REPUBLIC OF THE PHILIPPINES

THE FEASIBILITY STUDY
ON
THE IMPROVEMENT OF OPERATION AND MAINTENANCE
IN
PUMPING IRRIGATION SYSTEMS

MAIN TEXT

JANUARY, 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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Main Text

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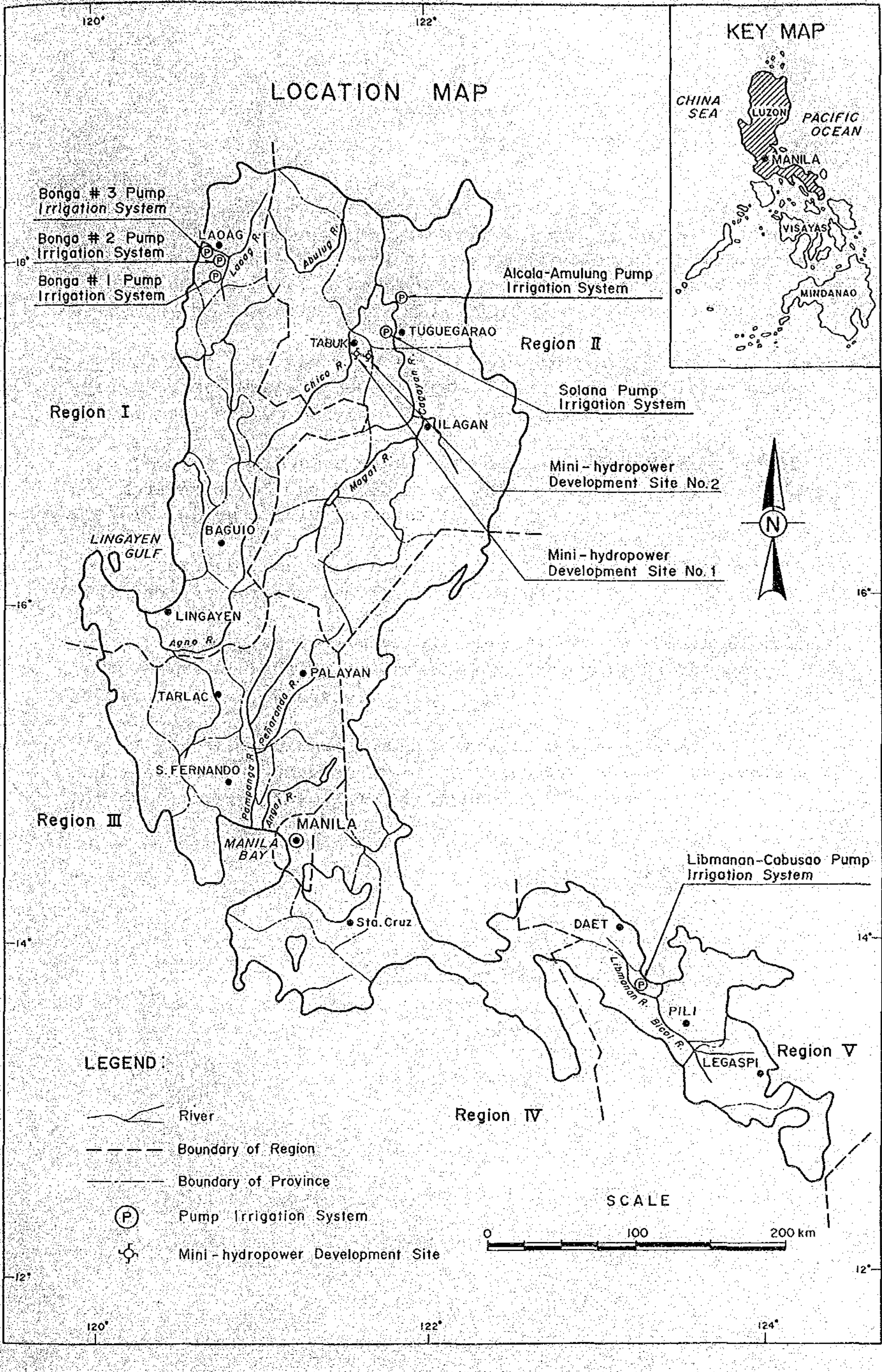

PREFACE

In response to a request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct a feasibility study on the Improvement of Operation and Maintenance in Pumping Irrigation Systems and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Republic of the Philippines a study team headed by Mr. Masashi SHONO, Nippon Koei Co., Ltd. three times in the period from August 1987 to August 1988.

The team exchanged views with the officials concerned of the Government of the Republic of the Philippines and conducted a field survey mainly in Luzon Island.

After the team returned to Japan, further studies were made and the present report was prepared.

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

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

January, 1989

Kensuke Yanagiya

Kensuke YANAGIYA
President
Japan International Cooperation Agency

SUMMARY

Conclusion

This final report of the feasibility study on the improvement of operation and maintenance of pumped irrigation systems in the Philippines was prepared by the JICA Study Team in accordance with the Implementing Arrangement for technical cooperation for the Study agreed upon the National Irrigation Administration and the Japan International Cooperation Agency dated February 19, 1987.

The main objectives of the Study were: (i) to formulate a development plan for the improvement of operation and maintenance of the National Pump Irrigation Systems geared towards increasing agricultural production and farmer's income, and (ii) to examine the technical and economic feasibility of the selected high priority projects including their financial justifiability.

In order to attain these objectives, investigations and preliminary studies for the following 12 national pump irrigation systems and 110 prospective sites for mini-hydropower development were made in order to select projects for feasibility study.

(1) Bonga Pump #1 Irrigation System
(2) Bonga Pump #2 Irrigation system
(3) Bonga Pump #3 Irrigation System
(4) Iguig, Alcala-Amulung Pump Irrigation system
(5) Solana Pump Irrigation System
(6) MARIIS (Pump #1, Pump #2 and Pump #3 Irrigation System)
(7) UPRIIS Penaranda Pump Irrigation System
(8) AMRIS (Bustos-Pandi, Buenavista and Tibagan Pumps Irrigation Systems)
(9) Cabuyao East Pump Irrigation System
(10) Santa Cruz River Irrigation System
(11) Santa Maria River Irrigation System
(12) Libmanan-Cabusao Pump Irrigation System, and
(13) 110 prospective sites for the mini-hydropower development

As a result the following 6 pump irrigation systems, and 2 prospective sites and a combination for the mini-hydropower development were selected.

(1) Bonga Pump #1 Irrigation System
(2) Bonga Pump #2 Irrigation System
(3) Bonga Pump #3 Irrigation System

(4) Alcala-Amulung Pump Irrigation System

(5) Solana Pump Irrigation System

(6) Libmanan-Cabusao Pump Irrigation System, and

(7) Site No.1 in the Tabuk Supply Canal No.1, and Site No.2 in the Chico Main Canal within the Chico River Irrigation System and a combination project of Sites No.1 and No.2

These irrigation systems were implemented in 1970's. However it has now become hard to operate and manage these systems efficiently. The irrigated areas have been significantly reduced in comparison with the original designed areas. The main reasons are considered to be as follows: (i) there were partial defects of design and construction of these systems, (ii) minor damages to the irrigation facilities caused by typhoon, accidents, and so on could not be immediately repaired and/or rehabilitated because of shortage of operation and maintenance funds due to low irrigation service fee collection efficiency. Under such circumstances these irrigation facilities have seriously deteriorated, (iii) proper supply of spare parts of the equipment could also not be carried out and (iv) the number of the trained O&M staff is insufficient in some systems. As a result the present problems and constraints on management of the selected pump irrigation systems may be summarized: (i) the financial status of the systems is marginal or is becoming worse and (ii) the farmer's economy of the beneficiary farmers in the systems remains at subsistence level.

The financial status of the systems has been seriously affected by rising operation and maintenance costs and a low collection efficiency of irrigation service fee. The rise in O&M costs results from (i) rising unit cost of electricity for pump operation, (ii) falling efficiency of pump facilities and (iii) falling overall irrigation efficiency due to deterioration of irrigation/drainage facilities and improper management of operation and maintenance. The efficiency rate and amount of irrigation service fee collection result from a complicated combination of (i) negative farmer's perception of NIA services caused by shortage of irrigation water supply, (ii) low payment capacity of farmers, and (iii) constraints on the fee collection method.

The subsistence farmer's poor economy is considered to be the result of low farm income due to (i) low unit yields of paddy, (ii) low cropping intensity and (iii) small farm size.

In order to solve the present problems and constraints on management of the pump irrigation systems, the approach to the project was formulated as follows:

(i) Cheaper electricity for pump operation will be obtained by direct purchase of electric power from NAPOCOR,

(ii) Raising the present efficiency of the pumps will be realized through improvement and/or replacement of pump facilities,

(iii) Irrigation efficiency will be improved through rehabilitation and/or improvement of the existing irrigation and drainage facilities,

(iv) Management of operation and maintenance will be improved by strengthening O&M and monitoring equipment, reinforcement of O&M staff in the systems and guidance/advice to the farmers, systematization/simplification of the recording system, improvement of communications and application of proper regulation/work schedules for O&M of the facilities,

(v) Increase of crop production will be realized by increasing cropping intensity and unit yields of crops through application of proper irrigation farming under adequate distribution of irrigation water, and

(vi) Crop diversification with higher profitability crops will be introduced into the systems to the extent that conditions of climate, soils and marketability of the crops permit.

Based on the approach to the project, the following development plans were formulated:

(i) Improvement plan of physical facilities such as pumps, power supply and irrigation/drainage facilities,

(ii) Improvement plan for system management including institutions, water distribution, monitoring system, maintenance rule, O&M equipment and training,

(iii) Farm management plan, and

(iv) Mini-hydropower development plan.

The development plans for the irrigation systems were formulated through studies of alternative plans taking into consideration (i) irrigation areas of the firmed-up service area and the maximum service area and (ii) electric power sources from NAPOCOR and the local electricity cooperatives. The firmed-up service area is defined as the area managed by the system office of NIA at present. The maximum service area is the maximum area capable of irrigation within the original design area in terms of topographical constraints.

