LAO PEOPLE'S DEMOCRATIC REPUBLIC
MINISTRY OF AGRICULTURE AND FORESTRY

FEASIBILITY STUDY
ON
AGRICULTURAL AND RURAL DEVELOPMENT PROJECT
IN
THE SUBURBS OF VIENTIANE

MAIN REPORT

JULY 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of Lao People's Democratic Republic (Lao PDR), the Government of Japan decided to conduct the Feasibility Study on Agricultural and Rural Development Project in the Suburbs of Vientiane and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent to Lao PDR a survey team headed by Mr. Yusaku TOYA, Nippon Koei Co., Ltd., from August to December, 1988.

The team held dicussions with the officials concerned of the Government of Lao PDR and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

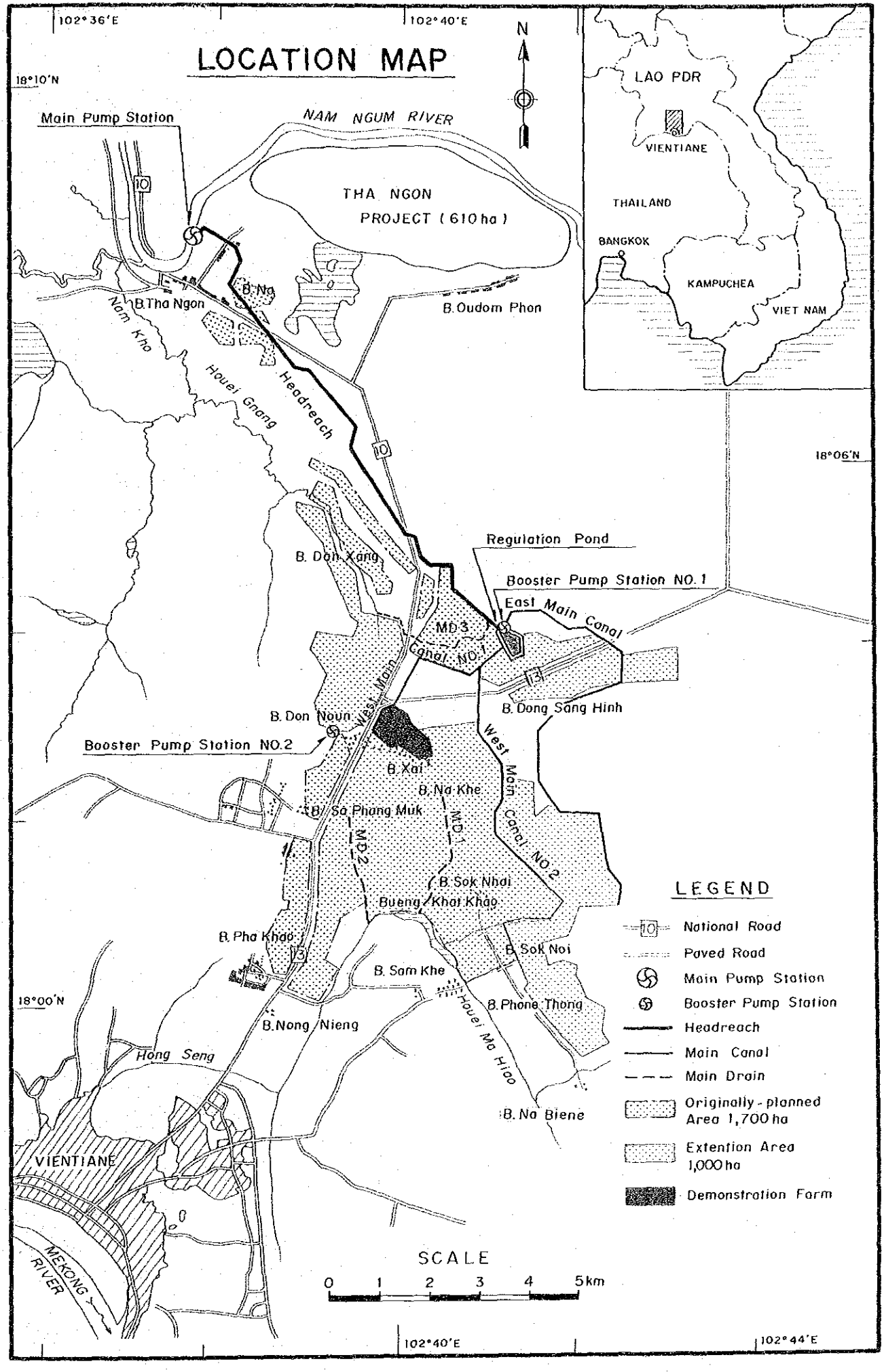
I hope that this report will contribute to the development of the Project and to the promotion of friendly relations between the two countries.

I wish to express my sincerest appreciation to the officials concerned of the Government of Lao PDR for their close cooperation extended to the team.

July 1989

Kensuke Yanagiya

Kensuke YANAGIYA
President
Japan International Cooperation Agency


LOCATION MAP
102°36'E
102°40'E
102°44'E
18°10'N
18°06'N
18°00'N
N
LAO PDR
VIENTIANE
THAILAND
BANGKOK
KAMPUCHEA
VIET NAM
Main Pump Station
NAM NGUM RIVER
THA NGON
PROJECT (610 ha)
B. Na
B. Tha Ngon
B. Oudom Phon
Nam Kha
Houei Gnang
Headreach
Regulation Pond
B. Don Xang
Booster Pump Station NO. 1
East Main Canal
MD 3
Canal NO. 1
West Main
B. Don Noun
Booster Pump Station NO. 2
B. Dong Sang Hinh
B. Xai
B. Na Khe
B. Sa Phang Muk
MD 2
MD 1
West Main Canal NO. 2
B. Sok Nhai
Bueng Khai Khao
B. Pha Khao
B. Sok Noi
B. Sam Khe
B. Phone Thong
B. Nong Nieng
Houei Ma Hiao
Hong Seng
B. Na Biene
VIENTIANE
MEKONG RIVER
LEGEND
National Road
Paved Road
Main Pump Station
Booster Pump Station
Headreach
Main Canal
Main Drain
Originally - planned Area 1,700 ha
Extention Area 1,000 ha
Demonstration Farm
SCALE
0 1 2 3 4 5km

BASIC DATA OF LAO PDR

1. Land area

Total area	236,800	km^2
- Land area	230,800	km^2
- Arable land	8,800	km^2

2. Population

Year	1976	1980	1985	1987
Whole country (1,000)	2,886	3,119	3,618	3,828
Increase rate (% per annum)		2.0 %	3.0 %	2.9 %
Population density (person/km^2)	12	13	15	16
Vientiane Municipality (1,000)	-	-	381	404

3. Demographic Indicators (1986)

Age Distribution	:	0 - 15 years	47 %
		15 - 60 years	47 %
		over 60 years	6 %
Urban population rate	:	15 %	
Crude birth rate	:	42 per thousand	
Crude death rate	:	18 per thousand	
Life expectancy (1983)	:	male	48.3
		female	51.2

4. Gross Domestic Product (estimated by the World Bank)

Year	1983	1984	1985	1986	1987
GDP (Kip million in 1986 price)	50,603	53,861	58,774	62,892	60,482

Growth rate (1982-1986)	:	6.4 % per annum	
GDP per capita (1986)	:	177 US$	
Use of resource (1986)	:	GDP (Y=C+S)	100.0 %
		Consumption (C)	103.3 %
		Domestic Savings (S)	-3.3 %
		Investment (I)	16.3 %
		Resource Gap (I-S)	19.6 %

5. Structure of Production

Sector	Share of GDP	Share of Employment
Agriculture & Forestry	65.2 %	80.0 %
Industry	14.0 %	2.2 %
Services	20.8 %	17.8 %

6. Foreign Trade (1986)

Export	US$ million	(%)
Electricity	27.8	56.3
Wood & wood products	8.7	17.6
Coffee	5.9	12.0
Others	6.9	14.1
Total	49.3	100.0

Import	US$ million	(%)
Petroleum products	34.0	35.4
Machinery & vehicles	29.5	30.7
Raw materials	9.0	9.4
Others	23.4	24.5
Total	95.9	100.0

7. External Aid Disbursement

(Unit: US$ million)

Year	1984	1985	1986
from Capitalist countries	36.8	57.5	46.8
from Socialist countries	45.6	54.2	39.4
Total	82.4	111.7	86.2

8. External Public Debt Disbursed and Outstanding

(Unit: US$ million)

Year	1984	1985	1986
from Capitalist countries	128.3	141.2	166.8
from Socialist countries	385.3	482.9	573.6
Total	513.6	624.1	740.4

9. Exchange Rate (as of Dec. 1988)

US$ 1.00 = Kip 450 (State Bank of Lao)

Sources:
1. World Bank, *Lao People's Democratic Republic ,Country Economic Memorandum*, June 1988
2. FAO, *Production Yearbook 1986*
3. Data obtained from Ministry of Economic Planning and Finance, Lao PDR

SUMMARY

INTRODUCTION

01 This is the Final Report for the Feasibility Study on "Agricultural and Rural Development Project in the Suburbs of Vientiane" (the Project), prepared in accordance with the "Scope of Work for the Project" agreed upon between the Ministry of Agriculture and Forestry of Lao PDR (MAF) and Japan International Cooperation Agency (JICA) on March 28, 1988. The report presents the comprehensive results of the feasibility investigation and study carried out by JICA from August 1988 to March 1989.

02 The "Scope of Work" concluded between MAF and JICA on March 28, 1988 is outlined as follows:

(i) Study area

The area covers a net irrigation area of 2,700 ha (consisting of the originally-planned area of 1,700 ha and the extension area of 1,000 ha), which lies on the right bank of the Nam Ngum river and extends from the river to the area adjacent to the north of Vientiane city along the national roads of routes 10 and 13.

(ii) Objectives of the study

To formulate an optimum pumping irrigation project with emphasis on irrigation and drainage development, agricultural development and rural development, and to verify the technical and economic feasibility of the Project.

BACKGROUND

03 Lao PDR is one of the least developed countries in the world, its per capita GDP in 1986 being US$177 equivalent. The economy is dominated by agriculture, mainly subsistence rice farming, which produces 65% of GDP and involves some 80% of the work force.

04 Most of the agricultural production is carried out on a small holder basis under the rainfed conditions. Consequently, the production is vulnerable to varying climatic conditions and yields are among the lowest in Asian countries.

05 Rice occupies more than 70% of the cultivated area, and most of this rice is of glutinous varieties. The planted area in the rainy season is about 650,000 ha, while that in the dry season is about 10,000 ha. Over the period of 1985-87, the annual production of rice averaged 1,350,000 tons. Though the rice production has been steadily increasing, the country still imports more than 20,000 tons of rice mainly from Thailand.

06 In 1986, the Government of Lao PDR commenced the Second Five Year Development Plan (1986-1990). This plan contains government commitment to a New Economic Policy which involves a comprehensive series of economic reforms covering agricultural price policy, adjustments of wage levels and introduction of profit-oriented principle to public enterprises. The major objectives of the policy in the agricultural sector of the plan are:

(i) To secure self-sufficiency in rice and maintain adequate security stocks
(ii) To diversify agriculture by expanding production of non-rice crops for domestic consumption and for export
(iii) To increase exploitation and improve conservation of forest resources, with particular emphasis on controlling and gradually reducing slash and burn agriculture

THE PROJECT AREA

07 The Project area covering an area of 4,750 ha in gross has, for the most part, a gently sloping topography from north to south with a slope of 1/1,000 to 1/2,000, except for the eastern border area which has steeper slopes of 1/200 to 1/500. The elevation of the area ranges from EL 171 m to EL 164 m.

08 Located in the tropical monsoon area, the Project area has a climate characterized by two distinct seasons, namely the rainy season from May to October and the dry season from November to April. Annual mean rainfall (1967-1987) is 1,608 mm, of which 1,450 mm or 90% falls in the rainy season. Monthly mean temperature varies seasonally with a minimum of 16.7°C in January and a maximum of 34.1°C in April. Annual mean temperature is therefore 26.5°C.

09 The Nam Ngum river is one of the major tributaries of the Mekong river. The catchment area of the Nam Ngum is 16,500 km^2 at Ban Tha Ngon. Mean monthly discharge of the river at Ban Tha Ngon varies from 210 m^3/sec in January to 1,843 m^3/sec in June, averaging 680 m^3/sec. The quality of the river water has proved excellent for irrigation.

10 Geologically the Project area consists of talus, terrace, and alluvial deposits developed on base rock of red bed and evaporite formed in the Tertiary or Quaternary Period. Hydro-geologically, the talus, terrace, and alluvial deposits are aquifers, while the red bed and evaporite are impervious. According to the hydro-geological investigation, there are two possible sites for tubewells, each with an expected yield of 1.8 lit/sec in Ban Phone Thong area.

11 The soils in the Project area are classified into three groups in conformity with FAO/UNESCO soil classification system, i.e. Fluvisols, Gleysols and Acrisols. Acrisols covers about 97% of the area. The effective soil depth is limited by a laterite layer and the texture of the top soil ranges from sandy loam to clay.

12 Land classification of the Project area is made in accordance with the system adopted by the National Institute of Agricultural Science of Japan. Out of the total area of 4,750 ha, 4,277 ha is evaluated as suitable for paddy cultivation, and 3,625 ha is suitable for cultivation of upland crops under irrigated conditions.

13 There are 12 villages in the Project area, i.e. 8 in Saythany District and 4 in Saysetha District. The total population is 12,257 (as of 1988), and its growth rate is estimated at 2.9% per annum. The total number of households is 2,052 and the average family size is 6.0 persons per household. The average available labor force for agriculture is estimated to be 2.6 persons per household.

14 The Project area is occupied mostly by paddy field (64%) and forest land (30%). The present land use in the Project area is as follows:

Category	Originally-Planned Area (ha)	Extension Area (ha)	Total (ha)	Proportional Extent (%)
Paddy field	2,259	771	3,030	64
Grass land	34	17	51	1
Forest	435	983	1,418	30
Village	179	28	207	4
Road	17	11	28	1
Fish pond	8	-	8	0
River/stream	8	-	8	0
Total	2,940	1,810	4,750	100

15 The paddy cultivation is in a labor intensive form of agriculture. Farming works are generally carried out by family workers. Buffaloes are often used for land preparation. Apart from simple equipment like plow and sickle, agricultural equipment is not commonly used.

16 The paddy rice planted is mostly of the glutinous variety. The present unit yield is estimated at about 1.5 tons/ha for rainy season paddy and 2.5 tons/ha for dry season paddy on the average. Annual production of paddy in the entire Project area is estimated to be about 4,900 tons in total. Most of this is used for home consumption.

17 All the land belongs to the National Community of Lao PDR. However, the people are allowed to own, rent and transfer land-use rights. Of the registered land owners in the Project area, about 90% cultivate the registered land themselves, while the remaining owners rent this right to other village farmers. The farm size in the Project area is estimated to be 1.6 ha per household.

18 Agricultural extension services in Lao PDR are under the direction of the Department of Information and Communication of Agricultural Technology of MAF at national level and Service of Agricultural and Forestry of provinces and districts at local level. Most extension activities are carried out by provincial and district staff. Despite the efforts made to strengthen extension services, both the number of extension workers and their capability have not yet reached a satisfactory level. Regarding agricultural credit, the State Bank of Lao (SBL) is only the formal source of credit and it is now preparing a new agricultural credit project, aimed at expanding credit services in rural areas.

DEVELOPMENT PLAN

19 The objectives of the Project are:

(i) To increase rice production and ease the chronic shortage of rice in the Vientiane Municipality and its neighboring area.
(ii) To produce upland crops to meet the increasing demand resulting from the promotion of agro-industrial development and export-crop cultivation, in line with the Government's crop diversification policy.
(iii) To provide rural infrastructures for enhancement of social and agricultural activities of farmers.
(iv) To improve the living standard of farmers by raising incomes, and providing rural infrastructures.
(v) To earn or save foreign currency for the Government by reduction of rice imports and production of export crops.

20 In order to achieve these objectives, the Project comprises three development plans, namely an irrigation and drainage development plan, an agricultural development plan and a rural development plan. The irrigation and drainage development plan is to make year-round irrigation possible on a net irrigation area of 2,700 ha through the provision of irrigation and drainage facilities and farm roads. The agricultural development plan will facilitate double cropping of paddy rice in one year, partly intercropped with upland crops, by introducing improved farming practices. The rural development plan consists of the provision of potable water supply facilities in villages, and the rehabilitation and improvements of village roads.

