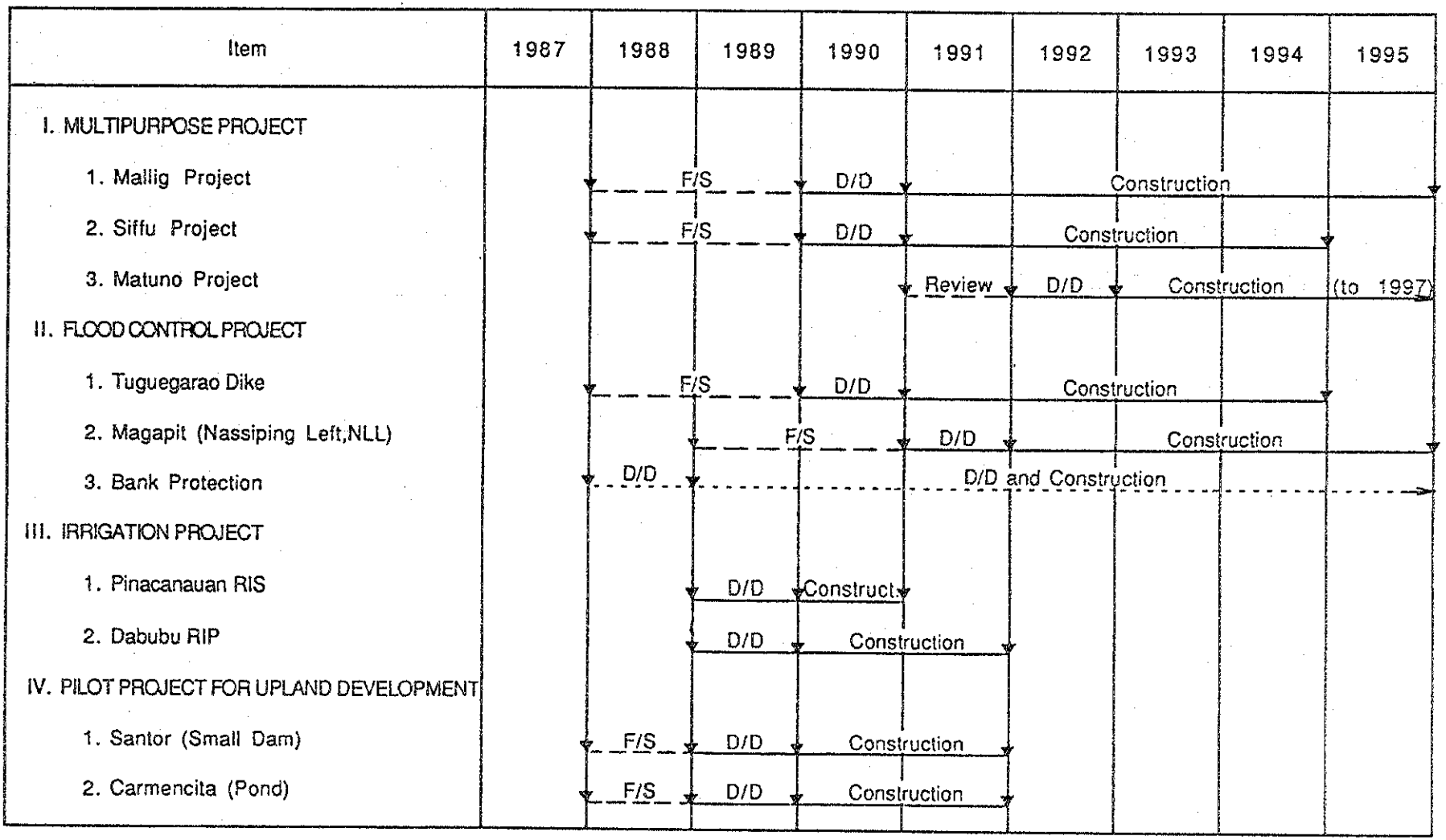


Fig. 13 IMPLEMENTATION SCHEDULE FOR SHORT TERM PLAN