As a result of the studies, the development for the irrigation systems is determined at the maximum service area under direct electric power from NAPOCOR as follows:

Name of System	Area (ha)
Bonga Pump #1 Irrigation System	426
Bonga Pump #2 Irrigation System	674
Bonga Pump #3 Irrigation System	202
Alcala-Amulung Pump Irrigation System	2,158
Solana Pump Irrigation System	1,960
Libmanan-Cabusao Pump Irrigation System	3,085

The basic concept of the improvement plan for pump facilities is to meet the proposed diversion water requirement and to maximize pump efficiency by means of replacement or rehabilitation of pump facilities.

Electric power supply is planned to depend on sources from NAPOCOR through either installation of NIA's own substation and transmission line or the existing local electricity cooperative's transmission line with an additional substation to be installed adjoining to cooperative's one.

With respect to rehabilitation and improvement of irrigation/drainage facilities, the general concept is to restore the capacity and functions of the facilities in all the systems to meet the proposed design discharge.

The principal physical works proposed are summarized below:

Items	Bonga Pump #1	Bonga Pump #2	Bonga Pump #3	Alcala-Amulung	Solana	Libmanan-Cabusao
1. Pump (nos.)	2	3	2	0	4	0
2. Elect. equipment (nos.)	2	3	2	0	4	4
3. Transmission line (km)	-	-	8.8	0	0.2	0
4. Substation (nos.)	1*	1*	1*	0	1	1
5. Enlargement of canal (km)	5.4	6.2	4.0	27.8	16.5	32.4
6. Improvement structures (nos.)						
turnout	31	24	41	6	38	45
headgate/checkgate	2	0	0	0	2	7
7. Drainage (km)						
embankment	0	0	0	12.7	18.5	44.6
new construction	9.0	14.6	4.5	1.1	0	0
8. Road (km)						
new construction	0.8	0	1.0	0	0	10.4
resurfacing	2.4	0	0	0	0	6.3
9. On-farm facilities (km)						
farm ditches	12.9	18.6	0	31.3	92.0	20.9
farm drains	28.8	47.2	14.1	133.7	176.3	171.6

*: shared by Bonga Pump #1, #2 and #3

The organizational structure of the present NIA system offices and the irrigator's association is simple. As no structural problems were observed, the present simple organizational structures of the system offices and the irrigator's association would not require any change in the future.

The work load of O&M staff is different among the system offices. The institutional plan for the system offices was formulated to allocate the optimum number of O&M staff to the offices. The proposed number of O&M staff is shown below:

Name of System	WM	DT	PO
Bonga Pump #1 Irrigation System	1	-	1
Bonga Pump #2 Irrigation System	1	-	1
Bonga Pump #3 Irrigation System	1	-	1
Alcala-Amulung Pump Irrigation System	2	6(-1)	2
Solana Pump Irrigation System	-	-	-
Libmanan-Cabusao Pump Irrigation System	3(+1)	11(+11)	1

WM: Watermaster, DT: Ditchtender, PO: Pump Operator
Plus or minus figures in parentheses indicate increased or decreased number of O&M staff in comparison with the present number of O&M staff in the system offices.

The basic concepts for formulating water distribution are: (i) To secure even water distribution throughout the service area, (ii) To avoid complicated gate adjustment as much as possible. In other words, to eliminate the factor of time lag as much as possible in discharge control at the gates, and (iii) To minimize the increase in flow capacity of the existing irrigation facilities.

The rotational distribution was set up based on the present constraints in water distribution, the basic concepts for water distribution, advantages and disadvantages in different methods of water distribution, and the anticipated capacity of watermasters and ditchtenders in water distribution.

The proposed rotational distribution is a combination of "rotation by section in the main canal or by lateral(s)" and "rotation by section or a group of turnouts in the laterals or sub-laterals".

The proposed numbers of rotation blocks for each system are as follows:

Name of System	Number of Rotation Blocks
Bonga Pump #1 Irrigation System	2
Bonga Pump #2 Irrigation System	3
Bonga Pump #3 Irrigation System	2
Alcala-Amulung Pump Irrigation System	3
Solana Pump Irrigation System	3
Libmanan-Cabusao Pump Irrigationn System	2

The annual irrigation schedule would be prepared by each system office or the irrigator's association in collaboration with each other. Prior to the commencement of every cropping, the annual irrigation schedule would be reviewed and confirmed for the programmed area in due consideration of the physical condition of the irrigation facilities and beneficiary farmer's intention.

The operation plan will consist of a seasonal plan and weekly plan. The weekly plan would cover the number of units of pumps to be operated and daily operating hours and gate operation schedule. Control of the irrigation water would be made by conventional method. The operation of irrigation water delivery will be done weekly. The proposed irrigation suspension schedule is as follows:

Previous Day Rainfall Range	Period of Suspension of Irrigation
below 7 mm	0 day
8 - 15 mm	1 day
16 - 23 mm	2 days
24 - 30 mm	3 days
31 - 38 mm	4 days
39 - 46 mm	5 days
above 47 mm	6 days

Meteo-hydrological measurements covering rainfall, irrigation discharge and river water level at the pump sites are essential. For this purpose one rain gage and one staff gage were planned to be installed at each pump station and at the head of lateral/sub-lateral canals. Monitoring of irrigated area, harvested area and lots with crop failure will be carried out systematically through the field inspection by O&M staff.

Communication within the system office or the irrigator's association will be performed by the present ordinary means such as meetings, official memorandum circulars and bulletin board because the organization of each system office and irrigator's association is simple.

Cleaning canals and daily maintenance of the pump equipment will be daily executed, while desilting of intake site, inlet channel and canals, reforming of canal section, resurfacing of service roads, repainting and greasing metalworks will be conducted during the irrigation cut-off period. Regular maintenance work on daily, weekly, monthly and yearly bases would be required for pumping facilities. To increase workability of the O&M equipment, preventative maintenance would be established through conducting regular maintenance by mechanics of the NIA Regional office. The plan for O&M equipment reinforcement was formulated for effective operation and maintenance of the systems. The appropriate number and kind of O&M equipment were determined from the standpoint of operation efficiency, ease of operation and low operation cost taking account of the width of canals and service roads, the locations of pump stations. In addition reinforcement of spareparts for elements of the existing and newly purchased equipment was planned for increasing their workability.

In the framework of reinforcing institutional aspects, quality improvement of O&M staff and farmers in the systems is one of the most important factors to improve management of the irrigation systems. For this purpose the O&M training programmes were planned to expand the knowledge, understanding and practical ability of O&M staff and farmers. In the programmes appropriate training methods, training modules, materials and training curricula were planned to be used. The training programmes will be undertaken during the first year of the implementation period. The proposed numbers of trainers and trainees in O&M staff training and farmer's training are summarized below:

Name of System	O&M Staff's Training Trainee WM	DT	PO	Trainer	Farmers' Training Trainee	Trainer
Bonga Pump #1 Irrigation System	1	0	1	2	451	15
Bonga Pump #2 Irrigation System	1	0	1	2	530	18
Bonga Pump #3 Irrigation System	1	0	1	2	22	1
Alcala-Amulung Pump Irr. System	2	6	2	3	643	22
Solana Pump Irrigation System	-	-	-	-	438	15
Libmanan-Cabusao Pump Irr. System	3	11	1	3	370	13

WM: watermaster, DT: ditchtender, PO: pump operator

The basic concept of farm management for the pump systems is to increase the farm income through full utilization of land and water resources for increase of agricultural production. Considering the above basic concept, the strategies of farm management plan for the pump systems were worked out on the following basis: (i) The unit yield and production of crops should be increased and stabilized through introduction of improved irrigated farming, and (ii) The year-round irrigation area should be expanded as much as possible and thereby the cropping intensity be increased.

The cropping pattern for each irrigation system was examined from the standpoint of climatic conditions, marketability of crops, farmer's experience and intention, profitability of crops, etc. Paddy was selected as the main crop for the proposed cropping pattern of all pump systems. In addition to paddy, garlic and tomato were selected as diversified crops only for the Bonga #1, #2 and #3 pump irrigation systems.

After implementation of the project, crop yield per ha will be expected to attain 4.5 tons of paddy in wet season, 5.0 tons of paddy in dry season, 4.5 tons of garlic and 10 tons of tomato. The anticipated production of crops in each irrigation system will be expected in the full development stage as follows:

(Unit: ton)

Crops	Bonga #1	Bonga #2	Bonga #3	Alcala-Amulung	Solana	Libmanan-Cabusao
Rice	3,550	5,350	1,580	20,500	18,620	29,310
Garlic	45	180	68	-	-	-
Tomato	900	950	250	-	-	-

In the circumstances, a significant increase in farm income can be expected for the farmers in the irrigation systems.

The basic concept of the mini-hydropower development projects is (i) to generate economic electric power and (ii) to sell all the electric power generated to NAPOCOR through the existing Tabuk sub-station.

The mini-hydropower development plans were studied for site No.1 and site No.2 and a combination of site No.1 and site No.2. The combination plan has the merit that the substation can be jointly used and shows the highest economic viability and financial justifiability.

The optimum scale of the mini-hydropower plant was decided at 700 kW for site No.1 and 770 kW for site No.2 through the comparative study of the least construction cost per kWh.

The electric power generated by the mini-hydropower plant at No.1 and No.2 sites was planned to be sent to the existing Tabuk sub-station via 13.8 kV transmission line to be newly installed. Then the transmitted electricity is planned to be connected with 69 kV bus of the existing switchgear from where electricity can be consumed in the service area of CAGELCO and Tuguegarao through NAPOCOR's 69 kV transmission line.

The main features of the mini-hydropower plant of the combination plan are summarized below:

Features	Site No.1	Site No.2
Maximum discharge (m^3/sec)	4	12
Effective height of drop (m)	22.10	8.55
Expected output (kW)	700	770
Annual possible power Generation (MWh)	4,500	5,060
Water turbine		
type	HF-1RS*	HF-1RS*
output (kW)	736	845
Generator		
type	SG	SG
output (kW)	700	770
output (kVA)	778	855
Transformer (common use)		
rated capacity (kVA)	1,600	
rated voltage (1st) (kV)	13.8	
rated voltage (2nd) (kV)	69	
Transmission line (km)	18.5	

*: Horizontal shaft Francis type one runner

Implementation of the projects will be administrated by NIA. It will be responsible for design, construction works and supervision of the projects. A special project group will be organized under the Assistant Administrator for Systems Operation and Equipment Management, who will be responsible for execution of overall project works, and will undertake coordination between relevant government agencies in connection with implementation of the projects. No new project execution office will be established in the field, but the relevant Regional Irrigation Offices will act as field offices.