IRRIGATION AND DRAINAGE DEVELOPMENT

21 The net irrigation area of the Project is 2,700 ha, consisting of the originally-planned area of 1,700 ha (the area previously proposed by MAF) and the extension area of 1,000 ha. The source of the irrigation water for the Project is the Nam Ngum river. Since the river water level is much lower than the elevated Project area, the use of irrigation pumps for the irrigation of the Project area is inevitable.

22 Crop water requirements for the Project are estimated for the proposed cropping pattern by the modified Penman method, using the climatic data in Vientiane. Applying the estimated overall irrigation efficiencies of 61% for paddy fields and 47%

for upland fields, the peak diversion water requirements are estimated at 4.86 m^3/sec for the entire irrigation area or 1.8 lit/sec/ha.

23 In order to determine the most appropriate pump irrigation layout, a comparative study is made from technical and economic viewpoints for the following plans:

Plan-I : The main pump station is designed to lift the Nam Ngum river water to a high point so that sufficient water head is secured to irrigate the whole irrigation area of 2,700 ha by gravity.

Plan-II : The main pump station is designed to lift the river water to a point with an elevation just sufficient to irrigate the low-lying land of 1,700 ha by gravity. For the irrigation of the remaining 1,000 ha, booster pump stations are to be provided to relift water from the regulation pond and a canal.

The study result shows that Plan-II is more economical than Plan-I in both direct construction cost and annual cost. Further, Plan-I requires a higher embankment and a longer syphon structure for the headreach than Plan-II, making the operation and maintenance works more complicate and difficult. Taking all these factors into account , Plan-II has been adopted.

24 The proposed irrigation facilities will comprise a main pump station, two booster pump stations, a regulation pond, a headreach, and main, secondary, tertiary and field canals with related structures. The irrigation water will be lifted at the main pump station located on the right bank of the Nam Ngum river and will be conveyed through the 11.4 km-long headreach to the regulation pond with an effective capacity of 110,000 m^3. Two main canals, i.e. the west canal No.1 and the east canal, will start from the pond. The west canal No.2 will branch off from the west canal No.1 at about 600 m downstream of the pond. The west canal No.1 will command an irrigation area of 1,640 ha, including the command area of the west canal No.2. The east canal will cover 770 ha, and an area of 290 ha scattered along the headreach will be supplied with irrigation water directly from the headreach.

25 The booster pump station No.1 will be located at the head of the east canal, whereas booster station No.2 will be on a secondary canal of the west canal No.1. The command areas of booster stations No.1 and No.2 are 770 ha and 230 ha

respectively. The irrigation water from the main canals and booster pump stations will mainly be distributed to farmlands through secondary, tertiary and field canals.

26 Drainage requirements for the Project are estimated separately for paddy fields and for non-paddy fields based on the probable daily maximum rainfall (164 mm) with a return period of 10 years. Assuming that submergence of a field for two days will not affect paddy yield, the drainage requirements for paddy fields are estimated at 5.4 lit/sec/ha. Since storage function is not expected of non-paddy fields, the drainage requirements for these fields is considered to be the peak runoff caused by design rainfall and are estimated separately for the 26 sub-areas. The estimated drainage requirements for non-paddy fields vary according to the size and topography of the respective sub-areas; average unit requirements being 12.3 lit/sec/ha.

27 The proposed drainage facilities consist of main, secondary, tertiary and field drains with related structures. Generally, excess water collected by field drains will be conveyed by tertiary, secondary and main drains and will be drained into natural rivers. For the drainage system, the Project area is broadly divided into two areas, namely the northern area located north of national road 13 and the southern area. In the northern area, water will be drained to the Nam Ngum river through the Houei Gnang and the Nam Kho rivers, while in the southern area it will be drained into the Mekong through the Houei Ma Hiao river.

28 For betterment of social and agricultural activities of farmers, as well as for smooth operation and maintenance of the Project facilities, farm roads will be provided along all the canals. The farm roads along the headreach and the main and secondary canals will be laterite-paved roads with a width of 4.5 m, while those along tertiary and field canals will be 3.0 m-wide unpaved roads.

29 The Project area includes forest land of 880 ha, which will be reclaimed and used as paddy fields under the Project. In reclaiming the land, land clearing and rough levelling will be conducted under the Project but the final levelling and finishing of the fields will be carried out by land owners. The recommended standard size of farm plot is 0.3 ha with a dimension of 100 m x 30 m. No land consolidation works are proposed for the existing paddy fields in the Project area, except for 64ha in the demonstration farm.

30 Under the Project, the construction of a demonstration farm has been proposed. The purpose of the farm is to execute (i) field trials and demonstrations of irrigated paddy

cultivation, improved farming practices, water management and use of farm machinery, and (ii) seed multiplication. The demonstration farm will have a net area of 64 ha, and the proposed site is located near to Ban Don Noun and Ban Xai. The farm will be provided with a warehouse for storage of agricultural equipment, seeds and other agricultural inputs.

AGRICULTURAL DEVELOPMENT PLAN

31 Paddy rice is proposed as the principal crop in both rainy and dry seasons in view of the fact that the climate and soils prevailing in the Project area are suitable for rice cultivation and that the demand for rice is still large in the Vientiane Municipality. Upland crops such as soybean, groundnuts and garlic are also proposed to be cultivated in the dry season, taking into account the Government's policy on crop diversification as well as the increasing demand from agro-industries for raw materials. The proposed land use may be summarized as follows:

Land Use	Originally-planned Area (ha)	Extension Area (ha)	Area (ha)
Paddy rice			
Rainy season paddy	1,700	1,000	2,700
Dry season paddy	1,432	718	2,150
Upland crops			
Soybean	170	180	350
Groundnuts	78	82	160
Garlic	20	20	40

32 With the introduction of improved farming practices under an assured irrigation supply as well as proper water management, crop yields will substantially increase. The anticipated crop yields are set out below:

Rainy season paddy	:	4.5 tons/ha
Dry season paddy	:	5.5 tons/ha
Soybean	:	2.0 tons/ha
Groundnuts	:	2.5 tons/ha
Garlic	:	7.0 tons/ha

33 Crop production will increase gradually during the build-up period of 5 years after completion of the construction works. The incremental annual crop production at the full development stage is estimated as follows:

(Unit: tons)

Crops	Without Project	With Project	Incremental Production
Rainy season paddy	4,545	13,202	8,657
Dry season paddy	348	11,825	11,477
Soybean	-	700	700
Groundnuts	-	400	400
Garlic	-	280	280

34 The net incremental benefit of the Project is defined as the difference between the respective net production values under future "with" and "without" project conditions. The estimated net incremental benefit is as follows:

(Unit: US$1,000)

Crops	Without Project	With Project	Incremental Production
Paddy rice	687	4,188	3,501
Soybeans	-	179	179
Groundnuts	-	74	74
Garlic	-	65	65
Total	687	4,506	3,819

RURAL DEVELOPMENT PLAN

35 The present conditions of such basic rural infrastructures as village roads, potable water supply facilities and post-harvest facilities have been examined for 12 villages located in the Project area. As a result, the existing post-harvest facilities proved of sufficient capacity to deal with the expected agricultural production resulting from the Project. Therefore, no provision of additional facilities is proposed.

36 The existing village roads in the Project area are in poor condition. In order to improve these roads, improvements and provision of 14 drainage culverts are proposed under the Project for a total length of 6.7 km.

37 Potable water supply in the Project area relies entirely on shallow dug wells with a depth of 3 m to 5 m. Of the 12 villages in the Project area, six villages face serious shortage of potable water supply; per capita supply in those villages being around 12 lit/day. In order to ensure enough potable water supply for these six villages, the following is proposed:

(i) Provision of distribution pipe lines, branching off from the main pipe line of the Vientiane municipal water supply system, already extended to the Project area along national road, route 13. Three villages, Ban Don Noun, Ban Xai and Ban Na Khe will benefit from this work.

(ii) Construction of two deep tubewells, to be located near Ban Phone Thong. Ban Sok Nhai, Ban Sok Noi and Ban Na Biene will benefit from this work.

PROPOSED PROJECT WORKS

38 The principal features of the proposed Project works may be summarized as follows:

(i) Main pump station

Design discharge	:	4.86 m^3/sec (0.81 m^3/sec x 6)
Pump, Type	:	Inclined pump (mixed flow)
Size	:	600 mm dia.
Nos.	:	7 units including standby
Rated water head	:	28.2 m
Motor output	:	380 kw x 7
Delivery pipe	:	1,000 mm dia. x 55 m
		1,200 mm dia. x 55 m
Transmission line	:	1.0 km

(ii) Booster pump station No.1

Design discharge	:	1.85 m^3/sec (0.925 m^3/sec x 2)
Pump, Type	:	Mixed flow pump
Size	:	700 mm dia.
Nos.	:	3 units including standby
Rated water head	:	6 m
Motor output	:	80 kw x 3
Delivery pipe	:	1,000 mm dia. x 340 m

	Transmission line	:	2.0 km

(iii) Booster pump station No.2

	Design discharge	:	0.56 m^3/sec (0.28 m^3/sec x 2)
	Pump, Type	:	Mixed flow pump
	Size	:	400 mm dia.
	Nos.	:	2 units
	Rated water head	:	2.4 m
	Motor output	:	10 kw x 2
	Delivery pipe	:	500 mm dia. x 20 m
	Transmission line	:	350 m

(iv) Regulation pond

	Storage capacity	:	110,000 m^3
	Pond surface area	:	11 ha

(v) Headreach

	Design discharge	:	4.86 m^3/sec - 4.34 m^3/sec
	Canal type	:	Concrete-lined canal
	Total length	:	11.4 km
	Canal structures	:	41 nos.

(vi) Main irrigation canals

	Design discharge	:	2.94 m^3/sec - 0.44 m^3/sec
	Canal type	:	Unlined earth canal
	Total length	:	19.3 km
	Canal structures	:	78 nos.

(vii) Secondary irrigation canals

	Design discharge	:	0.69 m^3/sec - 0.12 m^3/sec
	Canal type	:	Unlined earth canal
	Total length	:	20.8 km
	Canal structures	:	92 nos.

(viii) Drainage canals

	Main drains	:	8.9 km
	Secondary drains	:	30.5 km
	Drainage structures	:	54 nos.

(ix) Farm roads

Main roads	:	31.0 km
Secondary roads	:	21.0 km

(x) On-farm works

Tertiary and field canals	:	256.7 km
Tertiary and field drains	:	235.3 km
Tertiary and field roads	:	270.0 km
Land clearing and levelling	:	880 ha

(xi) Demonstration farm

Land consolidation	:	64 ha
Farm tractor	:	3 units
Warehouse	:	1 unit (700 m2)

(xii) Rural infrastructures

Deep tubewell	:	2 nos. 150 mm dia.
Distribution pipe line	:	8.5 km
Water supply tap	:	43 nos.
Village roads	:	6.7 km
Drainage culverts	:	14 nos.

39 The implementation of the Project is proposed in the following two stages:

Stage-I : Main pump station (civil works and 4 units of pump), headreach, and all other facilities for the originally-planned area of 1,700 ha, including demonstration farm and rural infrastructures

Stage-II : Remaining portion of main pump station, booster pump stations and all other facilities for the extension area of 1,000 ha.

The estimated construction period is three years in total.

40 The total construction cost for the Project is estimated at US$29.1 million equivalent, comprising US$26.1 million of foreign currency and US$3.0 million equivalent of local currency. The costs of the respective construction stages are summarized below:

(Unit: US$1,000)

	Items	Stage-I (1,700 ha)	Stage-II (1,000 ha)	Total
(1)	Preparatory works	233	210	443
(2)	Pump stations	2,118	2,882	5,000
(3)	Headreach w/pond	5,760	-	5,760
(4)	Major canals and drains	2,887	1,222	4,109
(5)	On-farm works	3,984	3,164	7,148
(6)	Rural infrastructures	358	-	358
(7)	Project office	154	-	154
(8)	Demonstration farm	156	-	156
(9)	O&M equipment	701	-	701
(10)	Engineering services	1,499	774	2,273
(11)	Contingencies	1,968	1,007	2,975
	Total	19,818	9,259	29,077

ORGANIZATION AND MANAGEMENT

41 MAF will be responsible for implementation of the Project. For the smooth implementation of the Project, it is recommended that MAF establish an executing agency (Project office) and, at the same time, organize a coordination committee comprising representatives of the relevant ministries, departments and offices.

42 After completion of the construction works, the Project will be transferred to Vientiane Municipality, and both the Project office and the coordination committee will be under authority of the governor of the Municipality. MAF will be a member of the coordination committee and will assist the Project office in operation and maintenance of the Project.

43 The Project office will be responsible for operation and maintenance of major facilities such as main pump station, headreach, regulation pond, booster pump stations, main and secondary canals, drains and farm roads. The operation and maintenance as well as the water management for on-farm facilities will be entrusted to the water users' associations, to be organized on a tertiary canal basis.

PROJECT EVALUATION

44 The economic feasibility of the Project has been evaluated in terms of the economic internal rate of return (EIRR) and the net present value (NPV) at the discount rate of

8% per annum. In the evaluation, the economic useful life of the Project is assumed to be 50 years and the exchange rate of US$1.0 = Kip 450 has been used. The results of the calculation are as follows:

EIRR : 11.1%
NPV : US$8,382,200 equivalent

45 In order to evaluate the feasibility of the Project in the event of possible future changes in economic conditions, sensitivity analysis has been made for the following cases:

Case-1 : 10% increase of the Project cost
Case-2 : 10% decrease of the Project benefit
Case-3 : Two years overrun of the build-up period
Case-4 : Two years overrun of the construction period

The effects of these changes on EIRR and NPV are summarized below:

Case	EIRR (%)	NPV 8% (US$ thousand)
Case-1	10.1	6,107.1
Case-2	10.0	5,268.9
Case-3	10.6	7,291.6
Case-4	10.2	6,256.6

46 The results of the economic evaluations indicate that the Project has a high economic viability and is insensitive to the possible changes in basic assumptions for the economic evaluations.

47 In addition to the direct benefits assessed in the economic evaluation, various secondary and intangible benefits are expected from the implementation of the Project. Among the major secondary and intangible benefits are (i) enhancing economic and social activities, (ii) meeting basic human needs, (iii) securing a stable food supply, (iv) increasing employment opportunities and (v) saving of foreign exchange.

RECOMMENDATIONS

48 The feasibility study shows that the Project is technically sound and economically viable. It is strongly recommended that for successful implementation and management of the Project MAF make the necessary arrangements including the following:

(i) to make arrangements for obtaining loan or grant aid from an international organization or possible donor countries.
(ii) to make arrangements for establishing a Project office, to be staffed by an adequate number of qualified personnel.
(iii) to strengthen and intensify present agricultural support services, and
(iv) to make arrangements for obtaining technical aid from a bi-lateral or international organization, including technical assistance by foreign experts and/or volunteers, and overseas training of Lao staff.

FEASIBILITY STUDY
ON
AGRICULTURAL AND RURAL DEVELOPMENT PROJECT
IN
THE SUBURBS OF VIENTIANE

MAIN REPORT

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ABBREVIATIONS

Lao PDR	:	Lao People's Democratic Republic
MAF	:	Ministry of Agriculture and Forestry
JICA	:	Japan International Cooperation Agency
GDP	:	Gross Domestic Product
NPV	:	Net Present Value
EIRR	:	Economic Internal Rate of Return
L.S.	:	Lump Sum
EL	:	Elevation
WL	:	Water Level
EC	:	Electrical Conductivity
Fig.	:	Figure
No(s).	:	Number(s)

Length

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

Area

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

Electric Measure

V	:	Volt
kV	:	Kilovolt
W	:	Watt
kW	:	Kilowatt
MW	:	Megawatt
A	:	Ampere
kVA	:	kilovolt ampere
Hz	:	Hertz (cycle)
kWh	:	Kilowatt hour
MWh	:	Megawatt hour

Currency

US$	:	U.S. Dollar
¥	:	Japanese Yen

Volume

lit	:	liter
kl	:	kiloliter
m^3	:	cubic meter
MCM	:	million cubic meter

Weight

mg	:	milligram
g	:	gram
kg	:	kilogram
t	:	ton (= 1,000 kg)

Other Measures

ppm	:	Parts per million
%	:	Percent
HP,PS	:	Horsepower
℃	:	Degree centigrade
µS/cm	:	Microsiemens per centimeter
m^3/sec	:	Cubic meter per second
rpm	:	Revolutions per minutes
hr	:	Hour
min	:	Minute
meq/l	:	Mili equivalent per liter
mm/hr	:	Milimeter per hour

I. INTRODUCTION

1.1 Authority

This is the Final Report for the Feasibility Study on "Agricultural and Rural Development Project in the Suburbs of Vientiane" (the Project), which has been prepared in accordance with the "Scope of Work for Feasibility Study on the Project" agreed upon between the Ministry of Agriculture and Forestry (MAF) of Lao People's Democratic Republic (Lao PDR) and the Japan International Cooperation Agency (JICA). The feasibility investigation and study of the Project were carried out in Lao PDR over five (5) months from August 1988 to December 1988 in close cooperation with MAF. At the end of December, the Interim Report presenting all the investigation and study results, and basic development plans was submitted to MAF, and basic development plans proposed in the report were discussed between MAF and JICA. Although some comments were made, the said development plans were basically accepted by MAF. In January and February 1989, further study and analysis of survey and investigation results obtained in Lao PDR were made in Japan, and the Draft Final Report was prepared, taking into account some of the points raised by MAF. In March 1989, the Draft Final Report was accepted by MAF after some discussions with JICA. In this way, this report (Final Report) has been prepared as a comprehensive result of the Feasibility Study on the Project.

1.2 Project History

Lao PDR is a land-locked country with an area of 236,800 km^2. The country is bordered by Vietnam in the east, Thailand in the west, Kampuchea in the south and, Burma and China in the north, stretching more than 1,000 km in a north-south direction. About 80% of the country is mountainous. The cultivable land is about 9,000 km^2 corresponding to 4% of the total land, and is limited to plain and low-lying areas scattered along the Mekong river and its tributaries.

The main industry of Lao PDR is agriculture, which dominates the national economy, contributing about 65% to GDP and employing about 80% of work force. In addition, about 59% of total amount of exports consists of agricultural products such as coffee and logs. However, self-sufficiency in foodstuffs, especially rice, the staple food, was not attained until 1980.

Lao PDR made a great effort to attain self-sufficiency in foodstuffs and increase agricultural production for export through the 3-year plan (1978 - 1980). In 1980, the

country became self-sufficient in rice nationally. However, there has been an imbalance between demand and supply of rice at a regional level. In particular, people living in the Vientiane Municipality, where about 10% of the total population is concentrated, have suffered from a chronic shortage of rice, mainly because of insufficient transportation facilities. Although self-sufficiency was attained, rice production is still vulnerable to climatic conditions since most of the paddy fields are rainfed. Under these circumstances, the Government of Lao PDR launched the 1st 5-year plan (1981 - 1985) and the 2nd 5-year plan (1986 - 1990), aimed at (i) securing self-sufficiency of rice, (ii) maintaining adequate security stocks of foodstuffs and (iii) diversifying agriculture by expanding production of non-rice crops for domestic consumption and export. In line with these plans, the Government of Lao PDR took up "KM-6 project" located near Vientiane city aiming at irrigation of an area of 1,700 ha net, mainly to ensure a stable rice supply to the Vientiane Municipality, and has prepared its development plan and preliminary design.

The Government of Lao PDR then requested the Government of Japan to provide technical assistance for the feasibility study on the project. In response to the request of the Government of Lao PDR, the Government of Japan sent a JICA preliminary survey team to Lao PDR on March 23, 1988. The project has been envisaged by including an adjacent area of 1,000 ha net as "the Agricultural and Rural Development Project in the Suburbs of Vientiane" (the Project). The area which has already been designed is hereinafter called the "originally-planned area" and the area which has been newly added is hereinafter called the "extension area". The Scope of Work for the Study and the Minutes of Meeting were agreed upon and signed on March 28, 1988 between MAF and JICA. The agreed Scope of Work is set out in Attachment-1.

JICA dispatched the feasibility study team (the Team) for the Project to Lao PDR on August 3, 1988. The Team submitted their Inception Report to MAF describing the plan of operation for the feasibility study on August 5, 1988, and held the inception meeting with MAF on the same day. The plan of operation proposed by the Team was agreed by MAF, and the feasibility investigation and study were started in accordance with the agreed plan of operation.

The feasibility investigation and study were carried out until December 27, 1988. During the investigation and study in Lao PDR, the Team held regular progress meeting with MAF every Monday for mutual understanding on the investigation and study. On December 22, 1988, the Team submitted their Interim Report to MAF presenting the interim results of investigation and study including proposed basic development plans. On December 23, 1988, the Team held discussions with MAF and exchanged views on the basic development

plans proposed in the Interim Report. The Interim Report was basically accepted by MAF although some comments and suggestions were given. The Minutes of Meeting is given in Attachment-2. On the basis of the Report, and comments and suggestions given by MAF, further study and analysis were made in Japan in January and February 1989, and the Draft Final Report was prepared. After some discussions with JICA, MAF accepted the Draft Final Report in March 1989 as given in Attachment-3, and this Final Report was prepared.

1.3 Outline of "Scope of Work"

The "Scope of Work" agreed on between MAF and JICA on March 28, 1988 may be outlined as follows:

(i) Study area

The area covers a net irrigation area of 2,700 ha (consisting of the originally-planned area of 1,700 ha and the extension area of 1,000 ha), which lies on the right bank of the Nam Ngum river and extends from the river to the area adjacent to the north of Vientiane city along the national roads of routes 10 and 13.

(ii) Objectives of the study

- To formulate an optimum pumping irrigation project with emphasis on irrigation and drainage development, agricultural development and rural development, and to verify technical and economic feasibility of the Project.
- To undertake on-the-job training and transfer of knowledge to Laotian counterpart personnel in the course of the investigation and study.

(iii) Scope of the study

- Work I : Review of the existing topographic maps at a scale of 1/5,000 prepared by the Government of Lao PDR, and technical assistance in the preparation of topographic maps at a scale of 1/5,000 for the extension area.
- Work II : Data collection, review of previous preliminary study conducted by the Government of Lao PDR, execution of field surveys and investigations, and formulation of basic development plans for the Project.

- Work III : Analysis of the results of field surveys and investigations, further study on development plans and preparation of the feasibility study report.

(iv) Work schedule

The study is scheduled to be carried out over a period of about seven (7) months from August 1988 to February 1989. The study is to be carried out in two (2) stages; field work stage for five (5) months from August to December 1988, and home work stage for two (2) months from January to February 1989. Work I and Work II are to be completed in Lao PDR as field work and Work III is to be completed in Japan as home work. At the beginning of March 1988, Draft Final Report is to be prepared as a result of the study. Final Report is to be prepared within two (2) months after the receipt of comments from MAF on the Draft Final Report.

1.4 Activities of the JICA Study Team

In accordance with the plan of operation agreed between MAF and the JICA study team (the Team) which was given in the Inception Report, the Team finished Work-I and Work-II at the field work stage and completed Work-III at the home work stage. The main activities of the Team at the respective stages were as follows:

(1) Work-I

The existing topographic maps at a scale of 1/5,000 covering the originally-planned area, which were prepared by the Government of Lao PDR, were reviewed in August 1987, and preparation of topographic maps at a scale of 1/5,000 covering the extension area was commenced in September 1988 and finished in December 1988 under the technical guidance of the Team.

(2) Work-II

Field reconnaissance, data collection, and review of previous study and available drawings were made in Lao PDR by the Team from August 1988 to December 1988. In addition, the following field survey and investigation for the study were made:

- Installation of three gauging staves and measurement of river discharge

- Soil and land use survey
- Geological and hydro-geological survey by electric prospecting, test drilling and pumping-test
- Inventory survey of existing irrigation projects
- Field measurements of evapotranspiration, percolation, intake rate and seepage loss
- Agricultural survey
- Paddy yield survey
- Rural infrastructure survey
- Canal route and topographic survey
- Survey for unit price, construction materials and construction machinery
- Socio- and agro-economic survey
- Laboratory tests and analysis of earth materials, concrete aggregates, soils and water

On the basis of the above survey and investigation, study, analysis and preliminary design were made, and three basic development plans for (i) irrigation and drainage, (ii) agriculture and (iii) rural infrastructures, were formulated. The details of these plans were compiled in the Interim Report, submitted to MAF in December 1988.

(3) Work-III

Further study, analysis of survey and investigation results, and preliminary design were made in Japan and the Draft Final Report was prepared at the beginning of March 1988.

Throughout the field work, the Team was supported by counterpart personnel assigned by MAF in every aspect of activity. The Team made an effort to provide on-the-job training and transfer of knowledge in the course of the field work. In order to deepen mutual understanding and to exchange views on the Project, an inception meeting, an interim meeting and a meeting for the Interim Report were held on August 5, November 8 and December 23, 1988 respectively, between MAF and the Team. Furthermore, a regular weekly meeting was held every Monday. On March 13, 1989, a meeting was held for the Draft Final Report between MAF and the Team.

II. ECONOMIC AND AGRICULTURAL BACKGROUND

2.1 General Economic Situation

Lao PDR has a total land area of 236,800 km^2. The population as in 1987 was estimated at about 3.8 million and the population density about 16 persons per km^2. The growth rate of the population during the last decade was about 2.6% per annum. The population growth rate has been slightly accelerating recently and the present growth rate is estimated at 2.9% per annum.

Lao PDR is one of the 37 least-developed countries (LLDCs) in the world/1. The gross domestic product (GDP) was estimated at Kip 62,891 million in 1986, per capita GDP being Kip 16,900 (US$177 equivalent). The economy had been growing rapidly during 1982-86, recording an increase of 6.4% per annum. However, in 1987 the GDP fell by 3.8% due to the impact of the 1987 drought which drastically reduced agricultural production and electricity generation. Net material product and GDP estimated for 1982 to 1987 are shown in Table II-1.

The economy of Lao PDR is dominated by agriculture, mainly subsistence rice farming, occupying 65% of GDP and 80% of the labor force as shown below:

Sector	Share of GDP	Share of Employment
Agriculture	65.2%	80.0%
Industry	14.0%	2.2%
Services	20.8%	17.8%

Note : for year of 1986
Source : World Bank, 1988

Foreign trade in Lao PDR is characterized by a persistent disequilibrium and a large share of a few commodities, namely, electricity, logs and wood products, and coffee for export. They accounted for 56%, 18% and 12% respectively for all exports in 1986 and 30%, 32% and 21% in 1987. The official estimate for trading value is given in Table II-2 and the composition of export and import is given in Tables II-3 to II-6.

/1: Overseas Economic Cooperation Fund, Japan, *Overseas Economic Cooperation 1988*

2.2 Agriculture in Lao PDR

(1) General

Agriculture is the backbone of the national economy of Lao PDR. This sector employs about 80% of the national labor force, produces 65% of GDP, and accounts for a significant percentage of earnings from exports.

Most agricultural production is carried out on a family smallholder basis and most land is cultivated under rainfed conditions permitting only one paddy or upland crop per annum. Consequently, yields are low, among the lowest in Asia, though they have been steadily increasing. Of all the crops produced in Lao PDR, rice is predominant as the staple food of Lao people. Apart from rice, significant edible crops are maize, root crops and vegetables. Coffee and tobacco are also important crops with export potential. Forestry too is an important sector accounting for nearly 10% of the value of exports and providing the basis for the wood processing industry.

Tables II-7, II-8 and II-9 show outputs, planted area and yield of major crops during 1976-87.

(2) Rice production

Rice occupies more than 70% of the area cultivated and is produced by almost every farmer. Most of the rice grown is of the glutinous variety. According to official national statistics/1, the planted area in the rainy season is about 650,000 ha, of which 60% is lowland and 40% upland. In the dry season, about 10,000 ha or 1.5% of total rice area is planted using irrigation. Over 1985-87 yields of paddy averaged 2.7, 2.8 and 1.3 tons/ha respectively for lowland rainy season paddy, irrigated dry season paddy and upland paddy. The average production amounts during the same period were estimated at 1,018,000 tons, 28,000 tons and 304,000 tons respectively, in total 1,350,000 tons.

Though the production of rice has been steadily increasing and the amount of imported rice has decreased compared to that of the 1970s, the country continues to import more than 20,000 tons of rice, mainly from Thailand as shown below:

/1: State Committee of Economy, Planning and Finance, *Basic Data about the Social and Economic Development of L.P.D.R. 1986 ,1987* , 1987 and 1988

Imported Amount of Rice

Year	1978-1982	1983	1984	1985	1986	1987
(ton)	68,000	26,500	38,000	23,000	24,000	22,000

Source: FAO Trade Yearbook, 1983,1985,1897

(3) Other food crops

Non-rice food crops such as maize, root crops, vegetables and beans are generally planted in the backyards of farm households, mainly for home consumption. Surplus products are sold in local markets. The main constraints on production are the lack of water in the dry season and the lack of an adequate supply of good seed.

(4) Industrial crops

The main industrial crops in Lao PDR are coffee, tobacco, sugarcane, and cotton. They are planted in areas of about 14,300, 4,900, 3,800 and 5,600 ha. Production of these crops is severely affected by the destruction of plantations carried out before the foundation of Lao PDR in 1975 and subsequent neglect.

Coffee is the traditional export crop and is grown almost exclusively on the Boliven Plateau in the southern part of Lao PDR. The area under cultivation is rapidly increasing but the unit yield is falling due to renewal of coffee trees.

Tobacco is grown on the drainage-free levee soils of the Mekong River and its tributaries in the dry season, using hand watering techniques or small pumps. Yield and quality are rather low due to poor management and lack of input.

Sugarcane is grown on small plots by private farmers for sale in local markets. Production is small and some 5,000 tons of sugar are imported every year.

Cotton is grown on small plots under rainfed conditions in the upland areas. Harvested seed cotton is currently ginned by hand using small, locally manufactured wooden roller gins. Much of the fiber is spun into yarn and used in cottage industries at a village level.

(5) Forestry

The forestry sector is potentially of enormous importance to the Lao economy. Logs and wood products are the country's second largest foreign exchange earner after electricity. It is estimated that Lao PDR has approximately 11 million ha of forest and about 4.4 million ha of it is economically exploitable. Most of this is located in the lower Mekong river basin and stocks include red wood, mahogany, iron wood, teak and pine.

2.3 National Development Plan

(1) The Interim Three Year Development Plan

After foundation of Lao PDR, the Government launched an Interim Three Year Development Plan (1978-1980) in order to restore the deteriorated economy and to increase production. The objectives of the plan were to develop the agricultural sector and to reach self-sufficiency of food by 1980, to expand exports of forestry products, to construct national road, route 9 as an alternative route to the coast through Vietnam and to expand education and training.

During this period, the Lao economy achieved a substantial recovery and self-sufficiency in food was improved. Paddy production increased by 15% per annum from 1977 to 1980. GDP was estimated to have grown at the rate of 7% per annum in real terms during the same period/1. However, the recovery was limited to certain areas, and the economic infrastructure was still insufficient.

(2) The First Five Year Development Plan

In view of the continuing deficiencies, the Government planned to continue the priorities of the previous three years, and formulated the First Five Year Development Plan (1981-1985). This plan focussed on the construction of infrastructure (roads, electricity, irrigation) in order to remove the perceived constraints to growth in the productive sectors such as agriculture and industry. This plan was oriented towards investment and management by the public sector, such as the state and state enterprises. As far as the agricultural sector

/1: The World Bank, *Lao People's Democratic Republic Country Economic Memorandum* July 15, 1986,

was concerned, the plan focussed on increasing production of rice by expanding cultivation areas and introducing irrigation.

During the period 1981 to 1985, the GDP increased by 5.4% per annum in real terms/1. Agriculture was the main growth area mainly because of the increase in paddy production, largely as a result of favorable climate conditions. However, despite relatively large investment in the industrial sector, investment returns were much less than initially anticipated by the plan during this period. This may be due mainly to the inefficiency of state industry and discouragement of the private sector.

(3) The Second Five Year Development Plan

In 1986, the Government commenced the Second Five Year Development Plan (1986-1990). This plan contains government commitment to a New Economic Policy which involves a comprehensive series of economic reforms covering agricultural price policy, adjustments to wage levels and introduction of profit-oriented principles to public enterprises.