The project works including detailed design and preparatory works for each of the irrigation systems and the mini-hydropower development were planned to be implemented over 3 years from 1990 to 1992 and 2 years 1990 to 1991, respectively.

The project cost, the annual O&M cost and fund requirement of each of the irrigation systems and the mini-hydropower development project were estimated as follows:

(Unit: 10^3 peso)

Project	Project Cost	Annual O&M Cost	Fund Requirement
Irrigation System			
Bonga Pump #1 Irrigation System	25,288	812	30,438
Bonga Pump #2 Irrigation System	30,874	1,061	36,868
Bonga Pump #3 Irrigation System	14,375	434	17,215
Alcala-Amulung Pump Irrigation System	30,100	4,944	38,285
Solana Pump Irrigation System	76,627	3,953	93,363
Libmanan-Cabusao Irrigation System	63,596	3,016	78,736
Mini-Hydropower			
Combination	110,166	1,659	128,184

The total benefits to be expected from the projects at the full stage are expected as follows:

(Unit: 10^3 peso)

Project	Benefit
Irrigation System	
Bonga Pump #1 Irrigation System	8,503
Bonga Pump #2 Irrigation System	12,589
Bonga Pump #3 Irrigatin System	3,811
Alcala-Amulung Pump Irrigation System	42,972
Solana Pump Irrigation System	38,784
Libmanan-Cabusao Pump Irrigation System	59,209
Mini-Hydropower	
Combination	17,325

The internal rate of return (EIRR) of the projects was evaluated assuming that useful life is 50 years for the irrigation systems and 35 years for the mini-hydropower development as follows:

Project	EIRR (%)
Irrigation System	
Bonga Pump #1 Irrigation System	19.4
Bonga Pump #2 Irrigation System	22.2
Bonga Pump #3 Irrigation System	15.6
Alcala-Amulung Pump Irrigation System	33.7
Solana Pump Irrigation System	27.4
Libmanan-Cabusao Pump Irrigation System	39.5
Mini-Hydropower	
Combination	14.0

The sensitivity analysis for possible adverse changes in the future indicates that the economic viability of the projects is rather insensitive.

Financial evaluation of the projects was made by analysis of farm budget, financial status of the systems and repayment of the project cost.

Net reserve or capacity to pay was recognized as the ability of the beneficiary farmers to bear present irrigation service fee. Net farm incomes of the average farm under with project condition will be expected to increase 2 to 4.5 times that of farmers under without project condition. The increased net reserves will offer incentives to farmers in the irrigation systems. However the present high irrigation service fee still burden the small scale farmer's economy with heavy production costs.

After the completion of the irrigation systems, the annual operation and maintenance cost for the systems is expected to decline. Financial status of the systems is expected to be much improved as shown below:

(Unit: 10^3 peso)

	Revenue*	Outgoings**	Balance
Bonga Pump #1 Irrigation System	1,491	812	679
Bonga Pump #2 Irrigation System	2,359	1,061	1,298
Bonga Pump #3 Irrigation System	707	434	273
Alcala-Amulung Pump Irrigation System	5,665	4,944	721
Solana Pump Irrigation System	9,604	3,953	5,651
Libmanan-Cabusao Pump Irrigation System	6,479	3,016	3,463

*: The revenue was estimated based on the present irrigation service fee rate under 100% of a collection efficiency.
**: The outgoings are the annual operation and maintenance cost.

The repayment capacity for the capital cost of the projects was examined by preparing a cash flow statement under soft loan conditions. The cash flow statements for the irrigation systems indicate that the repayment of the capital project cost will not be realized without subsidy. In case of the mini-hydropower development, the capital project cost will be able to be repayed.

In addition to direct benefit counted in the economic evaluation, various secondary and intangible benefit and/or favourable socio-economic impact, are expected from the implementation of the projects. These are; (i) increase of employment opportunity, (ii) increase of production of agricultural crops (iii) increase of farmer's income and upgrading living standard, and (iv) improvement of local transportation and so on.

Recommendation

The projects of the irrigation systems and the mini-hydropower development are technically sound and economically feasible. Furthermore, the projects will provide substantial and sustainable socio-economic benefits not only to the project areas but also to region and nation as a whole. Thus it is recommended that all the projects be implemented as early as possible.

PRINCIPAL FEATURES OF THE PROJECTS

1. Irrigation

	Bonga #1	Bonga #2	Bonga #3	Alcala-Amulung	Solana	Libmanan-Cabusao
Project Features						
1. Irrigation service area (ha)	426	674	202	2,158	1,960	3,085
2. Cropping pattern	P/P,P/D,S	P/P,P/D,S	P/P,P/D,S	P/P	P/P	P/P
3. Replacement of pump facilities						
- pump unit (nos)	2	3	2	0	4	0
- pump unit capacity (m^3/sec)	35.1	37.0	15.9	–	82.1	–
4. Power supply system						
- system	T*	T*	T*	**	NIA	T*
- sub-station (kVA)	5,000			**	1,750	5,000
- transmission line (km)	8.8*			**	0.2	–
5. Rehabilitation and new construction of irrigation/drainage facilities						
- irrigation canal (km)	5.4	6.2	4.0	27.8	16.5	32.4
- turnout (nos)	33	24	41	13	63	54
- gate (nos)	2	0	0	0	2	7
- drainage canal (km)	9.0	14.6	4.5	13.8	18.5	44.6
- service road (km)	3.2	0	1.0	0	0	16.7
- farm ditch/drain (km)	41.7	65.8	14.1	165.0	268.3	192.5
6. Implementation period (year)	3	3	3	3	3	3
Project Cost, Benefit and Evaluation						
1. Project cost (10^3 Peso)	25,288	30,874	14,375	30,100	76,627	63,596
- foreign currency portion	20,213	25,863	12,047	15,438	57,221	42,571
- local currency portion	5,075	5,011	2,328	14,662	19,406	21,025
2. Fund requirement (10^3 Peso)	30,438	36,868	17,215	38,285	93,363	78,736
- foreign currency portion	23,424	29,939	13,962	18,097	66,439	49,624
- local currency portion	7,014	6,929	3,253	20,188	26,924	29,112
3. Annual operation and maintenance cost						
- annual O&M cost (10^3 Peso)	812	1,061	434	4,944	3,953	3,016
- O&M cost per ha (Peso)	1,906	1,574	2,149	2,291	2,017	978
4. Economic cost (10^3 Peso)	24,005	29,607	13,786	26,391	71,717	58,277
5. Annual economic benefit (10^3 Peso)	8,503	12,589	3,811	42,972	38,784	59,206
6. Internal rate of return (%)	19.4	22.2	15.6	33.7	27.4	39.5

Remarks: P/P = paddy/paddy, P/D = paddy/diversified crops, S = sugarcane, T = tripartite
* = power supply system would be shared by the Bonga #1, #2 and #3
** = power for the Alcala-Amulung pump station is being directly supplied from NAPOCOR

2. Mini-hydropower Development

	Site No.1	Site No. 2
Project Features		
1. Maximum discharge (m^3/sec)	4	12
2. Effective height of drop (m)	22.10	8.55
3. Expected output (kW)	700	770
4. Annual possible power generation (MWh)	4,500	5,062
5. Water turbine		
- nos	1	1
- type	HF-1RS*	HF-1RS*
- output (kWh)	736	845
6. Generator		
- nos	1	1
- output (kW)	700	770
- output (kVA)	778	855
7. Transformer (Common use)		
- rated capacity (kVA)	1,600	
- rated voltage 1st (kV)	13.8	
- rated voltage 2nd (kV)	69	
8. Transmission line (km)	18.5	
9. Implementation period (year)	2	
Project Cost, Benefit and Evaluation		
1. Project cost (10^3 Peso)	110,166	
- foreign currency portion	77,980	
- local currency portion	32,186	
2. Fund requirement (10^3 Peso)	128,184	
- foreign currency portion	87,675	
- local currency portion	40,509	
3. Annual operation and maintenance cost	1,652	
4. Economic cost (10^3 Peso)	102,021	
5. Annual economic benefit (10^3 Peso)	17,325	
6. Internal rate of return (%)	14.0	

* Horizontal shift Francis type one runner

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ABBREVIATIONS

(1) Organization

INECO	Ilocos Norte Electric Cooperative Inc.
CAGELCO	Cagayan Electric Cooperative Inc.
NAPOCOR	National Power Corporation
NEB.ELEC COOP	Nueva Ecija Electric Cooperative Inc.
FLELCO	First Laguna Electric Cooperative Inc.
CA.SUR.ELEC.COOP	Camarines Sur 1 Electric Cooperative Inc.
MARIIS	Magat River Integrated Irrigation System
AMRIS	Angat-Maasim River Irrigation System
UPRIIS	Upper Pampanga River Integrated Irrigation System
LFLIS	Laguna Friar Lands Irrigation Systems
LBDP	Laguna de Bay Development Project
CIADP	Cagayan Integrated Agricultural Development Project
LCISC	Libmanan Cabusao Irrigators Service Cooperative
NIA	National Irrigation Administration
IBRD	International Bank for Reconstruction and Development
IRRI	International Rice Research Institute
JICA	Japan International Cooperation Agency

(2) Others

DGP	Gross Domestic Product
IRR	Economic Internal Rate of Return
NPIS	National Pump Irrigation System
O&M	Operation and Maintenance
WM	Watermaster
DT	Ditchtender
PO	Pump Operator
RF	Rainfed
IL	Irrigated Land
Y	Japanese Yen
US$	US dollar

(3) Measurement

Length

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

Area

cm^2 = square centimeter
m^2 = square meter
ha = hectare
km^2 = square kilometer

Volume

cm^3 = cubic centimeter
l = liter
kl = kiloliter
m^3 = cubic meter
MCM = million cubic meter

Weight

mg = milligram
g = gram
kg = kilogram
ton = metric ton

Electrical Measures

V = Volt
A = Ampere
Hz = Hertz (cycle)
W = Watt
kW = Kilowatt
MW = Megawatt
GW = Gigawatt

Other Measures

% = percent
m^3/s = cubic meter per second
kWh = Kilowatt hour
MWh = Megawatt hour
kVA = Kilovolt ampere

CHAPTER 1

GENERAL

1.1 Authority to Report

This Final Report of the feasibility study on Improvement of Operation and Maintenance in Pumping Irrigation Systems in the Philippines (hereinafter called the Study) was prepared by the JICA Study Team in accordance with the Implementing Arrangement for technical cooperation for the Study agreed upon between the National Irrigation Administration (NIA) and the Japan International Cooperation Agency (JICA) dated February 19, 1987.

The report comprises this MAIN TEXT and nine ANNEXES.

1.2 Objective of the Study

The main objectives of the Study were as follows:

(1) to formulate a development plan for the improvement of operation and maintenance of the National Pump Irrigation Systems geared toward increasing the agricultural production and farmers' income, and

(2) to examine the technical and economic feasibility of the selected high priority projects including their financial justifiability.

In order to attain these objectives, the Study was carried out in two stages. Stage I was commenced in July 1987. The inception meeting was held on August 4, 1987 between the JICA Study Team and the NIA, and the content of the inception report was mutually agreed. Based on the inception report, the JICA Study Team commenced investigations and preliminary studies for 12 national pump irrigation systems and 110 prospective sites of the mini-hydropower development. Then 6 pump irrigation systems were selected and mutually agreed between the JICA Study Team and the NIA in the meeting held on February 22, 1988. With regard to the mini-hydropower development, 2 sites and a combination of 2 sites were determined after more detailed studies at the end of March 1988.

The JICA Study Team next conducted a feasibility study for the six selected irrigation systems and two selected mini-hydropower development sites and one combination project of two selected sites from July 1988 to October 1988.

During the Study period, the JICA Study Team submitted to NIA the following reports:

Inception Report	4 August 1987
Field Report I	10 November 1987
Explanatory Note	22 February 1988
Interim Report	March 1988
Field Report II	29 August 1988
Draft Final Report	November 1988
Final Report	December 1988

1.3 The Study Area and Selection of High Priority Projects

The Study covered all the national pump irrigation systems throughout the country with the exception of the groundwater irrigation systems. All prospective sites of the mini-hydropower development within the national irrigation systems were included in the Study area.

In conclusion the Study area was delineated as follows:

(1) Bonga Pump #1 Irrigation System

(2) Bonga Pump #2 Irrigation System

(3) Bonga Pump #3 Irrigation System

(4) Iguig, Alcala-Amulung Pump Irrigation System

(5) Solana Pump Irrigation System

(6) MARIIS (Pump #1, Pump #2 and Pump #3 Irrigation System)

(7) UPRIIS Penaranda Pump Irrigation System

(8) AMRIS (Bustos-Pandi, Buenavista and Tibagan Pumps Irrigation Systems)

(9) Cabuyao East Pump Irrigation System

(10) Santa Cruz River Irrigation System

(11) Santa Maria River Irrigation System

(12) Libmanan-Cabusao Pump Irrigation System, and

(13) 110 prospective sites for the mini-hydropower development

For these irrigation systems and the mini-hydropower sites, studies were undertaken in Stage I to select projects for the feasibility study. Details are explained in Annex-A.

For selection of the irrigation projects, the problems and constraints of each of the pump irrigation systems were clarified. In order to solve the problems and constraints, the approach to each of the systems was formulated as follows:

(i) Cheaper electricity for pump operation will be obtained by direct purchase of electric power from the NAPOCOR,

(ii) Raising the present efficiency of the pumps will be realized through improvement and/or replacement of pump facilities,

(iii) Irrigation efficiency will be improved through rehabilitation and/or improvement of the existing irrigation and drainage facilities,

(iv) Land development will be carried out in areas where land levelling has not yet been done,

(v) Management of operation and maintenance, especially for raising irrigation efficiency, will be improved by strengthening O&M and monitoring equipment, reinforcement of O&M staff in the system and guidance/advice to the farmers, systematization/simplification of the recording system, improvement of communications and application of proper regulation/work schedules for O&M of the facilities,

(vi) Increase of crop production will be realized by increasing cropping intensity and unit yields of crops through application of proper irrigation farming under adequate distribution of irrigation water, and

(vii) Crop diversification with higher profitability crops will be introduced into the Systems to the extent that conditions of climate, soils and marketability of the crops permit.

Based on the approach to the project, the following development plans were formulated:

(i) Improvement plan of physical facilities such as pumps, power supply and irrigation/drainage facilities,

(ii) Improvement plan for system management including institutions, water management, O&M equipment, monitoring system and training,

(iii) Land development plan, and

(iv) Farm management plan.

Based on the plans, benefit and costs of each of the irrigation systems were estimated and economic viability of the systems were examined.

In order to select high priority national pump irrigation systems from the 12 systems, the following screening criteria were used:

(i) Management of O&M for the pump irrigation system should be undertaken by NIA,

(ii) The economic internal rate of return should be over 15%,

(iii) The beneficiary farmers in the system should have higher willingness to pay the irrigation service fee necessary for operation of the pump system,

(iv) The financial status of the system office should be showing a deficit at present,

(v) The potential financial soundness of both the system office and the beneficiary farmers is expected to be high, and

(vi) The system will be located in an economically depressed area. The gross domestic product per capita in the system will be less than the average gross domestic product per capita (Peso 9,130) of the whole Philippines with the exception of the National Capital Region.

Based on these screening criteria, 12 pump irrigation systems were assessed and the following national pump irrigation systems were selected.

(i) Bonga Pump #1 Irrigation System

(ii) Bonga Pump #2 Irrigation System

(iii) Bonga Pump #3 Irrigation System

(iv) Alcala-Amulung Pump Irrigation System

(v) Solana Pump Irrigation System

(vi) Libmanan-Cabusao Pump Irrigation System

As far as the mini-hydropower development was concerned, 17 prospective mini-hydropower sites were first selected from 110 potential sites within the national irrigation systems which NIA contemplated based on the following conditions.

(i) Drop height : 3 m in minimum

(ii) Canal discharge : perennial flow

(iii) Accessibility to sites

(iv) Distance between a substation and a potential site : less than 20 km

(v) Location of the existing pump station

Case No.	Site No.	System	Province	Canal	Station
1	1	Chico-RIS	Apayao	Tabuk Supply Canal No.1	STA8+615
2	2	Chico-RIS	Apayao	Chico Main Canal	STA22+317
3	3	Chico-RIS	Apayao	Chico Gobgob Main Canal	STA0+940 1+160
4	4	Chico-RIS	Apayao	Chico Gobgob Main Canal	STA0+940 1+160
5	5	Chico-RIS	Apayao	Quezon Main Canal	STA0+80 0+240,0+460
6	6	Agno RIS	Pangasinan	Agno Main Canal	STA5+000
7	7	Agno RIS	Pangasinan	Agno Main Canal	STA8+096 8+270
8	8	Dipalo RIS	Pangasinan	Dipalo Main Canal	STA0+800 0+963
9	9	Dipalo RIS	Pangasinan	Dipalo Main Canal	STA1+252 STA1+420
10	10	Tarlac RIS	Tarlac	Camling Main Canal	STA2+283 2+404
11	11	Magat RIIS	Isabela	South High Canal	STA10+372
12	12	Angat RIS	Bulacan	San Rafael Main Canal	North Constant Gate
13	13	Angat RIS	Bulacan	Bustos Main Canal	South Constant Gate
14	14	Angat RIS	Bulacan	Bustos Main Canal	Talanpas Check Gate
15	15	T-RIS	Pampanga	T-RIS Main Canal	STA5+30
16	16	P-RIS	Pampanga	P-RIS Main Canal	STA1+300
17	17	UPRIIS	N. Ecija	Penaranda Main Canal	STA5+226
18	1&2*	Chico-RIS	Apayao		

* Combination of site No.1 and No.2.

Next, the preliminary plans for the above 17 prospective sites were formulated. Based on the plans, benefit and cost of the mini-hydropower development project at the sites were estimated and their economic viability was examined. Based on economic internal rates of return, sites No. 1, No. 2 and the combination of No. 1 and No. 2, which have the highest value of internal rate of return, were selected for the feasibility study.

This report presents the feasibility study for the above irrigation systems and the mini-hydropower projects, located as shown on the location map.

1.4 Personnel Assigned

The JICA Study Team and the Philippines Counterpart Group who took part in the Study are listed in Table 1.

CHAPTER 2

AGRICULTURAL BACKGROUND

Agriculture plays a dominant role in the Philippines economy sharing about 27% of gross domestic product and contributing about 37% towards its gross export earnings. The sector employs about one-half of the country's 16 million strong labor force and sustains about one-half of its population. The sector's production base consists of 26 million ha of land, one million ha of inland fishing waters and 170 million ha marine coastal fishing zone. These lands are overwhelmingly managed by farmers with sized small farms in rural areas.

The agricultural sector managed to grow at an average annual growth rate of 1.5% during the period from 1983 to 1985. This growth rate is, however, much less than the 4% growth rate targeted in the previous Updated Development Plan and agriculture's average annual growth rate of 4.6% during the 1970s.

The main factors which have contributed to the low growth of agriculture were (i) the generally depressed economic conditions especially the falling the international market prices of crops, (ii) the adverse effects of political instability and (iii) the prolonged adverse effects of a long drought period.

As a result, these conditions have worsened agricultural production of crops, profitability of crops per ha, farmers' income, etc.

Under such situations the Government of the Philippines formulated its "Medium-Term Philippine Development Plan, 1987 to 1992".

This plan has the following seven objectives in the agricultural/rural sector.

(i) To enhance small farmers' incomes;

(ii) To sustain the increases in productivity;

(iii) To effect an equitable distribution of the improvements and the returns to production;

(iv) To attain food self-sufficiency/self-reliance for improved nutritional well-being;

(v) To create/increase agro-based employment opportunities among the rural population, particularly the landless rural workers and subsistance fishermen;

(vi) To improve the distribution system for agricultural crops/commodities, farm inputs and services; and

(vii) To institutionalize the expanded participation of farmers through cooperatives and other farmers' organizations.

In order to realize the objectives of the agricultural sector, the annual growth rate of agricultural production during 1987 to 1992 was targeted at 3.9% and the following policies/strategies were conceived;

(i) strengthening of the production system through more efficient use of land, promoting crop diversification, improvement of farm technology, etc., (especially expansion/rehabilitation of irrigation facilities for main food crops);

(ii) strengthening of the market support system through effecting price stability, providing rural market infrastructure, promoting market development/organization, etc.;

(iii) strengthening of support services and facilities through ensuring credit accessibility, strengthening farmers' organizations/extension work, etc.