The stated objectives of the plan are:

(i) Agricultural diversification, with emphasis on exportable products and reform of agricultural price policies, which will improve farmers' terms of trade
(ii) Maintenance of fiscal and monetary stability, with priority to promotion of exports to improve trade and the balance of payments and stabilization of debts
(iii) Strengthening planning and economic management with emphasis on the reform of the public sector
(iv) Small and medium-scale projects consistent with implementation
(v) Expansion of implementation capacity, through training of professional and technical specialists
(vi) Improvement of access to rural areas through rehabilitation of major roads and rural feeder roads

/1: The World Bank, *Lao People's Democratic Republic Country Economic Memorandum* July 15, 1986

(vii) Control of inflation, giving priority to reduction of monetary expansion, control of public sector debt, and expansion of domestic savings

The objectives of the policy in the agricultural section of the plan are:

(i) To secure self-sufficiency in rice and maintain adequate security stocks
(ii) To diversify agriculture by expanding production of non-rice crops, livestock and fishery products for domestic consumption and exports
(iii) To increase exploitation and improve conservation of forest resources, with particular emphasis on controlling and gradually reducing slash and burn agriculture
(iv) To expand collectivization of agricultural production activities

The Second Five Year Plan gives priority to crop diversification and development of cash crops, livestock and forest products, while the First Five Year Plan focusses on increase of rice production. Targets for production increase during 1986-1990 are 29% for paddy, 71% for coffee, 200% for mungbean and soybean, 340% for tobacco, 90% for groundnuts/1

In order to achieve these targets, firstly intensive cultivation will be introduced. It is planned to intensify land use and introduce high yielding varieties of crops suitable for land condition of each area. Secondly irrigation facilities will be improved. Rehabilitation of the existing facilities, as well as construction of new facilities is planned. Small and medium size projects will be given a high priority in irrigation development. By 1990, the area irrigated during the dry season will be expanded to three times the size of that irrigated in 1985.

(4) New Economic Policy

The 4th Resolution of Government announced in 1986 places emphasis on the implementation of two main programs; namely, further increase in production of foodstuffs and reduction of slash and burn cultivation for eliminating forest destruction. In 1987, the New Economic Policy came into force stressing increase in agricultural production, in order to progress from a subsistence economy to a market economy, by promoting the following:

/1: The Resolution of 5th Plenum of Secretary of Lao PDR's Central Committee in 1988 (Laotian version)

- Subsistence and semi-subsistence
- Small goods production
- Private enterprise
- Joint-venture between the State and private sector
- State-enterprise and cooperatives

All of the above five types of economy have equal priority, and no subsidies are given to any of them. The usual one price system which depends on market forces and trade liberalization has been adopted in line with the new policy. Under the new policy, agricultural production is to be based on family farms.

III. THE PROJECT AREA

3.1 Location

The Project area of 4,750 ha gross is located on the Vientiane Plain between the Nam Ngum river to the north and the Mekong river to the south. The Project area extends southward from the Nam Ngum river to the Bueng Khat Kao swamp along the national road routes 10 and 13 as shown on the location map. The latitude north and longitude east of the Project area are 18°00' to 18°08' and 102°39' to 102°43', respectively. The area is very near Vientiane city, the southern boundary of the area being located only 6 km from the center of the city. Administratively the area belongs mainly to Saythany District and partly to Saysetha District of the Vientiane Municipality.

3.2 Topography

For the most part, the Project area has very gentle slopes of 1/1,000 to 1/2,000 from the north to the south. The eastern border area has only a gentle upward slope of 1/200 to 1/500 from the west to the east. The elevation of the area ranges from EL 171 m to EL 164 m and the area is intersected by rivers and streams. The main river to the north flows northwestward into the Nam Ngum river via the Nam Kho river, while rivers in the southern part flow into the Bueng Khat Khao swamp running into the Mekong river through the Houei Ma Hiao river.

3.3 Climate

The Project area is situated in the tropical monsoon climate zone, and the climate is characterized by a rainy season from May to October and a dry season from November to April. Annual mean rainfall in the area is 1,608 mm, of which 1,450 mm or about 90% falls in the rainy season. The average rainfall observed by the Vientiane meteorological station during 21 years from 1967 to 1987 is as follows:

(Unit: mm)

J	F	M	A	M	J	J	A	S	O	N	D	Total
7	12	36	76	228	269	295	302	290	79	11	3	1,608

The mean temperature is 26.5°C with a maximum of 34.1°C in April and a minimum of 16.7°C in January.

The mean relative humidity is 72% over the course of a year with a maximum of 79% in August and a minimum of 64% in March. The mean evaporation from Class - A pan is 4.2 mm/day with a maximum of 5.1 mm/day in April and a minimum of 3.7 mm/day in January and August.

Winds are very light throughout the year, the mean wind velocity being 1.7 m/sec. Daily sunshine hours average 6.7 hours, ranging from 4.3 hours in August to 8.3 hours in December and January.

The meteorological data of the Vientiane meteorological station are shown in Tables III-1 and III-2, and illustrated in Fig. III-1. Details of meteorology are given in Annex I.

3.4 Water Resources and Hydrology

3.4.1 General

In and around the Project area there are four principal rivers; the Nam Ngum river, the Mekong river, the Nam Kho river and the Houei Ma Hiao river. The Nam Ngum river is the source for irrigation of the Project. The others are related to the drainage of the Project. The location of these rivers is shown in the location map. Details of water resources and hydrology are given in Annex I, and the major features of these rivers are described below.

3.4.2 The Nam Ngum river

(1) General

The Nam Ngum river is one of the larger tributaries of the Mekong river. The catchment area of the river is 8,460 km^2 at the Nam Ngum dam constructed in 1971. This dam is located about 80 km upstream of Ban Tha Ngon. The catchment area of the river at Ban Tha Ngon is 16,500 km^2 and that at the confluence of the Mekong is 17,340 km^2. The monthly mean discharge of the Nam Ngum river at Ban Tha Ngon for 1972 to 1988 was as follows:

(Unit : m^3/sec)

J	F	M	A	M	J	J	A	S	O	N	D	Total
210	269	533	1,100	1,671	1,843	980	481	314	266	245	246	680

(2) Low flow

The low flow analysis was made on the basis of annual minimum daily discharge recorded at Ban Tha Ngon for 1972 to 1988. The frequency analysis was also made by applying the logarithmic Pearson Type III distribution to the results of the low flow analysis. As a result, the following relationships of low flow and frequency were obtained:

Discharge/Water Level	Return Period in Years			
	2	5	10	20
Discharge (m^3/sec)	166	91	73	60
Water level above sea level (m)	153.6	152.9	152.7	152.6

(3) Flood

The flood discharge was estimated on the basis of annual maximum daily discharge recorded at Ban Tha Ngon for 1972 to 1988. The frequency analysis was made by applying the logarithmic Pearson Type III distribution. The results are as follows:

Discharge/Water Level	Return Period in Years			
	5	10	50	100
Discharge (m^3/sec)	3,270	3,650	4,430	4,750
Water level above sea level (m)	166.6	167.2	168.4	168.6

(4) Water quality

The Team carried out a water quality analysis for the Nam Ngum river water. The results of this show that the water can be classified as C1-S1, according to

the standards of USDA (United States Department of Agriculture). The water is excellent for irrigation purposes.

3.4.3 Other rivers

(1) The Nam Kho river

The excess water from the Project area is finally drained into two rivers, the Nam Ngum river via the Nam Kho river, and the Mekong river through the Houei Ma Hiao river. The Nam Kho river, the upstream reach of which is called Houei Gnang, is located in the north of the Project area. It collects and drains the excess water of the northern part of the Project area to the Nam Ngum river.

(2) The Houei Ma Hiao river

The excess water from the southern part of the Project area is drained firstly into the Bueng Khat Khao swamp located on the southern boundary of the Project area. The Hong Seng river collects the excess water from the major part of the Vientiane city and joins the swamp upstream, at Bueng Khat Khao. The Bueng Khat Khao swamp is the upstream reach of the Houei Ma Hiao river which runs eastward for about 30 km to the Mekong river. At the end of the Houei Ma Hiao river, there is a flap-gated drainage outlet structure to prevent flood water from the Mekong river from flowing back into the Houei Ma Hiao river. The flood discharge from the Hong Seng river with a 10-year return period is about 30 m^3/sec, and that from the Project area and its neighboring area is 48 m^3/sec. Consequently, the flood discharge for the Bueng Khat swamp is estimated at 78 m^3/sec. Since the crossing structures of bridges and culverts in the Bueng Khat Khao have the capacity of 50 m^3/sec, the balance of the discharge causes inundation in the Hong Seng and the Bueng Khat Khao. The inundation period lasts for approximately three to four days.

The water level of the Bueng Khat Khao swamp during a normal rainy season is estimated at EL 164.0 m to EL 164.5 m at Ban Nong Nieng and EL 163.5 m to 164.0 m at Ban Sok Noi. The difference in water level relates to the hydraulic gradient of the Bueng Khat Khao of 1/7,000 to 1/11,000.

(3) The Mekong river

In order to protect Vientiane city and its vicinity from flooding by the Mekong, a dike of about 40 km with about 20 drainage outlet structures is being constructed under the Project of "Flood Protection and Reclamation of Swamp and Marsh Land in the Vietiane Plain". About 70% of the dike has already been constructed. The flood discharge of the Mekong river is estimated as follows:

(Unit: m^3/sec)

Return Period in Years			
5	10	50	100
19,300	20,800	23,700	25,000

3.5 Geology and Hydro-geology

(1) Geology

The Project area geologically consists of talus, terrace, and alluvial deposits, which were formed in the Tertiary to Quaternary periods on the red bed and evaporite of Mesozoic Cretaceous period. The red bed and evaporite which are the baserock of the area, are highly weathered because of the tropical climate and consist of reddish clay, sandy clay, and silt. They are partly exposed on a hilly area and a gentle slope area. This baserock is called "Xaysomboune formation" or "$K2^{x}b$".

The talus and terrace deposits are surface layers which slightly extend in to the area. They consist of unconsolidated clay, silt, sand and gravel which were transported by surface water or were produced by weathering. The alluvial deposit which is also a surface layer and is mostly unconsolidated clay, sand and gravel, extends in very low-lying area of the Bueng Khat Khao and the Houei Gnang rivers. The talus, terrace, and alluvial deposits are called "N_2-Q". A geological map of the Project area is shown in Fig. III-2. Details of the geology are given in Annex III.

(2) Hydro-geology

Electric prospecting was conducted by the Team in October and November 1988 for three areas: (i) Ban Dan Xang, (ii) Ban Dong Sang Hinh and (iii) Ban Phone Thong in order to sound out hydro-geological conditions. In Ban Phone Thong area, test drilling and pumping-tests were also conducted by the Team. As a result, the following hydro-geological conditions were clarified:

(i) The Xaysomboune formation which is relatively impervious, is a hydro-geological baserock as well as a geological baserock.

(ii) The talus, terrace, and alluvial deposits formed on the Xaysomboune formation are unconsolidated and are aquifers.

(iii) The maximum depth to the Xaysomboune formation is 8 m in Ban Dan Xang area, 8 m in Ban Dong Sang Hinh area and 28 m in Ban Phone Thong area.

(iv) Six underground valleys formed by the Xaysomboune formation are overlain by the N_2-Q formation. Groundwater moves in N_2-Q formation and concentrates in such underground valleys. There are three underground valleys in Ban Dan Xang area, one in Ban Dong Sang Hinh area and two in Ban Phone Thong area.

(v) Should groundwater be required in the Ban Dan Xang and Ban Dong Sang Hinh areas, it is proposed to dig shallow wells with a diameter of 1.5 to 2 m and a depth of 8 m in the underground valleys.

(vi) If groundwater is required in the Ban Phone Thong area, it is proposed to drill deep tubewells with a diameter of more than 250 mm and a depth of 30 m at two underground valleys. Tubewell points are defined as N-41 and N-33 shown in Fig. IV-15.

(vii) The groundwater yield at N-41 is estimated to be 1.8 lit/sec based on the pumping test and that at N-33 is assumed to be the same as the yield at N-41, taking into consideration the similarity of hydro-geological conditions at the two points.

Details of the hydro-geology are given in Annex III.

3.6 Soils and Land Classification

3.6.1 Soils

The soils in the Project area are classified into three groups in conformity with the FAO/UNESCO soil classification system i.e., Fluvisols, Gleysols and Acrisols.

(1) Acrisols (Ferric Acrisols)

The ferric acrisols extend broadly over the Project area (area covered; 4,623 ha). They develop on flats of ancient alluvial deposits and are prone to flooding in the rainy season. The mother rock is of silicate and it is weathered and leached to form illuviated layer clay. The effective soil depth is limited by the laterite layer formed through podosolization. The texture of the top soil ranges from sandy loam to clay. At present, the area covered by this soil is utilized for paddy cultivation during the rainy season. The soil depth should be examined before development of this area.

(2) Fluvisols

The area of this soil group is 68 ha, distributing to the lower area along the Bueng Khat Khao swamp whose elevation is lower than EL 164 m. This soil has developed from recent alluvial deposits on a narrow riverine depression. Drainability of the soil is poor and the ground water table is high even in the dry season. At present this area is used mainly for the cultivation of floating rice. Though the soil in this area is suitable for agricultural use, flood control and drainage improvements are vital if the land is to be utilized.

(3) Gleysols (Humic Gleysols)

The area of this soil group is 58 ha, narrowly distributed over the depression along the Houei Gnang river located in the northwestern part of the Project area. This soil develops on recent alluvial deposits. The effective soil depth is generally shallow. The seasonal floods during the rainy season are severe and the ground water table is relatively high throughout the year. At present rainy season paddy is cultivated. The soil in this area is considered suitable for paddy

cultivation but not for upland crops, because of its high moisture content and low permeability.

A soil map of the Project area is given in Fig. III-4. The extent of each soil unit is shown in Table III-5. The details are shown in Annex II.

There is no salinity problem for cultivation of crops in the Project area except in a very limited area around the salt-pits. There are five salt pits in the Project area. Of these only one is in use; the others are no longer used. The salt is contained in Tha Ngon formation and its lower layers formed at a depth of 40 to 50 m below ground. It does not come out spontaneously from these layers.

3.6.2 Land Classification

Land classification of the Project area was made in accordance with the land classification system devised by National Institute of Agricultural Science, Japan/1 . The land in the Project area was classified into four classes, i.e., I, II, III and IV for both paddy and upland crops. Classification was made by examining the following 13 factors for crop cultivation. Details are given in Annex II.

- Thickness of top soil
- Effective depth of soil
- Gravel content in top soil
- Easiness of plowing
- Permeability under submerged condition
- State of redox potential
- Wetness of land
- Inherent fertility
- Content of available nutrients
- Degree of hazard
- Frequency of hazard
- Slope
- Erosion

/1: National Institute of Agricultural Science, *Outline of Land Classification based on Soil Survey in Japan* , March 1977, Tokyo, Japan

The results of the land classification are shown in Fig. III-5 and areas of each class are given in Table III-6 and may be summarized as follows:

(Unit: ha)

Class		Originally-planned Area	Extension Area	Total
Paddy	Upland			
II	IV	2,260	1,365	3,625
III	IV	445	157	602
IV	IV	235	288	523
Total		2,940	1,810	4,750

Land, classified into classes I, II and III is considered suitable for agricultural development. As a result, 4,227 ha has been assessed as suitable for paddy cultivation. For the cultivation of upland crops, all of the land is unsuitable under present conditions. However, once the Project is completed and the dry conditions can be countered by irrigation, 344 ha will be classifiable into class II and 3,281 ha into class III.

3.7 Human Resources

The Project area covers 12 villages, of which eight are in Saythany District and four are in Saysetha District. The total population of the 12 villages was 12,257 in 1988. This population is regarded as being identical to that of the Project area. The population growth rate is estimated at 2.9% per annum. According to the population census in 1985, the economically active population from 15 to 60 years old is 48% of the total population. The total number of households in 12 villages is 2,052 and the average family size is estimated to be 6.0 persons per household. For 70% of households at least one member is engaged in agriculture. The average available labor force for agriculture is estimated to be 2.6 persons per household based on the farm interview survey, assuming the coefficient of labor force at 0.8 for female farmers and farmers older than 60 years old. The population, number of households and farm households of each village is shown in Table III-7.

3.8 Social Infrastructures

(1) Transportation

The road network in and around the Project area consists of asphalt-paved roads and unpaved roads. The asphalt-paved roads are national roads, routes 10 and 13 which are well maintained. The unpaved roads in the Project area branch off from the national roads and extend to the inner area. They lack both quality and number.

There are four river ports around Vientiane city: KM-4, Thanaleng, Thadua and Wat Chanh on the left bank of the Mekong river, which are located within a distance of 25 km from the Project area. These ports are used for international and domestic transportation of passengers and cargoes.

Wat Tai airport is located 10 km southwest of the Project area. Lao aviation and a few international airlines provide services to neighboring countries and domestic areas of Lao PDR.

(2) Potable water supply

The Vientiane city is mostly covered by the municipal water supply system of the Lao Water Supply Company (Bo Ly Sath Nam Papa Lao), taking the water from the Mekong river. The Project area is not provided with a water supply from the Lao Water Supply Company at the moment. However, one pipe line of the system with a capacity of 3.6 m^3/min has already been extended to a point near Ban Sa Phang Muk (so-called KM-9 point) from Vientiane city along national road route 13, and in December 1989 this line was further extended from the said point, northwards along the national road for a distance of 5 km. A water supply service to villages along the national road is expected to start within the next few years. Potable water for inhabitants in the Project area is taken mainly from shallow wells but these are not satisfactory because the number of wells and the amount of water from them are small.