In conformity with these policies and strategies the Government has made every effort to rehabilitate the national irrigation systems and to implement new small scale irrigation systems nationwide.

At present the National Irrigation Administration maintains and operates 135 national irrigation systems with an aggregate service area of some 598,000 ha in 1986. Among these systems, twelve are irrigated either partially or entirely by pump irrigation systems. The total present service area is about 23,000 ha or about 4% of the whole area of the national irrigation systems. These pump irrigation systems extend over Regions I, II, III, IV and V in the Luzon island. Most of these pump irrigation systems were constructed between the mid-1970s and the mid-1980s.

In recent years the cost of energy for pump operation has been increasing and this is one of the most serious factors affecting operation and maintenance cost. As a result the present financial status of most of the systems is marginal and is becoming worse. In addition proper operation of these systems has been hampered by various factors such as; low irrigation efficiency due to lack of proper irrigation facilities and deterioration of irrigation/drainage facilities; low irrigation efficiency due to improper operation and maintenance; institutional problems; low collection rate of irrigation service fees due to low crop productivity; unstable irrigation water supply; etc.

Under such conditions the irrigation service area of the pump systems has declined year by year; the cropping intensity has also become very low; the unit yield of crops has been depressed and as a result the agricultural potential of the systems has not yet been fully realized and farmers' income remain low.

In order to solve these problems and to improve the situation, the NIA requested the Government of Japan to provide technical assistance for formulating an improvement plan of operation and maintenance in the national pump irrigation systems in the country. In response to the above request, the Government of Japan decided to provide the technical services for the study through JICA.

CHAPTER 3

PRESENT CONDITIONS AND CONSTRAINTS

3.1 General

In order to identify the present constraints of each of the selected irrigation systems; (i) Bonga Pump #1 Irrigation System, (ii) Bonga Pump #2 Irrigation System, (iii) Bonga Pump #3 Irrigation System, (iv) Alcala-Amulung Pump Irrigation System, (v) Solana Pump Irrigation System, and (vi) Libmanan-Cabusao Pump Irrigation System, field surveys were carried out with special emphasis being put on five major constraints, namely: (i) planning of irrigation, (ii) physical properties of the systems, (iii) system management, (iv) irrigators' association and (v) beneficiary farmers. In addition the necessity for and problems of the mini-hydropower plants were checked on.

The principal features and necessity for improvement of each of the systems were identified and these are summarized in Tables 2 and 3.

The present conditions and constraints in each of the systems and the mini-hydropower plants are described below. Details are presented in ANNEXEs-B, C, D, E and H.

3.2 Bonga Pump #1 Irrigation System

The Bonga Pump #1 Irrigation System is located in the lower reaches of the Bonga river. Administratively this system is under the jurisdiction of Sarrat and San Nicolas municipalities, Ilocos Norte province.

Operation of this project commenced in 1977. Its service area during 1978 and 1979 was said to be 426 ha. However, the present service area was reduced to 298 ha in 1986 because the lateral A area was not irrigated due to physical defects in the canal resulting in insufficient canal capacity. 165 ha (55%) were irrigated in the wet season and 57 ha (19%) in the dry season in 1987. The remaining area is mostly rainfed.

Irrigation facilities comprise 3.4 km of main canal, 6.1 km of lateral canals, and 102 related structures. These function fairly well though changes in the hydraulic gradient of canal lateral B and reinforcement of turnouts are needed. The pump station has 2 units with a total rated capacity of 75.7 m^3/min. However, the efficiency of the pumps has decreased to 43% of the rated capacity because of severe abrasion of the impellers. This fact represents one of the most serious factors that raise the operation cost. In addition, improper wiring installation/connection and no fuse at the primary circuit breaker were found.

This system was turned over by NIA to the Sarrat-San Nicolas IA in December 1985 in 'turn-over stage 2'. The IA membership is 272. The participation ratio of farmers to IA in the service area is estimated to be about 20%. Operation and maintenance (O&M) of the irrigation system and collection of irrigation service fee (ISF) are conducted by IA except for O&M of the pumps. NIA provides technical assistance to IA through assignment of one watermaster and one pump operator without charge. Water delivery is made relatively well by three-block rotation system. Maintenance of the irrigation canals is also good as a whole.

In such circumstances the farmers in the area employ three kinds of cropping pattern; (i) paddy-paddy, (ii) paddy-diversified crops (mainly garlic) and (iii) paddy-fallow. The unit yield of crops is estimated to be about 3.3 to 3.5 tons/ha for paddy and about 0.9 tons/ha for garlic. The varieties used predominantly are IR series for rice and local varieties for garlic. The cropping intensity is estimated to be 74% in the service area. In the service area the total number of farm households is estimated to be about 1,420. The average farm size is very small, being estimated at about 0.2 ha. The economic condition of farmers still remains at the subsistence level due to small farm size, low yield of crops and cropping intensity under irrigated condition.

With respect to crop diversification, a processing plant for tomato paste established in Sarrat has been in operation since 1985. This plant has a total processing capacity of 480 tons/day. At present the plant is running at only about 30% of its capacity. A private firm manages the plant and provides technical services to the farmers under contract. Judging from present market conditions, soil conditions and good drainage of the lands, it is considered that after garlic, tomatoes should be one of the promising crops in the system.

The rate of irrigation service fee (ISF) is 8 cavans of paddy/ha in the wet season, 12 cavans of paddy/ha in the dry season and 7.2 cavans of paddy equivalent/ha for diversified crops. The amount of ISF collected in 1987 was 283×10^3 pesos, showing a collection efficiency of 83%. On the other hand, the total O&M cost in 1987 was estimated to be 529×10^3 pesos or 2,383 pesos/ha/crop equivalent for the benefited area. About 75% of this cost is for pump energy charge. Electric power needed for pump operation is supplied by Ilocos Norte Electric Cooperative, Inc. (INECO) at an average price of 2.1 pesos/kWh which is about twice the power rate of the National Power Corporation (NAPOCOR). This fact is also a serious factor contributing to the high operation cost. The annual balance of income and O&M cost for the system showed a deficit of 246×10^3 pesos.

3.3 Bonga Pump #2 Irrigation System

The Bonga Pump #2 Irrigation System is also located in the lower reaches of the Bonga river. The system covers the area of San Nicolas and Laoag municipalities in Ilocos Norte province.

The system was operated in 1977. The design area seems to be 1,200 ha. The irrigation service area was 674 ha in 1987. The area commanded by the lower half of the main canal has been excluded from the service area due to (i) farmers' intention, (ii) higher operation cost for irrigation of such area, according to the information from the System Office. In 1987, 375 ha (56%) and 208 ha (31%) were irrigated in the wet and dry seasons, respectively. The annual irrigation ratio in the service area is only 87%. Most of the remaining area is under rainfed condition.

The irrigation system consists of 14.2 km of main canal, 20 km of lateral canals, 382 related structures and 21.8 km of service roads. All the canals are concrete lined. This irrigation system functions well. The pump station has 3 units but one unit is not operated due to defective bearings. The present efficiency of the operational pumps is estimated at 71%. No fuse at the primary circuit breaker and improper wiring installation and connection were also found. Abrasion of impellers caused by sand sucked up is also one of the problems.

All of the Bonga Pump #2 system was turned over to the San Nicolas-Laoag IA in December, 1985 in 'turn-over stage 2'. At present, 503 farmers are members of this IA. The participation ratio of farmers in this system is roughly estimated to be about 20%. This IA is very active. Operation and maintenance of the system and collection of ISF are carried out by IA. NIA provides technical services to IA. O&M are strictly controlled by IA. Rotational distribution with 16 blocks is carried out by applying intermittent irrigation with a 9-day interval.

In such circumstances the farmers employ four cropping patterns; (i) paddy-paddy, (ii) paddy-diversified crops, (iii) paddy-fallow and (iv) paddy-sugarcane-paddy for three years rotation. Most of the farmers utilize IR varieties for paddy and local varieties for garlic. The diversified crops, mainly garlic, are grown on land having a medium soil texture and good drainage. Sugarcane is grown to produce basi (local wine). As in the case of the Bonga Pump #1, tomatoes should be one of the most promising diversified crops for the future. The unit yields of crops are estimated to be 3.5 to 4.0 tons/ha of paddy, 1.7 tons/ha of garlic. The cropping intensity is estimated to be 87% for the service area. In the service area there are about 2,500 farmers. The average farm size is estimated to be 0.27 ha. The economic condition of most of the farmers is still at the subsistence level because of the small farm size and low productivity of crops.

The ISF rate is 8 cavans of paddy/ha in the wet season, and 12 cavans of paddy/ha in the dry season paddy and 7.2 cavans of paddy equivalent/ha for diversified crops. The ISF amount collected in 1987 was 509×10^3 pesos corresponding to a collection efficiency of around 60%. The total O&M cost in 1987 amounted to 790×10^3 pesos or 1,355 pesos/ha/crop for the area. The pump energy cost was 79% of the total cost. The electric power needed for pump operation is provided by INECO at an average rate of 2.1 pesos/kWh. This rate is about twice the NAPOCOR's rate. As a result, the annual accounts of the system showed a deficit of 281×10^3 pesos.

3.4 Bonga Pump #3 Irrigation System

The Bonga Pump #3 Irrigation System is again located in the lower reaches of the Bonga river. Administratively the system belongs to Laoag municipality of Ilocos Norte province.

The service area of the system was 202 ha in 1987. The irrigated area in 1987 was 140 ha (69%) in the wet season and 62 ha (31%) in the dry season. Most of he remaining area is under rainfed condition. One of the main causes of lower rate of irrigated area is the functional disruption of the canal and siphon in the Lateral A/B areas which were damaged by earthquake in 1983.

The irrigation system is composed of a 4.8 km main canal, 3.3 km of lateral canals and 91 related structures. All the canals are concrete lined. The condition of these irrigation facilities is fairly good in general. However, it is necessary to improve parts of the lateral canals because of their low embankments. Most of the turnouts have no control gates, and this impedes proper water control. There are 2 units of pumps at present but one is out of order because of a burned motor coil. The efficiency of the remaining operational pump is only 46% of its rated capacity due to abrasion of the impellers. Furthermore, there is no fuse at the primary circuit breaker and improper wiring. It is also essential to prevent river bank scour on the upstream side of the pumping station.

The entire system was turned over to the Western IA in April 1986 in 'turn-over stage 2'. This IA has a membership of 252 or about 60% of the total number of farmers in the system. The cash statement indicates that this IA is very active. Operation and maintenance of the system as well as collection of ISF are conducted by the IA. NIA provides technical services through assignment of one pump operator and one water master without charge. Two-block rotation is applied along with one-week interval intermittent irrigation. The main problem of water delivery is the lack of turnouts with gated structures. Maintenance of irrigation canals is carried out relatively well by IA.

In such circumstances, the farmers employ the following cropping pattern; (i) paddy-paddy, (ii) paddy-fallow, (iii) paddy-diversified crops and (iv) paddy-sugarcane-paddy for three years rotation. The soils in the service area are medium and fine in texture. It appears that the diversified crops are grown in the medium textured soils. The farmers use most of IR varieties for rice and local varieties for garlic. As same as in the case of the Bonga Pump #1, tomatoes should be one of the most promising diversified crops for the future. The yield of crops is estimated to be 3.8 to 4.1 tons/ha of paddy and 2.2 tons/ha of garlic. The cropping intensity is estimated to be 100% for the service area. About 420 farmers are settling in the service area. The average farm size is estimated at 0.5 ha. The economy of most of the farmers is still at the subsistence level.

The applied ISF rate in this system is 8 cavans of paddy/ha in the wet season, 12 cavans of paddy/ha in the dry season and 7.2 cavans of paddy equivalent/ha for diversified crops. The total amount of ISF collected in 1987 was 100×10^3 pesos, representing an estimated collection efficiency of 32%. The total O&M cost is estimated to be 313×10^3 pesos or 1,547 pesos/ha/crop for the benefited area. Energy cost for pump operation is 59% of the total O&M cost. Electric power for pump operation is provided by INECO at a rate of 2.1 pesos/kWh on an average in 1987. This power rate is about twice that of NAPOCOR. Balance of income and O&M cost in the system showed a deficit of 213×10^3 pesos.

3.5 Alcala-Amulung Pump Irrigation System

The Alcala-Amulung Pump Irrigation system is located in the lower reaches of the Cagayan river. Administratively, the system is under the jurisdiction of Alcala and Amulung municipalities, in Cagayan province.

Operation of the Alcala-Amulung system started in November 1982 under the Cagayan Integrated Agricultural Development Project - Irrigation Component (CIADP-IC). This system was handed over by CIADP-IC to the Region II office in January 1987.

The service area is 1,840 ha. The irrigated areas were 1,030 ha (56%) in the wet season and 996 ha (54%) in the dry season in 1987. The remaining area is under rainfed condition or fallow land. Such a low irrigation ratio is considered to be the result of (i) restriction of irrigation area due to physical defects in canals (insufficient canal capacity), (ii) the fact that farmers do not want irrigation water due to high ISF, (iii) improper water delivery and (iv) inundation problems.

The Alcala-Amulung area has a 9.9 km main canal, 22.0 km of lateral canals, 140 related structures and 18.2 km of service roads. Most of the canals are unlined. Related structures are in good condition. The problems are (i) silt deposits in the Alcala main canal as the result of sheet erosion on the hillside along the canal, (ii) low embankments in some portions of the canals. The total length of drainage canals amounts to 29.8 km. These canals do not function well due to insufficient canal capacity resulting from the lack of maintenance. The pumps in both areas have no specific problems. The operation efficiency of the existing pumps is over 90% of the rated capacity.

The systems are managed by the Iguig, Alcala-Amulung Pump Irrigation System office. Staffing of the office and their work load are conforming to the NIA criteria. Water distribution is conducted by rotational distribution method, applying 6-block rotation system in the Alcala-Amulung. Irrigation water supplied by the pumping system was as large as 28 million m^3/year or 11.5 mm/day in 1987, according to estimation based on pump operation records. In spite of this, illegal water intake and complaints of insufficient water distribution from the farmers still occur in the system. The principal reasons for improper distribution of irrigation water may be (i) physical defects in canals (silting problems), (ii) too much water intake from the upper reaches of canals and (iii) the fact that the farmers do not follow the irrigation schedule prepared by the system office.

The irrigators' association, the Amalia IA was instituted in 1988. The total membership of the IA amounts to 670 or 31% of the total farmers. The system office is now promoting another three IAs. It is urgently required to set up active IAs in the system for efficient water and system management.

The total number of farmers is estimated to be 2,190. The average farm size is estimated at about 0.84 ha. The cropping patterns prevailing in the area are (i) paddy-paddy and (ii) paddy-fallow. About 90% of the land in the service area are classified as 1st class rice land, but diversified crops are not cultivated in the service area at present due to such constraints as poor drainage, market and supporting systems. IR varieties are predominant in the service area. The unit yield of paddy is estimated to be 3.3 to 3.5 tons/ha. Because of small farm size and low yield of paddy, most of the farmers are still at the subsistence level. In view of the conditions of soils, drainage, market and supporting systems, the introduction of diversified crops to the entire service area in the system would require huge investment. Conditions will therefore remain difficult at present and even in the future.

The irrigation service fee levied on farmers is 7.5 cavans of paddy/ha in both wet and dry seasons. Total ISF collected in 1987 amounted to $1,572 \times 10^3$ pesos, corresponding to a collection efficiency of 63%. The total O&M cost in 1987 was estimated to be $2,450 \times 10^3$ pesos or 1,209 pesos/ha/crop for the benefited area. The power energy is tapped from NAPOCOR. The energy cost for pumps occupied about 62% of this total cost. The balance of income and O&M cost showed a deficit of 877×10^3 pesos in 1987.

3.6 Solana Pump Irrigation System

The Solana Pump Irrigation System is located about 5 km west of Tuguegarao. It extends over the left bank in the lower reaches of the Cagayan river. Administratively, the system covers Solana municipality, Cagayan province.

The system has been operated since May 1980. The design area is said to be 2,865 ha. However, the irrigation service area in 1987 was 1,320 ha. Such a large reduction of irrigation service area has been mainly due to the following; (i) two out of the 4 pump units have not been operated and (ii) although the pumps are planned to be operated 24 hrs/day, the actual operation duration was limited to 10-14 hrs/day due to the bad condition of the pump motors. In 1987 the pumps were operated only in the dry season and 847 ha were irrigated. This represents a yearly irrigation ratio of only 64%.

The system's irrigation facilities consist of a 18.4 km main canal, 25.6 km of lateral canals, 181 related structures and 32.9 km of service roads. It has also 19.1 km of drainage canals. All the canals are of unlined. The main problems of the canals are (i) deterioration of the lower portion of the main canal, (ii) siltation in the upper portion of the main canal and (iii) embankments of the main canal. Sedimentation in particular impedes drainage.

Two pump units are not in operational condition due to a defect in the control panel, excessive vibration of pump/motors and water leakage. At present, only 2 pump units are operated. As a result, the actual discharge capacity of 2 pumps corresponds to only 40% of their total rated capacity. Loss of energy through power transmission to the pump station is another constraint. Besides, sand sedimentation at the intake site of the pumps causes submergence every flood season. That is also one of the factors resulting in high maintenance costs.

The Solana irrigation system was turned over by NIA to the Solana Cagayan River IA in July 1988 in 'turn-over stage 3'. IA has a membership of about 810 which is equivalent to about 65% of the total number of farmers in the service area. Water delivery is done by intermittent irrigation (one week intervals), and three-block rotation. Operation and control of irrigation water are not carried out properly. The main problems are mainly physical defects of control structures, insufficient canal capacity, some illegal water intakes, etc. Maintenance of the canal seems not to be conducted properly. According to the data on performance of training for IA farmers, few training programmes have been executed. Therefore, realization of training programmes for IA farmers is essential for effective O&M.

At present 1,250 farmers are engaged in paddy cultivation in the service area. The average farm size is estimated at about 1.1 ha. The farmers apply the paddy-paddy or paddy-fallow cropping pattern. The unit yield of paddy is 3.1 to

3.3 tons/ha. Diversified crops are not cultivated at present. Most of the farmers still remain at a subsistence level.

The ISF rate applied in the system is the highest among all the pumping systems: 14 cavans of paddy/ha for both wet and dry seasons. The total ISF amount collected in 1987 was $1,166x10^3$ pesos, that means a collection efficiency of 60%. The total O&M cost was calculated at $2,227x10^3$ pesos or 2,629 pesos/ha/crop. Energy cost for the pumps occupied 78% of the total O&M cost. Electric power needed for pump operation is provided by the Cagayan Electric Cooperative, inc. at an average rate of 1.9 pesos/kWh. Income and expenditures showed a deficit balance of $1,061x10^3$ pesos in 1987.

3.7 Libmanan-Cabusao Pump Irrigation System

The Libmanan-Cabusao Pump Irrigation System is located about 15 km northwest of Naga city. It extends over the flat alluvial plains near the estuary of the Bicol river. It is under the jurisdiction of the municipalities of Libmanan and Cabusao in Camarines Sur province.

Construction of the system was started in 1976 and completed in 1981. During the construction period, an irrigators' organization was formed and the Libmanan-Cabusao Irrigators Service Cooperative (LCISC) was registered in 1981. A memorandum of agreement was signed between LCISC and NIA in April 1982 for joint management of the system. A management committee was created, being composed of 4 LCISC directors and 3 NIA representatives assisted by the chief of the system. The joint management was performed for four cropping seasons. LCISC, however, backed out of the contract in May 1985.

The service area has been originally designed to be about 4,523 ha, but was reduced to 2,195 ha in 1987. Such a reduction in area results from the fact that: (i) there are higher elevated lands which could not be irrigated by the existing system in the design area, (ii) the area at the end portion of the canal cannot be irrigated due to defects in irrigation canal facilities, and (iii) insufficient irrigation water supply from the pumps (2 out of the 4 pump units are out of order).

The system's irrigation facilities comprise main canals of 11.2 km long in total, 53 km of lateral canals, 297 related structures, 40.5 km of service roads and 11 flap gates. There are 56.8 km of drainage canals. Most of these facilities are rather poor in condition. The following physical defects are the most severe constraints for operation; (i) decrease of canal capacity due to siltation in the closed conduit in the upper reaches of the main canal, (ii) actual flow capacity being smaller than the designed capacity due to outcrop of hard rocks in the downstream portion of the said conduit, (iii) low embankment of the canals, (iv) decrease of flow capacity in considerable portions of the lateral canals due to silting and land slipping of canal slopes, (v) total deterioration of a catch drain, (vi) siltation in all the drainage canals, and (vii) deterioration of all the flap gates.