(3) Power supply

Electric power is generated at the Nam Ngum hydropower station located 60 km directly northwest of the Project area and conveyed to Vientiane and other areas through transmission lines.

Electricity for inhabitants of the Project area is supplied by the existing 22 kV electric power line of Lao Electricity Company (Bo Ly Sath Fay Fa Lao), which branches off from the said transmission line..

3.9 Existing Irrigation Projects

In and around the Project area, there are eleven (11) irrigation projects with a total irrigated area of 4,330 ha. All these projects employ pump-irrigation and the irrigation area of one project ranges from 70 ha to 1,100 ha. Of the eleven (11) projects, four (4) projects: Kao Liao II, Pakpa Sack, Phanh Manh and Hong Thong Projects take water from the Mekong river. The Kao Liao II project with an irrigation area of 1,000 ha is being operated as a Lao-Australian irrigation project. The Pakpa Sack project consists of only a pump station which lifts water from the Mekong river to the Hong Seng river in order to supply water to four downstream irrigation projects: Hong Seng I, Hong Seng II, Vieng Chareun, Sok Noi and Sam Khe projects located along the Hong Seng river and the Bueng Khat Khao swamp.

One (1) project of the remaining seven (7) projects takes water from the Nam Ngum river. This is the Tha Ngon irrigation project with an irrigation area of 610 ha, which was completed in 1974 and rehabilitated under grant aid from the Japanese Government in March 1989. The remaining six (6) projects take water from the Hong Seng river, the Bueng Khat Khao swamp and the That Luang marsh in the southern Vientiane Plain.

All the existing projects are listed in Table III-3 and their locations are shown in Fig. III-3.

3.10 Land Use and Agricultural Production

(1) Land use

The land in the Project area is classified into seven categories of land use, namely; paddy field, grass land, forest, village, road, fish pond and river. Present land use in the Project area is summarized below:

Category	Originally-planned Area (ha)	Extension Area (ha)	Total (ha)	Proportional Extent (%)
Paddy field	2,259	771	3,030	64
Grass land	34	17	51	1
Forest	435	983	1,418	30
Village	179	28	207	4
Road	17	11	28	1
Fish pond	8	-	8	0
River/stream	8	-	8	0
Total	2,940	1,810	4,750	100

Paddy field occupies 3,030 ha or 64% of the Project area. No other crop is cultivated on a large scale, though vegetables are planted in the backyards of farm houses. Present land use in the Project area is illustrated in Fig. III-6.

(2) Cropping pattern

The Project area is characterized as being a paddy mono-culture area. Most of the paddy fields are generally cultivated under rainfed conditions. In the dry season of 1987, only 139 ha of paddy fields located in the southern part of the Project area were irrigated and cultivated. No crops were grown on other lands during the dry season. The present cropping pattern is shown in Fig. III-7.

Rainy season paddy is planted at the onset of the rainy season, from May to June, and harvested from October to December. Transplanting is carried out from late June to late July. The cultivation of dry season paddy starts in late December or early January and ends in late April or early May. Transplanting is carried out in late January or early February.

(3) Farming practices

Paddy cultivation is carried out as a labor intensive form of agriculture from seeding to harvesting. Farming works are generally carried out by family workers though traditional labor exchange is common. Animal power, mainly buffaloes, is used extensively for land preparation. Apart from simple equipment

like plow or sickle, agricultural equipment is not commonly used. Fertilizer and agro-chemicals are on the whole scarce.

More than 70% of paddy grown in the Project area is glutinous rice, which is the staple food of the Lao people. Sampatong (glutinous) is the predominant variety being planted in 71% of the area, followed by Hom Mali (non-glutinous) which is planted in 23% of the area. Improved varieties such as RD16 are grown only in irrigated areas.

(4) Yield and production

The paddy yield and production under the present conditions are estimated on the basis of the farm interview survey and the yield survey. The present unit yield of paddy is estimated at 1.5 tons/ha for rainy season paddy and 2.5 tons/ha for dry season paddy. Such low yields are ascribed to irregular rainfall even in the rainy season, use of local varieties and lack of fertilizers. Present paddy production is estimated as follows :

Crops	Cultivated Area (ha)	Unit Yield (ton/ha)	Production Amount (ton)
Rainy season paddy	3,030	1.5	4,545
Dry season paddy	139	2.5	348
Total	3,169		4,893

3.11 Land Tenure and Farm Size

Since all land belongs to the National Community of Lao PDR, there is no land tenure system in Lao PDR. However, rent and transfer of land-use rights are permitted.

The average size of the farm household in the 12 villages is 1.6 ha. Of all the registered land owners in the 12 villages, 87.7% cultivate their registered lands themselves, and 7.8% live outside the villages and rent the land-use rights to village farmers. The remaining 4.5% of owners live in villages and rent the land-use rights to other village farmers. The distribution of the holding farm size over all the owners is as follows :

Land Holding Size	Percentage Distribution
0.5 ha and less	10.3%
0.5 - 1.0 ha	19.2%
1.0 - 1.5 ha	17.2%
1.5 - 2.0 ha	14.8%
2.0 - 3.0 ha	21.7%
more than 3.0 ha	16.8%

Most rent from land-use rights is in the form of the crop sharing in Lao PDR. In the Project area, the rent from land-use rights is generally 20% of total production.

3.12 Agricultural Support Service

(1) Agricultural research and seed multiplication

Research on rice and other crops centers on several stations located in Vientiane Plain. There are three main institutions for research and experiment: the Salakham Rice Research Station for rice research, the Agricultural Research and Experiment Station at Hat Dok Keo for research on non-rice crops and the Agricultural Research Center at Napok for research on both rice and non-rice crops. At the Salakham Rice Research Station, the main activities are to collect local varieties, test and screen IRRI varieties for suitability under conditions in Lao, and multiplying suitable varieties.

Seed multiplication of certified seeds is carried out at the above research stations and the Seed Production Center located adjacent to the Agricultural Research Center at Napok.

(2) Extension service

Agricultural extension services in Lao PDR are the responsibility of the Department of Information and Communication of Agricultural Technology of MAF at national level and the Service of Agriculture and Forestry of provinces and districts at local level. Most extension activities are made by provincial and

district staff. They visit villages periodically and give advice and information to farmers on improvement of farm practices and crop diversification.

Despite the promotion of aid-supported projects for strengthening extension services, the number of extension workers and their capability have not yet reached a satisfactory level for providing an adequate service.

(3) Agricultural credit

Agricultural credit has not yet been popularized among farmers in Lao PDR because of the subsistence farming practiced by most farmers. According to the result of the farm interview survey, only 4% of farmers interviewed seek credit in order to procure agriculture inputs. The State Bank of Lao (SBL) is the only formal source of credit in Lao PDR and no informal source of money lending exists.

At present the SBL is preparing a new agricultural credit project under the financial assistance of the International Fund for Agricultural Development (IFAD), aiming at the extension of credit services in rural areas. The credit will be provided to farmers through the District State Bank (a branch of the SBL) at an interest rate of 8% for short term loans (one year) and 6% for medium and long term loans (three years and seven years respectively).

(4) Farm inputs supply

Most inorganic fertilizers and agro-chemicals are imported by State Company Agro-Impex Lao, State Private Lao Phathana Import-Export Company and Societe du Commerce du Lao Import-Export. Imported goods are distributed to farmers through the provincial agricultural service, cooperatives and retail shops. Generally delivery systems are efficient but the quantities supplied are limited. However, the supply of farm inputs is expected to increase rapidly as a result of the revised policies on both trade and agricultural marketing.

(5) Agricultural cooperatives

The Government of Lao PDR has been attempting to collectivize agricultural production and encourage a cooperative movement. Accordingly, the number of cooperatives increased rapidly from 1,480 in 1978 to 3,703 in 1987.

Recently, the Government has revised its policy on the cooperative movement in line with its New Economic Policy, under which agricultural production is to be based mainly on family farms and cooperatives are expected to become the common purchaser of farm inputs, and to provide common use of farm machinery and sale of products.

At present, there are no agricultural cooperatives in the Project area, and only cooperatives for consumption are in operation.

3.13 Marketing and Prices

At present most of the paddy produced in the Project area is consumed by farmers. Only a small amount of surplus paddy is marketed. The marketable amount of paddy is purchased by Foodstuff Companies(district level) or private traders. Part of the procured paddy at the district level is supplied to district officials through the said companies after milling and the remaining is distributed to municipality officials and central government officials through the Foodstuff Company of the Vientiane Municipality and the Central Foodstuff Company. Private traders purchase paddy directly from farmers and sell it mainly at the market in Vientiane.

All surplus vegetables are purchased by private traders and sold at the market in Vientiane. Farm gate prices of farm products and inputs as of 1988 were estimated as follows:

	Description		Price
1.	Farm Products		
	Dried Paddy		50 Kip/kg
	Soybean		130 Kip/kg
	Groundnuts		60 Kip/kg
	Garlic		200 Kip/kg
2.	Farm Inputs		
	Seed	Paddy	55 Kip/kg
		Soybean	250 Kip/kg
		Groundnuts	250 Kip/kg
		Garlic(bulb)	500 Kip/kg
	Fertilizer	Urea	110 Kip/kg
		Ammophos	120 Kip/kg
	Agro-chemical	Diazion	720 Kip/kg
		Sevin	2,800 Kip/kg
		Foridan	850 Kip/kg
3.	Farm Labor		400 Kip/day

Source: Department of Cooperatives, MAF and farm interview survey

3.14 Farm Economy

At present, the total number of farm household in the Project area is 1,419. The average farm size is 1.6 ha and average family size is 6.0 persons per household. Farmers in the Project area generally rely on non-agricultural sources for a large part of their total income (about 40%). The result of farm budget analysis under present conditions may be summarized as follows:

(Unit: Kip/household/year)

Farm scale	1 ha and less	1 - 2 ha	more than 2 ha
Income	194,500	262,300	323,300
Farm income	109,000	135,700	213,000
Off-farm income	85,500	126,600	110,300
Expenditure	163,700	142,700	219,200
Farm expense	7,900	15,800	28,700
Agriculture Tax	4,200	8,400	15,300
Living expense	151,600	118,500	175,200
Net reserve	30,800	119,600	104,100

The above farm budget analysis indicates that not all farm households can earn enough income for their expenditure from agriculture, and must rely more on off-farm income for their cash expenses.

IV. THE PROJECT

4.1 General

The objectives of the Agricultural and Rural Development Project in the Suburbs of Vientiane are:

(i) To increase rice production to ease the chronic shortage of rice in Vientiane Municipality and its neighbouring area.

(ii) To produce upland crops, i.e. soybean, groundnuts and garlic to meet the increasing demand resulting from promotion of agro-industrial development and export-crop cultivation in line with crop diversification policy of the Government.

(iii) To provide rural infrastructures, i.e. potable water supply facilities and village roads, for betterment of social and agricultural activities in the Project area.

(iv) To improve living standards of farmers through increase in their farm production and incomes, and provision of rural infrastructures.

(v) To earn or save foreign currency for the Government by reduction of rice imports and production of export crops.

In order to achieve the above objectives, three development plans were formulated. The basic development concepts for respective plans are as follows:

(i) Irrigation and drainage development plan
To make possible year-round irrigation in a net area of 2,700 ha, by providing irrigation and drainage facilities including farm roads, and by reclaiming some forest land for paddy field.

(ii) Agricultural development plan
To make possible double cropping of paddy rice intercropped with soybean, groundnut and garlic by introduction of improved farming practice.

(iii) Rural development plan
To improve the present condition of the roads by rehabilitating existing village roads, and to ensure a supply of potable water by extending the existing municipal water supply line and drilling wells.

The main elements of the Project necessary for execution of the above plans would be as follows:

(i) Construction of irrigation and drainage facilities including farm roads
   - Major irrigation and drainage facilities
   - On-farm development work including land levelling work
(ii) Construction of rural infrastructures
   - Village road
   - Potable water supply facilities
(iii) Construction of a demonstration farm
(iv) Construction of a Project office
(v) Procurement of operation and maintenance equipment
(vi) Procurement of farm tractors for operation of the demonstration farm

The three development plans are detailed in Annexes IV, V and VI, and the Project facilities required for such development are shown in the Drawings (separate volume). The general descriptions of those plans are given in the following sub-chapters, and the principal features of major Project facilities are given in the Summary.

4.2 Irrigation and Drainage Development Plan

4.2.1 Alternative study on pump irrigation layout

(1) General

The net irrigation area of the Project will consist of the originally-planned area of 1,700 ha and an extension area of 1,000 ha. The originally-planned area is the irrigation area which was proposed in the original design made by MAF. Most of this area is existing paddy field located on flat land with a topographic slope of 1/1,000 to 1/2,000 and an elevation mostly ranging from EL 167 m to EL 164 m. The extension area is the irrigation area which has been proposed for further development. The area is mostly forest land located on a gentle slope with a topographic slope of 1/200 to 1/500 and an elevation of EL 171 m to EL 166 m.

The source of irrigation water for this area of 2,700 ha is the Nam Ngum river. Although this river has abundant water throughout the year, the water level of the river is too low for the gravity irrigation of the irrigation area. According to the hydrological study, the low water level of the river with 90% dependability is estimated at EL 152 m. Furthermore, 2,410 ha, the greater part of irrigation area, is located about 11 km far from the river, and a water head of several

meters is required only for conveyance of the water by canal. For the reasons mentioned above, the use of pumps is absolutely essential for the irrigation system of the Project.

(2) Alternative plan

On the right bank of the Nam Ngum river, a pump station would be provided to lift the river water. This station is hereinafter called "the main pump station". An irrigation canal would convey the pumped water to a regulation pond, which would be provided upstream of and near the greater part of the irrigation area, namely the 2,410 ha, to regulate the water according to irrigation operation. This canal is hereinafter called "the headreach". The larger part of the irrigation area, the originally-planned area of 1,410 ha and the whole extension area of 1,000 ha would be irrigated by the water to be released from the regulation pond. The remaining 290 ha, which are scattered along the headreach, would be supplied with irrigation water directly from the headreach.

In order to determine the most appropriate pump irrigation layout, the following alternative plans are compared from technical and economic viewpoints:

(a) Plan-I

The main pump station would be designed to lift the river water to a high point so that sufficient water head is secured to irrigate the whole irrigation area of 2,700 ha by gravity. Under this plan, the water head for the main pump station will be as high as 41 m, and the embankment of the headreach will inevitably become high.

(b) Plan-II

The main pump station would be designed to lift the river water to a point with an elevation just sufficient to irrigate the low-lying land of 1,700 ha (originally-planned area) by gravity. For the irrigation of the remaining 1,000 ha (extension area), booster pump stations would be provided to lift water from the regulation pond and an irrigation canal. The extension area consists of the eastern area of 770 ha and the western area of 230 ha. The water for the former would be pumped by booster pump station No. 1, while the water for the latter would be pumped by booster pump station

No. 2. Under this plan, the water head would be 28 m for the main pump station, 6 m for booster pump station No. 1 and 2.4 m for booster pump station No. 2.

A sketch and technical dimensions of the respective plans are shown in Fig. IV-1 and Table IV-1.

(3) Comparison

(a) Cost aspect

Cost comparison of those two plans is made for both direct construction cost and annual cost. The results are shown in the following tables:

Direct Construction Cost

(Unit: US$1,000)

Item	Plan-I	Plan-II
Main pump station	3,967	3,634
Headreach	7,952	5,600
Booster pump stations No. 1 & No. 2	-	1,366
Total	11,919	10,600

Annual Cost

(Unit: US$)

Item		Plan-I	Plan-II
(1)	Annual equivalent cost		
	- Civil work	211,200	156,000
	- Pumps & electrical work	165,100	203,600
(2)	Operation cost		
	- Electricity charges	184,500	135,000
	- Staff salary	1,100	3,300
(3)	Maintenance cost		
	- Civil work	4,100	3,100
	- Pumps & electric work	1,800	2,200
	Total annual cost	567,800	503,200

From the above tables, plan-II is found to be more economical than plan-I in both direct construction cost and annual cost.

(b) Technical aspects

Plan-I would require a high canal embankment with a height of 6 to 10 m for a reach of 4.8 km. In this study, a syphon is applied to such a reach instead of the high embankment canal for economic reasons. Plan-II also requires a high embankment, although the maximum height is about 6 m. A syphon is applied only to the crossing of national roads and rivers. The total syphon length is about 4,850 m for plan-I and 400 m for plan-II. Technically, a long syphon or excessively high embankment canal is not recommended for reasons of safety, smooth operation and maintenance work. For this reason, plan-II is technically more desirable than plan-I.

(4) Conclusion

On the basis of the above-mentioned comparative study, it is concluded that plan-II is economically and technically superior to plan-I and that plan-II should be adopted as the most appropriate pump irrigation layout for the Project.

4.2.2 Irrigation water requirements

(1) General

The crops proposed to be grown in the Project area are paddy rice and upland crops such as soybean, groundnuts and garlic. The irrigation water requirements for them are separately estimated based on the proposed cropping pattern. The irrigation water requirement consists of crop water consumption, irrigation losses and ancillary water demands for respective crops.

The irrigation water requirement for the crops was estimated on a monthly basis, using climatic data observed at Vientiane meteorological station during 20 years from 1968 to 1987.

The irrigation water requirement was estimated by the following procedure:

Paddy Rice

- Estimate of paddy rice water consumption (CU) from potential evapotranspiration calculated by climatic data and crop coefficients (Kc) varying with growth stages
- Estimate of percolation rate (P)
- Estimate of effective rainfall (ER)
- Estimate of nursery water (NW) and puddling water requirement (PW)
- Estimate of net irrigation water requirement (NR)
  NR = CU + P - ER + NW + PW
- Estimate of gross irrigation water requirement (GR) based on (NR) divided by irrigation efficiency

Upland Crops

- Estimate of crop water consumption (CU)
- Estimate of effective rainfall (ER)
- Estimate of net irrigation water requirement (NR)
  NR = CU - ER
- Estimate of gross irrigation water requirement (GR) based on (NR) divided by irrigation efficiency

(2) Water consumption

Water consumption by each proposed crop was calculated by multiplying potential evapotranspiration by crop coefficient (Kc). The potential evapotranspiration is calculated by the modified Penman method recommended in "Crop Water Requirements, FAO Irrigation and Drainage Paper No. 24, 1977 (FAO paper)" since this method is generally accepted as the most accurate formula. The crop coefficient (Kc) was also based on the FAO paper.

(3) Percolation

The percolation rate was estimated at 1.5 mm/day for the rainy season and 3 mm/day for the dry season, considering actual measurement result of percolation.

(4) Other water demands

(a) Puddling water requirement

The puddling water requirement consists of water equivalent to the difference in soil moisture before and after puddling, standing water required in soil surface, and evaporation and percolation losses from the paddy field. The amount largely depends on such factors as soil properties, puddling method and period, groundwater table in the paddy field, etc. Taking into consideration these factors, the puddling water requirement was estimated at 180 mm.

(b) Nursery water requirement

The nursery water requirement consists of water needed for preparation of the nursery bed, and evapotranspiration and percolation during the nursery period. The nursery water requirement was estimated at 420 mm, considering actual measurement results of evapotranspiration and percolation, and prevailing nursery method.

(5) Effective rainfall

Design rainfall for the estimate of water requirements is a probable minimum rainfall, corresponding to 1,243 mm in a year with a 10-year return period. The effective rainfall was estimated on a monthly basis, using the "monthly effective rainfall curve" developed by the Committee for Coordination of Investigation of the Lower Mekong Basin (so-called the Mekong Committee).

(6) Irrigation efficiency

The irrigation loss consists of farm application loss, operation loss and conveyance loss. The farm application loss of a paddy field is relatively small, but that in upland crop irrigation is significant since it includes percolation, surface runoff, etc. Taking into account the soil characteristics, topography, climate, irrigation practices and experience, etc., the application efficiency was assumed to be 85% for paddy rice irrigation and 65% for upland crop irrigation.

The operation loss is the irrigation water wasted due to improper canal gate operations and unskilled water management in the field. According to the results of measurements in irrigated paddy fields in South Asian countries, the total operation loss is 50 to 100% of net irrigation water requirement. Even after the canal operation practices and water management are improved through appropriate guidance to farmers, a certain amount of irrigation water, say 10-30% of net irrigation water requirement will be wasted. Considering these factors, operation efficiency is assumed to be 80%.

The canal conveyance loss is caused by seepage through the wetted perimeter of canal and evaporation from the canal water surface. The conveyance efficiency is estimated at 90% on the basis of actual measurements of canal conveyance loss carried out by the Team.

Overall irrigation efficiency is estimated at 61% for paddy rice irrigation and 47% for upland crop irrigation as shown below:

Irrigation Efficiency

Efficiency	Paddy Rice	Upland Crop
Application efficiency	85%	65%
Operation efficiency	80%	80%
Conveyance efficiency	90%	90%
Overall efficiency	61%	47%

(7) Diversion water requirement

The diversion water requirement was estimated by dividing the total net irrigation water requirement by the overall irrigation efficiency. The total net irrigation water requirement consists of the net irrigation water requirements for paddy rice and upland crops. However, since the net irrigation water requirement for upland crops is smaller than that for paddy rice, and the irrigation area for upland crops is much smaller than that for paddy rice, it is assumed in estimating the diversion water requirement that all the area is paddy field. This assumption is also made to accommodate possible future crop diversification. As a result, the maximum diversion water requirement is estimated at 4.86 m^3/s.

The net irrigation water requirements for rainy season paddy rice, dry season paddy rice and upland crops are shown in Fig. IV-2, IV-3 and IV-4.

The estimated monthly diversion water requirement for the Project is shown below:

Diversion Water Requirement

(Unit: m^3/sec/2,700 ha)

J	F	M	A	M	J	J	A	S	O	N	D
3.73	4.86	4.65	1.68	-	0.78	2.84	0.06	0.25	2.00	0.19	0.14
(1.8 lit/sec/ha)											

(8) Design discharge

The maximum diversion water requirement of 4.86 m^3/sec corresponds to 1.8 lit/sec/ha when pump operation and irrigation are made on a 24-hour per day basis. Design discharge for irrigation canals and related structures depends on pump operation and irrigation hours. In the existing irrigation projects, irrigation of paddy rice is carried out for 16 to 24 hours per day. However, night-time irrigation is poorly supervised by farmers, and as a result water is wasted and improperly distributed. 18-hour irrigation is therefore proposed for this Project taking into consideration practical irrigation hours.

In order to store irrigation water for the six (6) non-irrigation hours, a regulation pond is required. The regulation pond will be provided at a point about 11 km downstream from the diversion site. Two design discharges are determined as follows for the canals and related structures:

(i) Design discharge for main pump station and headreach:
1.8 lit/sec/ha
(ii) Design discharge for booster pump stations and all canals:
1.8 x 24/18 = 2.4 lit/sec/ha

4.2.3 Drainage water requirements

(1) General

The Project area will consist of paddy field and upland field. In the estimation of drainage water requirements the upland field is defined as of the non-paddy field type such as upland field, fallow land, forests, etc. Since the drainage characteristics of these lands are different, particularly in runoff time and runoff discharge, they are separately estimated for paddy field and for upland field. In this estimate, the estimated daily maximum rainfall with a 10-year return period is employed as design rainfall, namely 164 mm.

(2) Drainage water requirement for paddy field

In order to estimate the drainage water requirement for paddy field, the following need to be established:

- The submergence period allowed in the paddy field or the duration for draining excess water from the paddy field is two (2) days.

- Effective water depth and standing water depth in paddy fields are 100 and 30 mm, respectively.

Based on the above assumptions, the drainage water requirement was estimated at 5.4 lit/sec/ha as shown below:

$$Q = q \times A$$
$$q = RE24 \times 10\ m^2/(3{,}600\ sec \times 48\ hours)$$
$$= 0.058 \times 94 = 5.4\ lit/sec/ha$$
$$RE24 = R24 - (D1-D2) = 164 - (100-30) = 94\ mm$$

Where; Q = Design drainage water requirement (m^3/sec)
q = Unit drainage water requirement per ha
A = Drainage area (ha)
R24 = Design rainfall, 164 mm/day
D1 = Effective water depth in paddy field, 100 mm
D2 = Standing water depth in paddy field, 30 mm
RE24 = Excess rainfall to be drained, 94 mm

(3) Drainage water requirement for upland field

Rainfall water runs off from upland field immediately after rainfall. There is no storage function in the upland field. The drainage water requirement for the upland field is considered to be the peak runoff from the upland field. In order to estimate the peak runoff, the upland field including outer drainage area of the Project is divided into 26 subareas, taking into account topography and future layout of drains. The peak runoffs from those areas are individually estimated by applying a triangular unit hydrograph, and the unit drainage water requirement thus estimated averages 12.3 lit/sec/ha. The formula employed for the estimate is as follows:

$$qi = 2 \times Q / (Tp + Tr)$$

Where; Q = Total runoff in mm, 65.6 mm (40% of design rainfall)
qi = Peak rate in mm
Tp = Time in hour from start of rise to peak rate (D/2+L)
Tr = Time in hour from peak rate to end of triangle (2xTp)
Tb = Total time of hydrograph
D = Rainfall period in hour, 12 hours
L = Lag time from center of excess rainfall to peak time in hour to be determined by V.T. Chow's equation in "Handbook of Applied Hydrology"

4.2.4 Irrigation and drainage system

(1) Irrigation system

The irrigation facilities for supplying water to fields will consist of a main pump station, two booster pump stations, a regulation pond, a headreach, and main, secondary, tertiary and field canals with related structures.

The water for an entire irrigation area of 2,700 ha will be lifted from the main pump station located on the right bank of the Nam Ngum river and most of the water will be conveyed through the 11.4 km long headreach to the regulation pond with a capacity of 110,000 m^3. Two main canals will be started from the pond; west main canal No. 1 and east main canal. At 600 m downstream of the pond, west main canal No. 2 will branch off from the west main canal No. 1. The west main canal No. 1 will command 1,640 ha including a command area of the west main canal No. 2; 1,410 ha of the originally-planned area and 230 ha of the extension area. The east main canal will cover 770 ha of the extension area. The irrigation area of 290 ha, located along the headreach and included in the originally-planned area, will be covered by the headreach.

As mentioned in the alternative study on the pump irrigation layout, at the starting point of the east main canal, booster pump station No. 1 will be provided to supply water for the extension area of 770 ha and booster pump station No. 2 will be provided for the extension area of 230 ha on secondary canal W1-1 which branches off from the west main canal No. 1. The water will generally be conveyed from main canals to fields through secondary, tertiary and field canals. The general canal layout is shown in Fig. IV-5.

(2) Drainage system

The drainage facilities of the Project will consist of main, secondary, tertiary and field drains, and related structures. All water coming from the Project area will be drained by gravity. Generally, excess water collected by field drains will be conveyed by tertiary, secondary and main drains and drained into natural rivers. The Project area is largely divided into two with respect to drainage; the northern area and the southern area, divided generally by the national road, route 13. The excess water from the northern area will be drained into the Nam Ngum river through the Houei Gnang river and the Nam Kho river, while the excess water from the southern area will be drained into the Mekong river through the Bueng Khat Khao swamp and the Houei Ma Hiao river.

4.2.5 Irrigation and drainage facilities

(1) Main pump station

The main pump station will be provided on the right bank of the Nam Ngum river to lift the river water at 4.86 m^3/sec. For design of the main pump station, selection of pump type is made firstly from economic and technical viewpoints. The following five cases are compared for the selection.

Case-I : Mixed flow pump (vertical shaft), ϕ900 mm x 4 units
Case-II : Submersible pump, ϕ500 mm x 10 units
Case-III : Inclined pump, ϕ600 mm x 7 units
Case-IV : Floating pump station with volute pump, ϕ600 mm x 4 units x 2 pontoons
Case-V : Volute pump (horizontal shaft), ϕ900 mm x 4 units

Since the pump type is closely related to the civil work of the station, a cost comparison is made for the entire pump station by adding costs of civil work, electrical work and operation house to the cost of pumps with auxiliary facilities. The basic conditions for the comparative study are as follows and main pump stations for five cases are shown in Fig. IV-6.

- Design discharge : 4.86 m^3/sec
- Nam Ngum river
  - High water level with 90% dependability : EL 167.00 m
  - Low water level with 90% dependability : EL 152.00 m
- Outlet structure
  - Water level : EL 175.5 m
- Static water head : 23.5 m
- Pump operation hour at peak time : 24 hours/day

Approximate construction costs for five cases are as follows:

(Unit: US$1,000)

Case	Pumps	Cost
I	Mixed flow pump	4,087
II	Submersible pump	5,378
III	Inclined pump	3,634
IV	Floating pump	5,038
V	Volute pump	3,555

Technical comparison was made with emphasis on ease of operation and maintenance work, and it was concluded that the mixed flow pump and inclined pump are technically preferable to the remaining three types. As shown in the above table, the inclined pump is economically superior to the mixed flow pump. Considering all these factors, the inclined pump (Case III) was finally selected as the most appropriate type for the main pump station. The main pump station will consist of inclined concrete base, suction pipes with pumps and motors, delivery pipes and switchyard. In order to supply electric power of 2,280 kW to the station, a 1 km long distribution line will be provided, branching off from an existing 22 kV line.

(2) Booster pump station

Two booster pump stations will be constructed for irrigation to the extension area of 1,000 ha. Booster pump station No. 1 will be provided on the bank of the regulation pond to lift water at 1.85 m^3/sec from the pond for the east main canal covering 770 ha. Booster pump station No. 2 will be provided at turnout

No. 1 of the secondary canal W1-1 to lift water at 0.56 m^3/sec for the irrigation of the remaining 230 ha. Total water heads for booster pump stations No. 1 and No. 2 are 6 m and 2.4 m respectively. The mixed flow pumps with horizontal shafts were selected as the most suitable for both the booster pump stations. Diameter and required number of pumps are 700 mm and three units for the booster pump station No. 1, and those for booster pump station No. 2 are 400 mm and two units, taking some allowance of capacity into consideration. These stations will consist of suction pits, pumps with motors, suction pipes, delivery pipes and switchyards. In order to supply electric power to the stations, new power distribution lines will be attached to the existing lines. The length of this line will be 2,000 m for booster pump station No. 1 and 350 m for booster pump station No. 2. Locations of these stations are shown in Fig. IV-5.

(3) Regulation pond

Irrigation water will be conveyed by the headreach from the main pump station on a 24-hour basis, but irrigation operation at the fields will be 18 hours per day. In order to store the water for the balance of 6 hours, a regulation pond will be required at the end of the headreach. The storage capacity is estimated at 110,000 m^3. The high water level of the pond will be 171 m and the low water level will be 170 m. The banks of the pond will have a 4 m crest width and 1:2.0 side slopes. Inlet and outlet and spillway structures will be provided.

(4) Irrigation canals and structures

The irrigation canals of the Project will be the headreach, main canals, secondary canals, tertiary canals and field canals. The headreach will convey water from the main pump station to the regulation pond. Main canals will convey water from the pond to secondary and tertiary canals. Secondary canals will convey the water to tertiary and field canals. The headreach channel will be concrete-lined to facilitate operation and maintenance, while other canals will be unlined for reasons of economy. Typical cross sections of these canals are shown in Fig. IV-7. Approximate command areas and total lengths of the canals will be as follows:

Canals

Canals	Command Area (ha)	Total Length (km)
Headreach	2,410 to 2,700	11.4
Main canal	250 to 1,640	19.3
Secondary canal	60 to 380	20.8
Tertiary canal	12 to 120	70.7
Field canal	≦ 24	186.0

An irrigation flow diagram prepared on the basis of the design discharge of 1.8 lit/sec/ha is shown in Fig. IV-8.

In order to convey and regulate irrigation water in the canals and to protect the canals, a number of canal structures such as turnouts, checks, syphons, culverts, spillways and division boxes will be provided on these canals. All of these will be of concrete and the total number of canal structures will be about 4,770.

(5) Drains and related structures

The drains of the Project will be main, secondary, tertiary and field drains. All the drains will be trapezoidal unlined channels and typical cross sections of drains are shown in Fig. IV-9. Approximate catchment area and total length of the drains will be as follows:

Drains

Drains	Catchment Area (ha)	Total Length (km)
Main drains	550 to 1,700	8.9
Secondary drains	110 to 890	30.5
Tertiary drains	10 to 180	41.3
Field drains	≦ 24	194.0

A drainage flow diagram prepared on the basis of the drainage water requirement is shown in Fig. IV-10.

In order to convey excess water coming from the Project area to natural rivers across roads and canals, drainage structures such as drainage culvert and drainage syphons will be provided on drains and canals. All the drainage structures will be of concrete, and the total number of structures will be about 220.

(6) Farm roads

National roads, routes 10 and 13 run through the Project area from north to south as shown in the location map. They are asphalt-paved and well maintained. However, roads in the Project area are relatively poor in quality and few in number. In order to strengthen the road network in the Project area with the objectives of (i) smooth village to village traffic, (ii) efficient transportation of agricultural inputs and outputs to and/or from village and market, and (iii) smooth operation and maintenance work of canals and structures, farm roads will be constructed as part of the Project. Farm roads will be provided alongside the headreach, main canals, secondary canals, tertiary canals, and field canals. The farm roads will furthermore be connected to the national and other existing roads. The general layout of farm roads will be almost the same as the canal layout shown in Fig. IV-5.

The farm roads will be earthen type roads, 4.5 m wide for the headreach, and main and secondary canals, and 3.0 m wide for the tertiary and field canals. The surface will be paved with laterite, 3.5 m wide and 0.15 m thick, in the case of farm roads by the headreach, main and secondary canals taking into consideration the importance of these roads. Typical cross sections of these roads are shown in Fig. IV-7.

4.2.6 On-farm development work

On-farm development work is necessary for irrigation and drainage development of the Project. This will consist of the following work:

- Construction of tertiary and field canals with related structures
- Construction of tertiary and field drains with related structures

- Construction of farm roads with a width of 3.0 m to be provided alongside tertiary and field canals

In addition, land clearing and land levelling works will be carried out for the present forest land, a total of 880 ha; 170 ha in the originally-planned area and 710 ha in the extension area, which will be used as paddy field under the Project. Land levelling will not be carried out for the present grass land, since such land is mostly fallow-land and farmers can carry out the levelling work by themselves if necessary. The land levelling work generally consists of rough levelling and precise finishing work. Under the Project, only the rough levelling work will be carried out and the remaining finishing work will be left to the farmers.

For design of land levelling work, the standard farm plot size is determined through a preliminary comparative study. In determining the farm plot size, future use of farm machinery is considered although use of buffaloes is proposed in the agricultural development plan. Three farm plot sizes are conceived, namely 1 ha (200 m x 50 m), 0.5 ha (100 m x 50 m) and 0.3 ha (100 m x 30 m). However, since 1 ha is relatively large for paddy cultivation, the comparative study was made only for 0.5 ha size and 0.3 ha The study was made in respect to cost, i.e. earth-moving volume per hectare. The result is as follows:

Land Slope	Earth-Moving Volume (m^3/ha)	
	0.3 ha (100 m x 30 m)	0.5 ha (100 m x 50 m)
1/1,500 to 1/750	140	160
1/ 750 to 1/500	200	230
1/ 500 to 1/200	500	580

A farm plot size of 0.3 ha is adopted as an appropriate standard size.

4.2.7 Water management

In order to develop some ideas for water management to be carried out under the Project, the present practices prevailing in the existing projects were studied, and the following findings were obtained:

(i) There is little systematic discharge measurement carried out in the existing projects due mainly to lack of measuring devices in canals and structures.

(ii) Appropriate amounts of irrigation water do not reach all the fields mainly because of improper water distribution and insufficient maintenance work on canals.

(iii) Irrigation operation hours in the fields is usually 24 hours per day at peak times but at night time there is no supervision at all. This results in a considerable amount of wasted water.

(iv) Pump operation hours for irrigation are mostly set for two stages, i.e. peak time and harvest time. This could be changed to supply the optimum amount of water if discharge measurements were made. In this case costs of pump operation could be saved.

(v) Irrigation is only carried out on dry season paddy rice cultivation, and no irrigation is generally made on rainy season paddy in order to save operation costs.

The aim of proper water management is equitable and efficient water distribution to achieve optimum agricultural production. Clearly present practice is not always satisfactory. When applied to the Project, such management will have to be improved. Examining the problems surrounding present methods, two main improvements can be made. The first is to manage the water quantitatively by discharge measurement. For this purpose, a measuring device will be provided at the head of each canal under the Project. The second point is to guide or level up farmers on proper water use, for equitable and efficient water distribution and proper maintenance of irrigation facilities. Under the Project it is proposed that technical training and guidance be provided by the Project office.

Water management generally has to solve local and specific problems, and has to be perfected by successive improvements through trial and error over a certain period.

The following points outline the proposed water management for the Project:

(i) A Project office has to be established to provide proper water management. At the same time, water users' associations should be organized under the guidance of the Project office.

(ii) Water management for the main irrigation facilities should be undertaken by the Project office, while that for on-farm facilities will be made by the water users' association under the technical guidance of the Project office.

(iii) Prior to commencement of irrigation, the Project office will prepare an annual irrigation schedule based on the cropping pattern, and irrigation water distribution, made on the basis of the irrigation schedule.

(iv) Irrigation water must be measured at the head of each canal periodically by the Project office and the measured record be checked against the irrigation schedule.

(v) Daily operation hours of the main pump will be 24 hours, but those of the booster pumps will be 18 hours at peak time for practical irrigation of fields.

(vi) Pump discharge and opening degree of turnout gates will have to be set biweekly or monthly, depending on the irrigation schedule.

(vii) Irrigation should be made even for rainy season cultivation, otherwise the expected crop yield will not be achieved. During rainy season irrigation, rainfall will be monitored by the Project office and irrigation water reduced depending on the effective rainfall amount to save pump operation costs.

(viii) Irrigation facilities will have to be well maintained during irrigation by both Project office and water users' association. If a breach of canal bank is found, this matter must be reported to the Project office to minimize wastage of water and further damage to the canal bank. The Project office will dispatch a maintenance group for emergency treatment.

(ix) The Project office will carry out technical training and guidance to pass on knowledge of proper water management to all farmers through the water users' association.

4.2.8 Demonstration farm

Introduction and extension of improved farming practices and water management practices are vital for achievement of optimum agricultural production in the Project area. Such practices will have to be improved through field trials to meet the specific local requirements of the area. In addition, in order to secure seeds for irrigated paddy cultivation of 2,700 ha, seed multiplication is required. In order to execute such extension, field trial, and seed multiplication, construction of a demonstration farm (64 ha net) will be proposed under the Project.

The proposed site is located near Ban Don Noun and Ban Xai, and the western border of the farm is adjacent to national road route 13 as shown in Fig. IV-5. This area is located in the center of the Project area, and very near to the proposed Project office. This location will be very effective for demonstration and will be convenient for carrying out technical guidance of the Project office.

The site proposed is at present mostly under rainfed paddy fields, the rest being grass land. The whole area is privately owned by farmers of Ban Don Noun, Ban Xai and Ban Na Khe.

For optimum demonstration purposes, the following points are taken into account regarding the demonstration farm:

(i) Land consolidation, while not proposed for the irrigation area of the Project, will be applied to the demonstration farm, for maximization of the demonstration effect.

(ii) While the use of buffaloes is proposed in the agricultural development plan, the use of small tractors is proposed instead of draft animals for land preparation of the demonstration farm.

The demonstration farm will consist of two tertiary blocks. Irrigation water will be supplied from the west main canal No. 1 and drainage water will be collected by secondary drains 1-3 and main drain 1 connected to the Bueng Khat Khao. The general layout of the demonstration farm is prepared as shown in Fig. IV-11.

Operation and maintenance of the farm will be undertaken by farmers under the technical guidance of the Project office. For the use of tractors in the demonstration farm, 3 units of tractors (30PS) will be procured by the Project office. The operation and maintenance of such tractors will also be made by the Project office.

In order to store agricultural farm machinery and equipment, and their spare parts as well as multiplied seeds and agricultural input, a warehouse with a total floor area of 700 m^2 will be constructed near the Project office. The warehouse will be managed by the Project office.

4.3 Agricultural Development Plan

4.3.1 Proposed land use

As described under land classification in Chapter III, an area of 4,227 ha which is classified into Class I, II and III for either rice or upland crops, is evaluated as suitable for cropping. Forest areas where soils are shallow and contain gravel in the top soil, and inundated floating rice areas are classified as unsuitable land for development.

Future land use is determined, taking the present land use and topographic conditions into consideration. Some of the areas classified as unsuitable land but presently cultivated as paddy field are included in the irrigation area. For the area, in which the soil texture is sandy loam (Mapping symbol 1 to 4 in Fig. III-5), rotational cropping of rice and upland crops is proposed considering the fitness of the soils, soil improvement and the necessity for crop diversification. Proposed future land use may be summarized as follows :

(Unit: ha)

Future Land Use	Originally-planned Area	Extension Area	Total
Rainfed paddy field	400	301	701
Irrigated paddy field	1,432	718	2,150
Irrigated Paddy/Upland field	268	282	550
Forest	253	269	522
Village	179	28	207
Pond and Stream	16	0	16
Infrastructure	300	176	476
Road and residential area	92	36	128
Total	2,940	1,810	4,750

A future land use map is given in Fig. IV-12 and land demarcation for future land use in comparison with present land use is given in Table IV-2.

4.3.2 Selection of crops

In selecting the proposed crops and cropping pattern to be adopted by the Project, the following factors were considered:

- Suitability of land and climate for crops
- Profitability of crops for both farmers and nation as a whole
- Marketability of products
- Acceptability to farmers
- Agricultural policy of both Central Government and Vientiane Municipality

In consideration of the above factors, rice is proposed as the main crop, and soybean, groundnuts and garlic are proposed as upland crops to be cultivated in the dry season.

Rice is the most suitable crop for most of the Project area in view of the prevailing climate and soils. On account of its high expected yield and fairly stable price, rice is the most profitable crop for farmers. Farmers have had a great deal of experience of rice cultivation and are eager to adopt irrigated rice cultivation to maximize production. Since the Vientiane Municipality and its vicinity suffer from chronic rice shortages and Lao PDR is still a rice importing country, the increase of rice production will possibly contribute to foreign exchange saving. Consequently, rice is proposed as the principal crop in both rainy season and dry season.

The rice shortage is expected to be considerably alleviated once the Project is completed, and crop diversification will be main subject for further agricultural development. Even now, diversification of agriculture by expanding production of non-rice crops is advocated as one of the objectives of the Government's agricultural policy. In addition, demand for raw material from agro-industry has been increasing in accordance with promotion of agro-industry for import substitution.

As a result of the crop selection, the following three are proposed as recommendable upland crops.

(1) Soybean

A promising demand for soybean is expected from a processing plant presently under construction. The area proposed for cultivation is 350 ha, where the equivalent of about half of the annual capacity of the plant can be produced.

(2) Groundnut

The Government plans to increase production of groundnuts for export, since a fairly large market is expected for this crop. The proposed area for groundnuts is 160 ha considering the amount sought for export in the past.

(3) Garlic

Garlic is one of the most profitable vegetables owing to its high market price. The potential for increasing consumption in Vientiane is rather high. Thailand could also be a market with good prospects. The area proposed for garlic is 40 ha, of which the amount of production expected corresponds to a possible consumption increase in Vientiane city.

Upland crops other than the above are not recommended for the Project for the following reasons :

- unsuitable climate (coffee, cardamon, tea, pepper)
- relatively shallow soils (maize, sugarcane, etc.)
- small market (vegetables)
- no definite plan for processing plant (tobacco, mungbean)

4.3.3 Cropping pattern

Cropping patterns to be adopted for the Project were chosen so as to achieve the maximum yields of crops based on the above crop selection. Proposed cropping patterns are explained below and are illustrated in Fig. IV-13.

(1) Double cropping of rice

The optimum cropping calender for double cropping of rice is designed from the following viewpoints:

(i) Both maturity and harvesting of paddy should take place in the dry season.
(ii) A low temperature of less than 15°C, which may cause severe damage to paddy yield, should be avoided during the generative growth period.

High yielding varieties of rice are proposed to be introduced to maximize the effect of irrigation and the intensive cultivation method. In the rainy season, glutinous rice varieties such as RD-8, RD-16, etc. are recommended, considering Lao taste preference. In the dry season, CR-203 is recommended considering its resistance to stemborers and brown hoppers, and the higher expected yield as well as short growth duration.

(2) Rainy season paddy and upland crops in dry season

The cropping calender for rainy season paddy will be the same as that proposed for the double cropping of rice. In framing cropping calenders for upland crops, the following average growth periods are taken into account :

- Soybean 105 days
- Groundnuts 150 days
- Garlic 135 days

Of these three crops, groundnuts has a relatively long growth period and it is therefore planned to plant this by the end of November and to harvest it before the end of April, so as to avoid rain damage during the harvesting period. Accordingly, in order to plant groundnuts, harvesting of rainy season paddy should be finished by early November. As for soybean and garlic which have shorter growth periods, cropping calenders are determined mainly to reduce peak labour requirements.

4.3.4 Farming practices

The farming practices to be introduced by the Project are based on the following assumptions:

(i) Irrigation and drainage system is provided.
(ii) Animal power is main draft power.
(iii) Average farm labor (2.6 person/family) is available.
(iv) Farming work is mostly carried out by family members though some seasonal labor should be employed.

(1) Rice cultivation

(i) Seeding and nursery preparation

40 kg per ha of seeds are sown on about 500 m^2 of nursery bed and grown for 25 days in the nursery. The nursery has to be prepared as flat as possible. Seed selection using a salt solution is necessary.

(ii) Field preparation

The field preparation is carried out by animal power at least 10 days before transplanting. Harrowing and puddling of soil are also required after plowing. Basic fertilizer application, about one third of the total requirement of nitrogen and all of the phosphate, must be made in order to prepare a fertile soil foundation for transplanting.

(iii) Transplanting

Transplanting will be made by manual labor with a spacing of 30 cm x 15 cm. 2 to 3 seedlings per hill is recommended. Irrigation water must be drained just before transplanting so that transplanting is carried out in a shallow depth to accelerate vigorous tillering. Irrigation water should be supplied to the field again after rooting.

(iv) Fertilizer application

Considering the test results of crop fertilization made at the Salakham Rice Research Station and the soil condition of the Project area, a total fertilizer requirement for rice cultivation was estimated as shown in Table IV-4. The split-application method is recommended in order to control growing conditions.

(v) Weeding and plant protection

After transplanting, weeding is carried out by hand, depending on the rate of weed growth. For plant protection, intensive application of insecticide is required to control plant hoppers, stem borers, etc. It is recommended that plant protection work should be carried out in a systematic way, such as through cooperatives. Individual protection is not recommendable because insects and diseases are not limited to one farm. Unless systematic protection is undertaken, the farm will be re-infected.

The basic principle of plant protection, however, is to make the plant healthy. If the rice plant is strong and healthy, it will resist diseases and insects. Attention should therefore be paid to proper water management and fertilization.

(vi) Harvesting

Harvesting is carried out by hand, and the harvested paddy is laid out on the ground to dry. In the future, introduction of artificial driers should be considered since at present a considerable amount of harvested grain is damaged after harvesting due to rain.

(2) Upland crops

(i) Soil preparation

After harvesting rainy season paddy, plowing, harrowing and ridging are carried out using animal power. The ridges are made in a trapezoidal shape. The base width of ridges should be 60 to 75 cm and the height about 25 to 30 cm for groundnuts and soybean. A base width of 80 to 90 cm and a height of 20 to 25 cm is required for garlic. Spacing of furrows is 80 cm for soybean and groundnuts, and 90 cm for garlic. Application of basic fertilizer is also necessary.

(ii) Seeding

Soybean and groundnuts are sown directly on the apex of the ridge. Thinning and control of seedlings is required after establishing the seedlings on each hill. In the case of garlic, the bulbs are planted by regular planting at 15 cm x 10 cm spacing. After planting, the laying rice straw on top of the ridges is recommended to protect the bulbs from birds and to reduce evaporation of irrigated water.

(iii) Weeding, plant protection and fertilization

Weeding is carried out at least twice during the cropping period. Insecticide is sprayed at least twice for soybean and three times for groundnuts. For soybean, application of additional calcium is recommended. No insecticide is required for garlic. Suitable kinds of fertilizers and their amounts are shown in Table IV-4.

(iv) Harvesting

Harvesting of upland crops is carried out by hand as for rice.

(3) Mechanization

Rapid introduction of farm mechanization to the Project area seems unnecessary in view of availability of labor and animal power, and the lack of trials and the necessary support system for mechanization.

However, some farmers who have more farmland than average have already been introducing farm mechanization. For future necessity, it is recommended that research on proper farm mechanization and technical training of extension workers be carried out in the near future.

4.3.5 Farm input and labor requirement

Farm inputs and labor requirements were estimated on the basis of the proposed farming practices mentioned above. The information from the Salakham Rice Research Station and the Agricultural Research and Experiment Station at Hat Dok Keo is referred to in the estimation.

(1) Farm input

The input necessary for each crop is shown in Table IV-3 and IV-4. As described in farm input supply of Chapter III, delivery systems are efficient and can supply the required amount of fertilizers and agro-chemicals. Seeds of improved varieties will be produced at research stations of MAF and the demonstration farm and will be distributed through the Project office and/or district and provincial offices.

(2) Labor requirement

Labor requirements for cultivation of paddy and upland crops per hectare of farm land are estimated at 152 man-days for rainy season paddy, 155 man-days for dry season paddy, 97 man-days for soybean, 104 man-days for groundnuts and 126 man-days for garlic. Compared to the present requirements, the proposed farm work requires 25 more days for rainy season paddy and two more days for dry season paddy. Monthly labor requirement for the average farm of 1.6 ha in the case of double cropping of paddy is estimated as follows:

Month	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total
Man-days	38.4	86.4	10.5	6.7	16.7	83.1	17.9	88.3	28.0	5.6	62.8	44.6	489.0

Since the available agricultural labor force per household is 2.6 persons, the maximum monthly labor capacity of one household is estimated at 78 man-days (2.6 x 30 days). Accordingly, family farm labor is not enough in July,

November and January. In these months, farm labor will be hired or family members who are engaged in non-farm work will join in farm work temporarily.

(3) Production cost

The agricultural production cost for each crop is estimated based on the above-mentioned input and labor requirement. Production costs thus estimated are Kip 121,800/ha for rainy season paddy, Kip 123,000/ha for dry season paddy, Kip 101,200/ha for soybean, Kip 107,100/ha for groundnut and Kip 610,500/ha for garlic. As compared with present production costs, the production cost of rainy season paddy will increase by 162% and that of dry season paddy by 45%, while the amount of production is expected to increase by 200% and 120% respectively. Breakdowns of the production costs are given in Annex VII.

4.3.6 Expected yields and production

Expected yields of proposed crops under with-project condition are estimated taking into account the information from the Salakham Rice Research Station, the Agricultural Research and Experimental Station at Hat Dok Keo, and the Agricultural Research Center at Napok as well as the yields in other similar areas in the world.

Estimated yields for the proposed crops are 4.5 tons/ha for rainy season paddy, 5.5 tons/ha for dry season paddy, 2.0 tons/ha for soybean, 2.5 tons/ha for groundnuts and 7 tons/ha for garlic. On the other hand, under without-project condition, the present low yield of rice would remain unchanged due to such constraints as rainfed conditions and low levels of farming techniques.

Future annual agricultural production is forecasted as follows:

Crops	Without Project			With Project		
	Area (ha)	Yield (ton/ha)	Production (ton)	Area (ha)	Yield (ton/ha)	Production (ton)
Rainfed Rainy Season Paddy	3,030	1.5	4,545	701	1.5	1,052
Irrigated Rainy Season Paddy	0	-	-	2,700	4.5	12,150
Irrigated Dry Season Paddy	139	2.5	348	2,150	5.5	11,825
Paddy Total	3,169	-	4,893	5,551	-	25,027
Soybean	-	-	-	350	2.0	700
Groundnut	-	-	-	160	2.5	400
Garlic	-	-	-	40	7.0	280

The expected increase in agricultural production is 20,134 tons for paddy, 700 tons for soybean, 400 tons for groundnuts and 280 tons for garlic.

4.3.7 Marketing

The marketable amount of paddy after the achievement of projected yields is estimated on the basis of the following assumptions.

(i) Projected production will be fully attained in 1998.
(ii) The present agricultural population of 8,718 will increase at the rate of 2.9% per annum.
(iii) Per capita consumption of rice will be 300 kg/year.
(iv) Agro-Tax will be 160 kg/ha of paddy for irrigated field and 100 kg/ha for rainfed field.
(v) Seed stock will be 50 kg/ha for each crop season of which 40 kg/ha will be sown after seed selection.
(vi) Handling and storage losses will be 5% of total production.

The annual marketable surplus of paddy is consequently estimated as follows:

Item	Paddy amount (ton)	Note
Production	25,027	
Self-consumption	3,481	$8,718 \times 1.029^{10} \times 0.3$
Agro-Tax	502	$0.16 \times 2,700 + 0.1 \times 701$
Seed stock	278	$0.05 \times (2,700+2,150+701)$
Losses	1,251	$25,027 \times 0.05$
Marketable surplus	19,515	
Consumption of Non-agricultural population	1,413	$3,539 \times 1.029^{10} \times 0.3$
Net areal surplus	18,102	

The marketable surplus is thus estimated at about 19,500 tons, and considering the consumption amount by the non-agricultural population, net areal surplus is computed at 18,100 tons.

The surplus marketable amount of paddy will be purchased by the Foodstuff Company and/or private traders, and marketed in the Vientiane urban area where rice is short. This amount of paddy will be substituted for imported rice, which presently amounts to about 20,000 tons (equivalent to 33,000 tons of paddy). The population of Vientiane Municipality increased at a rate of 2.9% per annum during 1983 - 1987, and is expected to increase more rapidly in future. Since the demand for rice will also increase in line with population increase, the supply of rice in the Vientiane urban area will still be insufficient even after the completion of the Project.

For upland crops, almost all production will be marketable. These will be purchased by the State Agro-processing Company, state trading companies and private traders.

4.4 Rural Development Plan

4.4.1 General

Rural development is one of the major objectives of the Project. It aims to improve and raise the living standards of villagers through improvement of basic rural infrastructures. In preparing a rural development plan for the Project only such basic infrastructures as village roads, post-harvest facilities and potable water supply facilities are taken up for examination, since those facilities are closely related to and essential for the social and agricultural activities of villagers. The present conditions and capacities of existing facilities related to the said three items, and necessity for their improvement or new development were studied for 12 villages with a total population of about 12,260. These were Ban Pha Khao, Ban Sa Phang Muk, Ban Don Noun, Ban Xai, Ban Na Khe, Ban Dan Xang, Ban Dong Sang Hinh, Ban Na, Ban Sok Nhai, Ban Sok Noi, Ban Phone Thong and Ban Na Biene. Locations of those villages are shown in Fig. IV-15.

The rural development plan is detailed in Annex VI, and the outline of the plan is given below.

4.4.2 Village roads

The present road network in and around the Project area consists of asphalt-paved national roads, routes 13 and 10, and unpaved village roads. The village roads with a width of 4 to 7 m branch off from the two national roads, and provide access to villages off the national roads. At present, the village roads in the Project area are poor in quality and insufficient in density. Road structures such as wooden bridges and culverts are also insufficient in number and most of them are in poor condition. Villagers are inconvenienced by the poor conditions of the existing roads. In particular, in the rainy season, the roads become very muddy, hindering agricultural and social activities in the Project area.

Under the irrigation and drainage development plan of the Project, farm roads with a width of 4.5 or 3.0 m will be provided alongside all the proposed canals of 308 km in total length. Since they will be useful in solving the above-mentioned problems, only rehabilitation of existing village roads is proposed under the rural development plan. The village roads are 8.2 km in total length, of which a 6.7 km-long stretch is proposed for rehabilitation by reshaping of the road embankment and provision of a 15 cm thick laterite pavement. In addition, replacement of existing bridges and construction of new culverts is

proposed for 14 places along the roads. Typical cross sections of village roads are shown in Fig. IV-14, and the village roads to be rehabilitated are shown in Fig. IV-15.

4.4.3 Potable water supply facilities

(1) Present conditions

Villagers in the Project area rely mainly on groundwater from wells for daily use. According to an inventory survey of the existing wells, there are 488 wells in 12 villages with a total population of 12,257 or 2,052 households. Of 488, 287 wells are used for potable water supply and the remaining 201 wells are non-potable because of the salty taste and contamination by surface water.

All the existing wells are shallow dug with a diameter of 1 to 1.5 m and a depth of 3 to 7 m, and are for villagers' common use. On average, one well for potable water supply is used by 7 households (42 persons), and one well for non-potable water supply by 10 households (60 persons). Villagers carry water from wells to their houses over a distance of 20 to 300 m (110 m on the average). The average yield of the wells is estimated at 5.7 m^3/day in the rainy season and 2.3 m^3/day in the dry season. Because of this seasonal variation of yields villagers are forced to reduce their water consumption in the dry season.

For all the 12 villages, the average per capita supply of potable water from existing wells is estimated at 55 lit/day in the dry season, since one well with a yield of 2,300 lit/day is used by 7 households (42 persons) on average. However, due to an uneven distribution of wells, this amount is not guaranteed, particularly in the six villages of Ban Don Noun, Ban Xai, Ban Na Khe, Ban Sok Nhai, Ban Sok Noi and Ban Na Biene. One well for potable water in those villages is used by 20 to 103 households, averaging 32 households. The per capita supply of potable water in those villages is only 12 lit/day, which is well below the standard requirement. Thus, the present potable water supply for the said six villages has been proved to be insufficient and is proposed to be improved under the Project. For the remaining six villages, the present supply of potable water is considered acceptable.

(2) Potable water supply facilities

Of the 12 villages, it is proposed to supply the six villages of Ban Don Noun, Ban Xai, Ban Na Khe, Ban Sok Nhai, Ban Sok Noi, and Ban Na Biene with potable water facilities under the rural development plan, in order to secure a per capita supply of at least 60 lit/day, which is considered necessary in order to maintain normal life of villagers.

For the three villages of Ban Don Noun, Ban Xai and Ban Na Khe, potable water supply is proposed by extending the existing municipal water supply pipe line, while for the water supply to the remaining three villages of Ban Sok Nhai, Ban Sok Noi and Ban Na Biene, construction of deep tubewells and provision of distribution pipe lines is proposed. The water requirement is estimated to supply the population of villages in year of 2000, applying an annual population growth rate of 2.9%.

(a) Extension of existing municipal water supply pipe line

One main pipe line of the municipal water supply system of Vientiane city was already extended to a point near Ban Sa Phang Muk alongside national road, route 13 (so-called KM-9 point), by Lao Water Supply Company or Bo Ly Sath Nam Papa Lao (Nam Papa). In December 1988, this pipe line was further extended from the said point northwards, for a distance of 5 km alongside the national road as shown in Fig. IV-15.

Since the three villages of Ban Don Noun, Ban Xai and Ban Na Khe are located near to the said extension pipe line, water supply to those villages from the extension line will be ensured by providing distribution pipe lines under the Project. The water demand for the extension line is estimated at 250 m^3/day in total, taking into account the present capacity of the existing useful wells. The pipe line has a capacity of 3.6 m^3/min with a water pressure of 4 kg/cm^2 at KM-9, and has a satisfactory capacity for the water demand of three villages. The length of the proposed distribution pipe line will be about 4 km in total and the diameter of the pipe will be 25 to 100 mm. Communal taps, diameter 25 mm, will be provided on the line. The required number of taps is 26 in total, consisting of 13 for Ban Don Noun, 10 for Ban Xai and 3 for Ban Na Khe. The general layout of distribution pipe lines is given in Fig. IV-15.

(b) Deep tubewell and distribution pipe line

The three villages of Ban Sok Nhai, Ban Sok Noi and Ban Na Biene are a long way from the municipal water pipe line and the water supply from the municipal pipe line to those villages is judged to be uneconomical. Accordingly, water supply to these villages will be ensured by drilling two deep tubewells and constructing of distribution pipe lines. The water demand for the two tubewells is estimated at 175 m^3/day in total, taking into account the present capacity of existing useful wells.

According to the hydro-geological investigation, there are two tubewell sites at Ban Phone Thong. A pumping test showed that the expected yield was 1.8 lit/sec or 155 m^3/day per well. Therefore, these tubewells are deemed capable of satisfying the water demand for three villages. The proposed tubewells will be 150 mm in diameter and about 30 m in depth. The length of distribution pipe line will be about 4.5 km in total and the diameter of the pipe line will be 25 to 100 mm. Communal taps with a diameter of 25 mm will be provided on the line. The required number of taps will be 17 in total, consisting of 3 for Ban Na Biene, 9 for Ban Sok Nhai and 5 for Ban Sok Noi. The proposed sites of the tubewells and the general layout of the distribution pipe line are shown in Fig. IV-15.

The quality of water taken from the test tubewell was examined at the laboratory of Nam Papa and the water proved suitable for drinking.

4.4.4 Post-harvest facilities

(1) Rice mills

(a) Present conditions

In the Project area, there are 18 private rice mills including mills under construction, and two rice mills of the Foodstuff Company. All milling equipment is made in Thailand and is classified into two types: type-I and type-II, type-I for husking and polishing, type-II for cleaning, husking, separating of paddy and brown rice, polishing and removing crushed brown rice. The recovery rate is 50 to 60% for type-I and 60-70% for type-II. Type-I is not popular among farmers mainly because of the low

recovery rate, and it tends to be replaced by type-II. The existing rice mills by type are as follows:

Existing Rice Mills

Rice Mill	Type-I (unit)	Type-II (unit)	Total (unit)
Private rice mills	8	10	18
Foodstuff Company	1	1	2

The milling capacity of type-I is 200 to 300 kg/hr, while that of type-II is 600 to 800 kg/hr. At present, the operation hours of the mills are 8 to 10 hours per day for rainy season paddy, and 2 to 5 hours per day for dry season paddy. Full time operation occurs only for a few months in a year. All the mills still have considerable milling capacity. Assuming that operational hours are 8 hours/day and operation days are 300 days per year, the annual rice milling capacity of the existing rice mills is estimated at 23,880 tons as follows:

- Type-I (9 units)

  0.25 ton/hr x 8 hr x 300 days x 9 units = 5,400 ton

- Type-II (11 units)

  0.7 ton/hr x 8 hr x 300 days x 11 units = 18,480 ton

Total : 23,880 ton

(b) Milling capacity for the expected production of the Project

The expected production of paddy at full development stage of the Project is estimated at about 25,030 tons/year. Since the present annual milling capacity is 23,880 tons, most of the paddy produced under the Project could be milled in the Project area. Shortage of milling facilities can be solved by increasing the operation hours of the rice mills. In addition, in Vientiane city there are 6 Foodstuff Company rice mills with annual milling capacity of 14,000 tons, and those mills could also be used. Construction of rice mills is not therefore proposed under the Project.

(2) Storehouses

(a) Present conditions

In the Project area there are four types of storehouses, namely farmer's storehouses, communal storehouses, agricultural tax storehouses and Foodstuff Company storehouses.

The farmer's storehouse is a storehouse owned by farmers and is provided in premises of farmer's house. There are 1,419 farmer's storehouses in the Project area, each having a floor size of 1.5 to 2.5 m x 2.5 to 3.5 m and a height of 2 m. The storage capacity of one storehouse is 7 tons on average with a conversion factor of 0.56 ton/m^3, the total capacity being 9,933 tons.

Communal storehouses are storehouses managed by the village administration. They are used mainly to store communal paddy for mutual food aid among villagers. There are seven communal storehouses, one in each of seven villages of Ban Pha Khao, Ban Dan Xang, Ban Dong Sang Hinh, Ban Sok Nhai, Ban Sok Noi, Ban Phone Thong and Ban Na Biene. One storehouse has an average storage capacity of 11 tons with a floor size of 2 to 3 m x 3 to 5 m and a height of 2 m. The total storage capacity is estimated at 77 tons.

Agricultural tax storehouses are used to store paddy tax and are managed by the chief of sub-districts. There are two agricultural tax storehouses in Ban Don Noun, each with a floor size of 8 m x 20 m and a height of 2 m. The storage capacity is 180 tons per unit and the total capacity is 360 tons.

The Foodstuff Company storehouses are owned by Foodstuff Company of Saythany and Saysetha Districts. There are five Foodstuff Company storehouses in the Project area. The floor size and height of the storehouse is 18 m x 10 m and 4 to 5 m respectively. The storage capacity is 450 tons per unit and 2,250 tons in total.

Thus, the total storage capacity of all the existing storehouses in the Project area is estimated at 12,620 tons as shown below:

Storage Capacity

Storehouse	Nos. of storehouse	Capacity (ton)
Farmers' storehouse	1,419	9,933
Communal storehouse	7	77
Agricultural tax storehouse	2	360
Foodstuff Company's storehouse	5	2,250
Total	1,433	12,620

(b) Storage capacity for the expected production of paddy

The anticipated amount of paddy production at the full development stage of the Project is estimated at 13,200 tons for rainy season paddy and 11,830 tons for dry season paddy. Since the present storage capacity is 12,620 tons, most of the paddy could be stored in the existing storehouses of the project area. In addition, in Vientiane city there are storehouses of the Foodstuff Companies with a total storage capacity of 13,500 tons, and those storehouses could be made available. Therefore, no new construction of storage facilities is proposed under the Project.