There are 4 pump units in the pump station. Out of these, 2 units are not operational due to defects of their motors and fuses. Other operational pumps have no specific problems, and run at over 90% of their rated capacity.

The system is managed by the Libmanan-Cabusao Pump Irrigation System office at present. The field O&M staff consists of two water masters and one pump operators. No ditchtenders are assigned to the system. Judging from the NIA standard on work load, reinforcement of staff with emphasis on ditchtenders is essential.

Delivery and control of irrigation water are not conducted properly due to physical defects of irrigation/drainage facilities as well as shortage of O&M staff.

In order to reorganize of the irrigators' associations, NIA assigned one irrigation community organizer to the system. Up to the present, two irrigators' associations have been registered; Handong IA and CUISA IA. The total membership of both IAs is 232 or 22% of the total number of farmers in the service area. The total irrigation area commanded by IAs is 235 ha or about 10% of the total service area of the system. The Handong IA and the CUISA IA were turned over in June 1987 and January 1986, respectively. Both IAs are under 'turn-over stage 3'. At present these IAs are very active.

There are about 1,050 farmers in the service area and their average farm size is 2.1 ha. About 60% of the lands in the service area are low lying lands classified as second- and third-class rice land. At present, these lands are very poorly drained due to non-functioning of the drainage canals. This seriously affects the rice yield. The farmers cultivate only paddy. The prevailing cropping patterns are (i) double cropping of paddy per year and (ii) paddy-fallow. The unit yield of paddy of 2.8 to 3.3 tons/ha is the lowest in all the systems. The cropping intensity is about 51% in the irrigated area.

The ISF rate in the system was set at 6 cavans of paddy/ha for both seasons. The total ISF amount collected in 1987 was 182×10^3 pesos. This represents a collection efficiency of 16% which is the lowest in the pumping systems. The O&M cost was 667×10^3 pesos in total or 597 pesos/ha/crop for the benefited area. Electric power cost for the pumps was calculated to be 55% of the total O&M cost. Electric power for the pumps is supplied by the Camarines Sur Electric Cooperative, Inc. at an average rate of 2.1 pesos/kWh. The annual accounts of the system showed a deficit of 485×10^3 pesos.

3.8 Power Supply and Mini-Hydropower Plants

The power supply system in the Philippines is organized by two agencies, NAPOCOR and National Electrification Administration (NEA), and one incorporated system.

NAPOCOR generates electricity by power plants and transmits and distributes electricity to NEA, the cooperatives and other consumers at a selling price.

NEA installs power plants, transmission lines, substations and distribution lines for electrification in regional areas, the NEA takes over distribution facilities to regional cooperatives.

The regional cooperatives buy electricity from NAPOCOR and sell the electricity to the customers through the distribution grid.

The source of power for the pump irrigation systems is from feeders branched from the power grids of NAPOCOR and the local electric cooperatives as mentioned above.

Recently electricity costs have risen steeply due to an increase in fuel costs, and management of the pump systems has been severely affected.

In order to solve this problem, the NIA hopes to develop alternative power sources for the pump systems by installation of mini-hydropower plants in the existing irrigation systems.

At present there are several mini-hydropower plants such as Tumauini, Baligatan, Magat A and B and Penaranda Chute plants in the NIA irrigation systems. However these plants do not always function well due to the following major causes;
(i) large fluctuation of discharge in irrigation canals,
(ii) installation of water turbines with fixed gates and runner blades which cannot manage control of discharge corresponding to changes of irrigation water and (iii) insufficient maintenance of power plants.

CHAPTER 4

THE PROJECT

4.1 Basic Development Concept

As clarified in chapter 3, the present problems and constraints of management of the selected pump irrigation systems may be summarized as follows; (i) the financial status of the systems is marginal or is becoming worse and (ii) the farmer's economy of most of the beneficiary farmers in the systems remains at a subsistence level.

The financial status of the systems has been seriously affected by rising operation and maintenance costs and a low collection efficiency of irrigation service fee. The rise in O&M costs results from (i) rising unit cost of electricity for pump operation, (ii) falling efficiency of pump facilities and (iii) falling overall irrigation efficiency due to deterioration of irrigation/drainage facilities and improper management of operation and maintenance. The low collection efficiency and high amount of irrigation service fee results from a complicated combination of (i) negative farmers' perception of NIA services caused by shortage of irrigation water supply, (ii) low payment capacity of farmers, and (iii) constraints on the fee collection method.

The subsistence farmers' poor economy is considered to be the result of low farm income due to (i) low unit yields of paddy, (ii) low cropping intensity and (iii) small farm size.

The basic development concept for this study is, therefore, (i) to improve the financial status of the systems and (ii) to increase the farmers' income in the systems. Accordingly the approach to the study was formulated as follows:

(i) For the systems which depend at present on the local electricity cooperatives for power sources, cheaper electricity for pump operation will be obtained by direct purchase of electric power from the National Power Corporation.

(ii) Raising the present efficiency of the pumps will be realized through improvement and/or replacement of pump facilities including electrical equipment,

(iii) Irrigation efficiency will be improved through rehabilitation and/or improvement of the existing irrigation and drainage facilities in the systems,

(iv) Management of operation and maintenance, especially for raising irrigation efficiency, will be improved by strengthening O&M and monitoring equipment, reinforcement of O&M staff in the systems and guidance/advice to the farmers, systematization/ simplification of the recording system, improvement of communications and application of proper regulation/work schedules for O&M of the facilities,

(v) Increase of crop production will be realized by increasing cropping intensity and unit yields of crops through application of proper irrigation farming under adequate distribution of irrigation water, and

(vi) Crop diversification with higher profitability crops will be introduced into the systems to the extent that conditions of climate, soils and marketability of the crops permit.

The approach to the Study is shown in Fig. 1.

4.2 Delineation of the Project Area

The project areas for the pump irrigation systems were preliminarily delineated by using the topographic maps (1/4,000), parcellary maps (1/2,000 or 1/4,000) and schematic irrigation diagrams. Then delineation of the project areas was finalized based on the results of the canal route surveys, the specific conditions in each of the systems such as habitual inundation areas, the pump irrigation areas proposed by organizations other than NIA, the irrigation areas well managed by IAs in turnover stage 3, etc. Details are explained in ANNEX-C.

The project areas are as follows:

(Unit: ha)

Name of System	Firmed-up Service Area	Maximum Service Area
Bonga Pump #1 IS	298	426
Bonga Pump #2 IS	674	674*
Bonga Pump #3 IS	202	202
Alcala-Amulung Pump IS	1,652	2,158
Solana Pump IS	1,100	1,960
Libmanan-Cabusao Pump IS	1,838	3,085

* The maximum service area could not be demarcated due to shortage of data and was treated as same as the firmed-up service area in this study.

The firmed-up service area is defined as the area managed by the system office of NIA at present. The maximum service area is the maximum area capable of irrigation within the original design area in terms of topographical constraints.

The improvement plan for the systems was studied for both the firmed-up service area and maximum service area as an alternative.

Economic feasibility for both service areas was examined. As a result the maximum service area has a higher economic internal rate of return in all the irrigation systems. (Details are shown in ANNEX-G.) The project area in the respective systems is defined to be the maximum service area of the respective systems.

Location of each of the systems is shown in Figs. 2 to 7.

4.3 Improvement Plan of Physical Facilities

4.3.1 Pump Facilities

The basic concept of the improvement plan for pump capacity is to meet the proposed diversion water requirement and to maximize pump efficiency by means of replacement or rehabilitation of pump facilities.

The pump facilities of the Bonga Pump #1, #2, #3 and Solana systems are already over their useful life and, therefore, the pump efficiency decreases. These facilities were planned to be replaced. For the Libmanan-Cabusao system one unit of the motor will be replaced. The pump facilities of the Alcala-Amulung system function well and do not need to be replaced.

The capacity of the pumps to be replaced was determined based on the proposed diversion water requirement. The numbers of pump units were decided from the standpoint of the optimum control of water distribution. The new pumps were planned to be of familiar vertical mixed flow type as used at present so as to facilitate their operation.

The electrical equipment was planned to be installed from the standpoint of stable power distribution to and safe control of the respective motors.

The proposed works are shown in Table 4.

4.3.2 Power Supply System

At present electric power for all the systems except the Alcala-Amulung system is supplied from the local electricity cooperatives. The cost of electricity from the cooperatives is about twice that of NAPOCOR.

To examine the electrical charge for operation, two alternatives were studied; (i) direct tapping of electricity from NAPOCOR's grid (Direct Tapping) and (ii) using electricity from the local electric cooperatives (Indirect Tapping).

The direct tapping of electricity from NAPOCOR's grid is considered to comprise two alternative systems; (i) direct NIA-NAPOCOR system and (ii) tripartite system. Under direct NIA-NAPOCOR system, NIA taps directly its power source from NAPOCOR's grid through NIA's own sub-station and transmission line. Under the tripartite system, NIA utilizes the existing transmission line connecting the pump station with the cooperative sub-station. Due to the insufficient capacity of the existing sub-station it was planned in this study that NIA should provide an additional sub-station connected to that of the cooperative to secure stable power supply even during the period of peak power demand.

To select the tapping system for each of the systems, a cost comparative study was undertaken (Details are explained in section 3.4 in ANNEX-C). The tapping system for each system was decided as follows:

Name of System	Tapping System
Bonga Pump #1 IS	Tripartite
Bonga Pump #2 IS	Tripartite
Bonga Pump #3 IS	Tripartite
Solana Pump IS	Direct NIA-NAPOCOR
Libmanan-Cabusao Pump IS	Tripartite

In case of electric supply from the local electricity cooperatives, no specific improvement plan was formulated because both the sub-station and the transmission line are owned and maintained by the local electricity cooperatives.

The proposed works for the power supply system are shown in Table 4.

4.3.3 Irrigation and Drainage Facilities

(1) Irrigation Water Requirement

The design discharge for irrigation facilities was determined to be the weekly peak water requirement. The diversion water requirement for each of the systems was estimated based on the proposed unit water requirement, irrigation area, water distribution method and the proposed cropping pattern (Details are shown in section 6.3.3, ANNEX-E).

(2) Drainage Water Requirement

The unit drainage water requirement in the paddy field was computed by the following formula:

$$q1 = (R - 0.8*D)/8.64*T$$

where,

- q1: unit design discharge (l/s/ha)
- R: 3-day stormy rainfall (mm) with a 5-year return period
- D: retention depth of rainfall (100 mm)
- 0.8: paddy field ratio to gross drainage area
- T: drainage period (3 days)

The volume of water to be drained from the hilly lands was estimated by using the rational formula with a one-day stormy rainfall.

The unit drainage requirements for each of the systems are shown in section 3.3.2, ANNEX-C.

(3) Rehabilitation and Improvement Plan

The facilities to be rehabilitated and/or improved are irrigation canals and related structures, drainage canals and related structures, service roads (O&M roads), and on-farm facilities.

The general concept is to restore the capacity and function of the facilities in all the systems to meet proposed design discharge. If the existing canal is insufficient in flow capacity to meet the proposed design discharge, it was planned that its flow capacity be increased in such a way as to minimize the right-of-way as follows:

(i) First, to increase the flow capacity by canal lining without substantial change of the existing flow area,

(ii) Second, to increase the flow capacity by canal lining and changing the existing inside slope of 1:1.5 to 1:1.0, in case the proposed design discharge is not satisfied by the above (i), and

(iii) Finally, to increase the flow capacity by canal lining and widening canal section, if the proposed design discharge is not satisfied by the above ii).

If the existing turnouts have insufficient flow capacity to meet the proposed design discharge, it was planned to provide additional turnouts adjoining the existing turnouts instead of replacing them.

Service roads were planned to be constructed along the whole length of the main and lateral/sub-lateral canals as a rule.

All regulating structures such as headgates, checks and turnouts were planned to be equipped with steel gates. Calibrated staff gages would be installed immediately downstream of each headgate and check.

Installation of on-farm canals was planned to be made at a density of 70 m/ha for main and supplementary farm ditches and 60 m/ha for farm drains. Related structures would also be proposed for these canals.

The proposed works are shown in Table 4.

4.4 Improvement Plan for System Management

4.4.1 System Office and Irrigator's Association

The present irrigation systems are managed by the NIA system offices and/or the irrigator's associations. Management of the Bonga Pump #1, Bonga Pump #2 and Bonga Pump #3 irrigation systems is shared by NIA and the irrigators' associations under the conditions set forth for the turn-over stage 2. The Alcala-Amulung and the Libmanan-Cabusao pump irrigation systems are fully managed by the NIA system office. The Solana pump irrigation is fully managed by the irrigators' association under the conditions set forth for the turn-over stage 3 (see Chapter 4, ANNEX-E).

The organizational structure of the present NIA system offices is simple. An irrigation superintendent is fully responsible for overall O&M management of the system. Under the irrigation superintendent there are two sections; administrative section and operation & management section. As no structural problems were observed, the present simple organizational structure of the system offices would not require any change in the future.

The work load of O&M staff differs between the system offices. The institutional plan for the system offices, therefore, was formulated to allocate the optimum number of O&M staff to the offices, especially ditchtenders, watermasters and pump operators. The total number of O&M staff to be required in the system offices was estimated on the basis of about 1.5 times the minimum requirement of work load which is defined in the NIA criteria in "Small" National Irrigation System as follows:

(Unit: No. of staff)

Name of System	WM (1)	DT (2)	PO (3)
Bonga Pump #1 IS	1	-	1
Bonga Pump #2 IS	1	-	1
Bonga Pump #3 IS	1	-	1
Alcala-Amulung Pump IS	2	6(-1)	2
Solana Pump IS	-	-	-
Libmanan-Cabusao Pump IS	3(+1)	11(+11)	1

(1) WM: Watermaster, (2) DT: Ditchtender, (3) PO: Pump operator
plus or minus figures in parentheses indicate increased or decreased number of O&M staff in comparison with the present number of O&M staff in the system offices.

In addition to allocation of the optimum number of O&M staff, quality improvement of the O&M staff is also essential for effective system management as shown in section 4.4.6.

With respect to the irrigators' associations in the Bonga Pump #1, #2, #3, Solana and Alcala-Amulung systems, there are five officers under the Board of Directors. They are president, vice president, secretary, treasurer and auditor. The president is supported by several committees. Under the president there are irrigators' groups which are organized for each turnout. Structurally there are no problems.

For the Libmanan-Cabusao and part of the Alcala-Amulung systems, irrigators' associations are now being set up.

Institutional reinforcement of the irrigators' associations will be executed by improving the quality of farmers. For this purpose training programmes are proposed as mentioned in section 4.4.6.

4.4.2 Water Distribution

(1) Basic Concepts of Water Distribution

In all the systems, the irrigation facilities were constructed with a concept of continuous water supply and simultaneous distribution. During the initial operation stage, water shortage problems occurred in areas remote from the pump station. This may be attributed mainly to over application of irrigation water in the upper part of the system and lack of skill in doing complicated gate operation. Then, rotational distribution was introduced to improve uneven water supply. This rotational distribution, however, caused a water deficit within each rotation block because the schedule of the rotational distribution was formulated without taking into consideration the existing flow capacity of the canals and structures.

Taking such bitter experience of the system offices into consideration, the basic concepts for formulating the water distribution method were set up as follows:

a) To secure even water distribution to every part of the service area,

b) To avoid complicated gate adjustment as much as possible. In other words, to eliminate the factor of time lag as much as possible in discharge control at the gates, and

c) To minimize the increase in flow capacity of the existing irrigation facilities.

(2) Proposed Water Distribution Method

A rotational distribution was set up based on the present constraints in water distribution, the basic concepts for water distribution, advantages and disadvantages in different methods of water distribution, and the anticipated capability of watermasters and ditchtenders in water distribution.

The proposed rotational distribution is a combination of "rotation by section in the main canal or by lateral(s)" and "rotation by section or a group of turnouts in the laterals or sub-laterals".

The proposed boundaries of the rotation blocks for each system are schematically shown in ANNEX-C, and the proposed numbers of rotation blocks for each system are as follows:

Name of System	Number of Rotation Blocks
Bonga Pump #1 IS	2
Bonga Pump #2 IS	3
Bonga Pump #3 IS	2
Alcala-Amulung Pump IS	3
Solana Pump IS	3
Libmanan-Cabusao Pump IS	2

(3) Irrigation Schedule

The annual irrigation schedule would be prepared by each system office or the irrigators' association concerned in collaboration with each other before the outset of every dry season crop on the basis of the proposed cropping pattern and the proposed unit water requirement. The schedule would consist of (i) cropping calendar, (ii) programmed irrigation area by turnout, (iii) weekly land soaking program, (vi) weekly rotational distribution schedule, (v) diversion water requirement in accordance with the above-mentioned distribution schedule, (vi) estimated power consumption, etc.

Prior to the commencement of every cropping season, the annual irrigation schedule would be reviewed and confirmed for the programmed area in due consideration of the physical condition of the irrigation facilities and beneficiary farmers' intention through discussion with the irrigators' association.

(4) Control of Irrigation Water Delivery

Control of irrigation water delivery for each system would be made by conventional methods.

Delivery of the irrigation water would be managed through the following general procedure (i) data collection, (ii) data processing, (iii) establishiment of operation plan and (iv) operation & monitoring.

The data required for operation would consist of, at least, (i) farming activities, (ii) canal water level at every measuring device, (iii) daily rainfall, and (iv) river water level at pumping site.

The data processing work would involve the conversion of the data collected into the necessary dimensions required for operation and preparation of the operation plan.

The operation plan will consist of a seasonal plan and a weekly plan. The weekly plan would cover (i) number of units of pumps to be operated and daily operating hours, and (ii) gate operation schedule.

In accordance with the operation order which would be issued based on the weekly operation plan, the field O&M staff would set the irrigation facilities to the right position weekly unless occasional order is issued. Occasional orders would cover such matters as suspension and resumption of pump operation.

(5) Irrigation Suspension Schedule

The proposed irrigation suspension schedule is as follows:

Previous Day Rainfall Range	Period of Suspension of Irrigation
below 7 mm	0 day
8 - 15 mm	1 day
16 - 23 mm	2 days
24 - 30 mm	3 days
31 - 38 mm	4 days
39 - 46 mm	5 days
above 47 mm	6 days

4.4.3 Monitoring System

Monitoring of meteo-hydrological measurements, irrigated area, harvested area and lots with crop failure is one of the most important key factors for operation.

Meteo-hydrological measurements covering rainfall, irrigation discharge and river water level at the pump sites are essential. For this purpose one rain gage and one staff gage were planned to be installed at each pump station and at the head of lateral/sub-lateral canals, respectively.

At present the meteo-hydrological measurement equipment is considerably deteriorated and insufficient in quality except for a Parshall flume for measuring river water level and pumped up discharge. Reinforcement and rehabilitation of monitoring equipment was planned. The proposed numbers of monitoring equipment are shown in Table 5.

Monitoring of items other than the meteo-hydrological measurement will be carried out systematically through the field inspection by O&M staff.

Communication within the system offices or the irrigator's association will be performed by the present ordinary means such as meetings, official memorandum circulars and bulletin board, because the organization of each system office and irrigator's association is simple.

For effective performance for the monitoring and communication, reinforcement of transportation equipment was also planned in accordance with NIA's criteria.

With respect to the monitored records, a standardized format for recording of data monitored was planned to be applied and prepared as shown in ANNEX-I.

4.4.4 Maintenance Rule of Irrigation and Drainage Facilities

Maintenance of the canal systems would comprise daily maintenance work and seasonal maintenance work. The former would cover cleaning of canals and daily maintenance of pumping equipment. While the latter would be conducted during irrigation cut-off period and consist mainly of (i) desilting of intake site, inlet channel and canals, (ii) reforming of canal section, (iii) resurfacing of service roads, (iv) repainting and greasing metalwork. Regular maintenance work on daily, weekly, monthly and yearly basis would be required for pump facilities, the details of which are presented in ANNEX-I.

In addition to maintenance of the irrigation and drainage facilities, maintenance of the O&M equipment will also be required. To increase workability of the O&M equipment, preventive maintenance would be established through regular maintenance by mechanics of the NIA Regional office.

Some of the facilities and equipment such as mechanical and electrical works and O&M equipment would be replaced at a certain period within the anticipated project life because of their shorter useful life.

4.4.5 Reinforcement Plan for Operation and Maintenance Equipment

The plan for O&M equipment reinforcement was formulated covering the following: