BASIC DESIGN STUDY REPORT

ON

AGRICULTURAL AND RURAL DEVELOPMENT PROJECT IN THE SUBURBS OF VIENTIANE

IN

LAO PEOPLE'S DEMOCRATIC REPUBLIC

MARCH 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

BASIC DESIGN STUDY REPORT ON AGRICULTURAL AND RURAL DEVELOPMENT PROJECT IN THE SUBURBS OF VIENTIANE IN LAO PEOPLE'S DEMOCRATIC REPUBLIC
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PREFACE

In response to a request from the Government of Lao People's Democratic Republic (Lao PDR), the Japanese Government decided to conduct a basic design study on the 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. Haruo Suzuki, Deputy Director, Grant Aid Management Department of JICA, from November 21 to December 11, 1989.

The team held discussions with concerned officials 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.

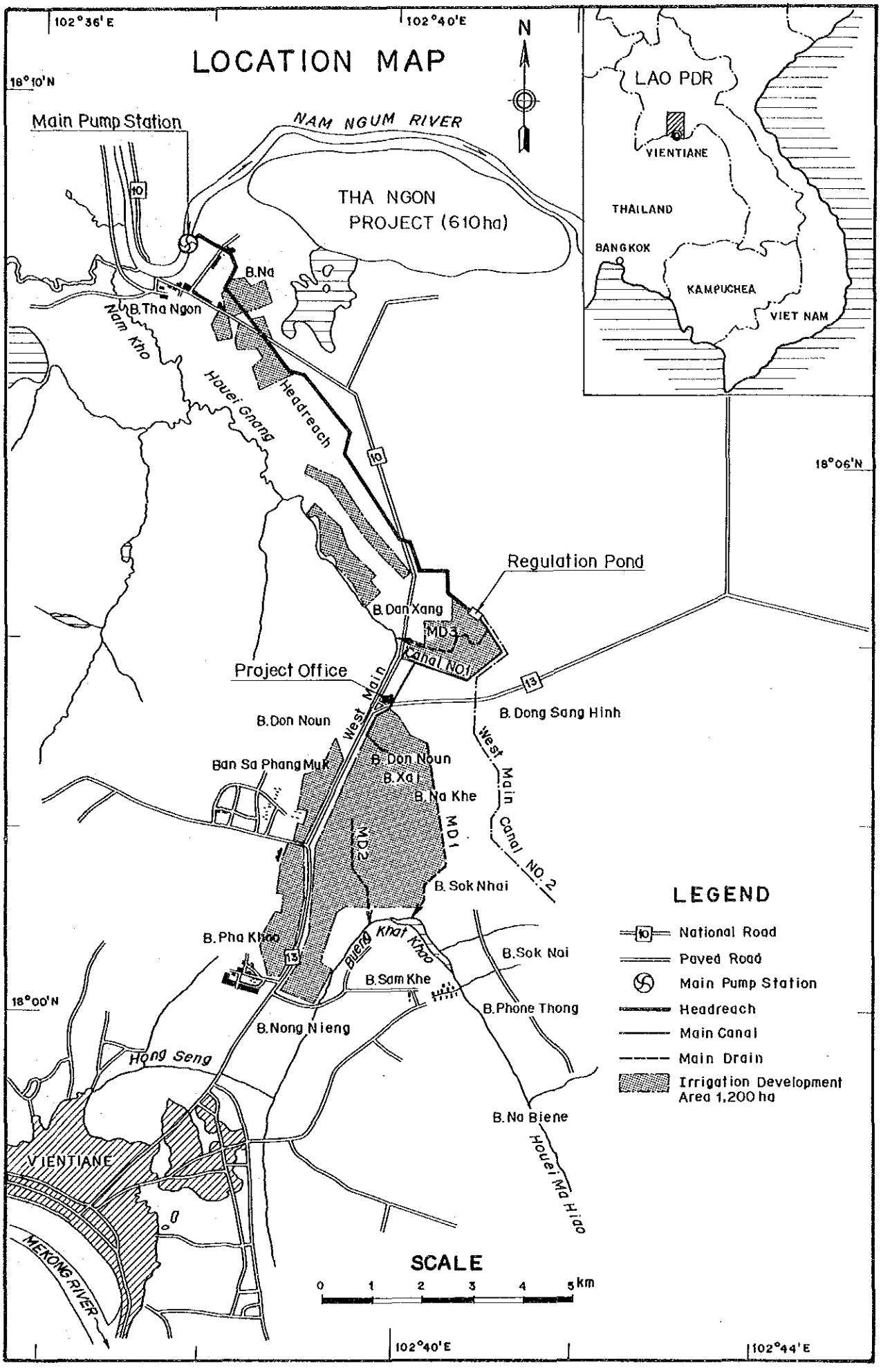
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincerest appreciation to the officials concerned of the Government of Lao People's Democratic Republic for their close cooperation extended to the team.

March, 1990

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 (610ha)
B.Na
B.Tha Ngon
Nam Kho
Houei Gnang
Headreach
Regulation Pond
B.Dan Xang
MD3
Canal NO1
Project Office
West Main
B.Don Noun
B.Dong Sang Hinh
West Main Canal NO.2
Ban Sa Phang Muk
B.Don Noun
B.Xai
B.Na Khe
MD1
MD2
B.Sok Nhai
B.Pha Khao
Buen Khai Khao
B.Sok Nai
B.Sam Khe
B.Phone Thong
B.Nong Nieng
Hong Seng
B.Na Biene
Houei Ma Hiao
VIENTIANE
MEKONG RIVER
SCALE
0 1 2 3 4 5km
LEGEND
National Road
Paved Road
Main Pump Station
Headreach
Main Canal
Main Drain
Irrigation Development Area 1,200 ha

SUMMARY

SUMMARY

The Government of Lao PDR made a great effort to attain self-sufficiency in foodstuffs and increase agricultural production for export through the 3-Year Development Plan (1978-1980). As a result, self-sufficiency in rice was attained at the national level. However, there has been an imbalance between demand and supply of rice at a regional level. In particular, the Vientiane Municipality, where more than 10% of the total population is concentrated, have suffered from a chronic shortage of rice. Further, the rice production is still vulnerable to varying climatic conditions since most of the paddy fields are rainfed.

Under these circumstances, the Government of Lao PDR launched the 1st Five Year Plan (1981-1985) and the 2nd Five Year Plan (1986-1990), aimed at i) securing self-sufficiency of rice, ii) maintaining adequate security stocks of foodstuffs and iii) expanding production of non-rice crops. In line with these plans, the Government of Lao PDR took up "the Agricultural and Rural Development Project in the Suburbs of Vientiane" (the Project) and gave a high priority for its implementation. A feasibility study for the Project was carried out in 1989 with the technical cooperation of the Government of Japan.The Project area covers an area of 2,940 ha, which extends southward from the Nam Ngum river to the Bueng Khat Kao swamp along the national roads routes 10 and 13. The area is characterized as being a paddy mono-culture area, and most of the paddy fields are cultivated under rainfed condition.

Encouraged with the favorable results of the feasibility study and also owing to the urgent necessity of increase of rice production to ease serious rice shortage caused by the recent droughts, the Government of Lao PDR requested the Government of Japan to extend a grant aid for the implementation of the Project. In response to this request, the Government of Japan decided to conduct a basic design study, and JICA sent a Basic Design Study Team to Lao PDR from November 21, 1989 to December 11, 1989 to make surveys and study on the background of the request, the scope of the Project works, and its significance, effects and propriety as a project to be executed under the Japan's grant aid. The Team examined the viability of the Project and executed a basic design study on the Project works, including selection of required equipment and materials, estimate of the implementation costs, formulation of a basic plan for operation and maintenance, etc. This report presents the results of this basic design study.

The results of the basic design study are outlined as follows:

(1) Since the requested works were considered too large in scale to implement under a grant aid, discussions were made with the concerned officials of the Government of Lao PDR on the possible reduction of the scope of the works. In reducing the scope of works, a careful consideration was given to the following;

i) Increase of rice production through irrigation development is the most urgent and important target of the Project.

ii) High priority should be given to the development of the area, where the development benefits will quickly accrue in view of soils, topography and socio-economic conditions.

iii) Improvement of rural infrastructures should be limited to villagers, which are located within the selected priority area.

iv) Assuming that the Tha Ngon Project, located adjacent to this Project, will function as a demonstration farm, implementation of the demonstration farm planned under the Project is excluded from the Project works.

(2) Based on the above, a basic plan of the Project was formulated so as to be suited for implementation under a Japan's grant aid. The outline of the plan is as summarized below;

a) Executing agency; Ministry of Agriculture and Forestry of the Government of Lao PDR

b) The following works will be executed under the Project, thereby increasing rice production through the introduction of double rice cropping and improving living standard of farmers.

- Construction of a main pump station, headreach and regulation pond, all with capacities sufficient to irrigate 1,700 ha (net) of paddy fields,
- Construction of irrigation and drainage systems and farm roads, including on-farm facilities, for a net area of 1,200 ha,
- Provision of potable water supply facilities and improvement of village roads for five villages,

- Construction of buildings for the use of operation and maintenance of the Project, and
- Supply of equipment for the use of operation and maintenance of the Project.

c) The principal features of the facilities and equipment to be provided are as follows;

1) Main Pump Station	;	4 units of incline pump, 600 mm dia., civil works for installation of 5 units.
2) Headreach	;	Open channel with concrete-block lining, length: 10.96 km, related structures: 64 nos.
3) Regulation pond	;	Storage capacity: 66,100 m^3
4) Main irrigation canal	;	Earth canal, length: 4.83 km, related structures: 26 nos.
5) Secondary irrigation canal	;	Earth canal, length: 12.13 km, related structures: 54 nos.
6) Main drain	;	Earth canal, length: 9.18 km, related structures: 8 nos.
7) Secondary drain	;	Earth canal, length: 8.83 km, related structures: 15 nos.
8) Field ditch and drain	;	Field ditch: 54.54 km, Field drain: 45.79 km
9) Farm road	;	Main farm road: 28.39 km, Secondary farm road: 56.02 km
10) Rural infrastructure	;	Village road: 1.70 km Water distribution line: 4.05 km Communal tap: 28 nos.
11) O&M office	;	1 unit, floor area: 832 m^2
12) Warehouse	;	1 unit, floor area: 700 m^2
13) O&M equipment	;	24 units (bulldozer, backhoe, truck, etc.)

(3) In consideration of the scale of the Project works, work volume, time required for construction, climatic conditions of the Project area, etc., the Project is proposed to be implemented in three stages. The works to be executed in each stage and its construction period are as summarized below;

Stage	Construction Period	Works
Stage I	12 months	- Civil works for Main Pump Station - Earthworks for Headreach - Regulation pond - Canals, drains & roads for 348 ha-area - O/M office building - Installation of one set of pump
Stage II	12 months	- Lining to Headreach - Canals, drains & roads for 441 ha-area - Installation of one set of pump
Stage III	9.5 months	- Canals, drains & roads for 411 ha-area - Rural infrastructures - Warehouse - O&M equipment - Installation of 2 sets of pump

(4) Various direct and indirect benefits are expected to accrue from the implementation of the Project. The major direct benefits will be the substantial increase of rice production and the resulting increase of farmers' incomes, foreign exchange saving by reducing food imports, and improvement of living standard of farmers. Among the indirect benefit will be the enhancement of socio-economic activities of inhabitants, stable supply of foodstuffs, increase of employment opportunities, etc. Details of these major benefits are as described below;

- At the full development, the rice production in the Project area will be increased to around 17,000 tons per annum, corresponding to about five times of the present production of 3,700 tons. The average unit yield of paddy will be increased to 10 tons/ha (rainy season : 4.5 tons/ha, dry season : 5.5 tons/ha), which is about six times larger than the present yield of 1.65 tons/ha.

- About 20,000 tons of rice is imported to Lao PDR every year. Implementation of the Project will reduce this rice import by some 40%, contributing to the foreign exchange saving of about US$4 million equivalent.
- Farm income after the Project implementation is expected to be about six times more than at present, and disposable income of a farm household will also be increased to about 3 times, improving greatly the farm budget.
- Socio-economic activities of farmers will be enhanced and living conditions of inhabitants will be improved through improvements of village roads and provision of potable water supply facilities.
- Implementation of the Project will increase employment opportunities for local people and provide a favorable impact on the national economy through the multiplier effect.

Through the field surveys in Lao PDR and the subsequent analyses and studies, it was clarified that implementation of the Project will generate various direct and indirect benefits as explained above and will make favorable socio-economic impacts on the country as well as on the Vientiane Municipality. Further, it was confirmed that the Government of Lao PDR has ample experiences in the implementation and management of similar projects, which could be applied to those of the Project. From these facts, implementation of the Project under a Japan's grant aid is judged practicable and justifiable.

For the smooth implementation, operation and maintenance of the Project, the following recommendations are made to the Government of Lao PDR.

- On-time completion of the works to be executed by the Government of Lao PDR
- Establishment of an organization for implementation, operation and maintenance of the Project
- Budgetary arrangements for implementation, operation and maintenance of the Project
- Periodical maintenance and repair of the Project facilities and equipment
- Intensification of agricultural extension services, including training of farmers, supply of agricultural inputs, etc.
- Receipt of a technical assistance from the Government of Japan such as acceptance of JICA experts, training of local staff in Japan, etc.

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Table of Contents

TABLES

FIGURES

APPENDICES

DRAWINGS

CHAPTER I INTRODUCTION

CHAPTER I INTRODUCTION

The Government of 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). As the results, paddy production increased by 15% per annum, and self-sufficiency in rice was attained at the national level. 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 more than 10% of the total population is concentrated, have suffered from a chronic shortage of rice due mainly to insufficient transportation facilities. Further, the rice production is still vulnerable to varying 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 non-rice crops for domestic consumption and export. In line with these Plans, the Government of Lao PDR took up an irrigation development project (KM-6 Project) covering 1,700 ha of paddy fields located in the vicinity of Vientiane city and prepared its development plan and preliminary design.

In order to make the project plan more comprehensive and concrete, the Government of Lao PDR requested the Government of Japan to provide a technical assistance for a detailed feasibility study on the project. In response, JICA sent a survey mission to Lao PDR and conducted investigations and study. The final feasibility study report was prepared and submitted to the Government of Lao PDR in July 1989. Under the feasibility study, the project was envisaged by including an adjacent area of 1,000 ha as "the Agricultural and Rural Development Project in the Suburbs of Vientiane" (the Project). The proposed development plan under the Project comprises irrigation and drainage plan, agricultural development plan and rural development plan, aiming at the following:

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

(ii) To produce upland crops to meet the increasing demand resulting from promotion of agro-industrial development and export-crop cultivation,

(iii) To provide rural infrastructures for betterment of social and agricultural activities of villagers,

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

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

Through the feasibility study, the Project proved to be technically sound and economically viable. Encouraged with this and also owing to the urgent necessity of increase of rice production to ease serious rice shortage caused by the recent droughts, the Government of Lao PDR requested the Government of Japan to extend a grant aid for the implementation of the Project. In response to this request, the Government of Japan decided to conduct a basic design study on the Project, including studies and assessments on the scope of the works and its significance, effects and propriety as a project to be executed under the Japan's grand aid, and JICA sent a Basic Design Study Team to Lao PDR for this purpose from November 21, 1989 to December 11, 1989. The Team was headed by Mr. Haruo Suzuki, Deputy Director, Grant Aid Project Management Department of JICA.

The Team conducted investigations and survey in the Project area to clarify the present agriculture and the conditions of rural infrastructures, and to confirm the background of the Project. The Team held discussions with the concerned officials of the Government of Lao PDR on the scope of the Project works to be implemented and other basic issues relating to the implementation of the Project. The agreed minutes of these discussions are given in Appendix-4. The members of the Basic Design Study Team, itinerary for the Team and list of personnels contacted are given in Appendices-1, 2 and 3, respectively.

Basing on the results of the field investigations and the discussions, the Team examined the rationale and viability of the Project and carried out a basic design study of the Project works, including selection of required equipment and materials, estimate of the implementation costs, formulation of a basic plan for operation and maintenance of the Project, etc. This report presents the comprehensive results of this basic design study.

CHAPTER II BACKGROUND

CHAPTER II BACKGROUND

2.1 General Economic Situation

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 Myanmar 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 plains and low-lying areas scattered along the Mekong river and its tributaries. The population as in 1988 was estimated at about 3,940,000 and the population density about 17 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.

Since foundation of Lao PDR in 1975, the Lao economy has been growing steadily. During the period from 1982 to 1986, the gross domestic product (GDP) was estimated to have grown at the average rate 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. The GDP in 1986 was estimated at about 62,900 million Kips, per capita GDP being 16,900 Kips(US$177 equivalent). The economy of Lao PDR is dominated by agriculture, occupying 65% of GDP and 80% of the labor force as shown below:

Share of GDP and Employment by Sectors
(1986)

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

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. Especially, export of electricity occupies the largest share in the total export, its amount in 1986 being about US$28 million or 56% of the total export earnings. As for imports, major items are petroleum products, machinery and materials, which accounted for about US$96 million in total in 1986.

Lao PDR possesses a huge potential for hydro-power generation and forest development. It is also well endowed with land and water resources for agricultural development as well as many valuable minerals including iron, copper and tin, which are essential for economic development of the country. Owing to the combination of such adverse factors as unstable climate, low population density, constraints as a land-locked country and poor social infrastructures, however, such resources have not been effectively exploited and the country's economy has remained underdeveloped.

2.2 Agriculture in Lao PDR

Of the total cultivable land of 18,400 km^2, only 9,000 km^2 (or 4%) is presently utilized for cultivation. About 2,800 km^2 (or 35%) of the total cultivated land is located in mountainous areas and cultivated with upland rice mostly under a slash-and-burn farming system. The remaining is in lowlying areas and cropped with paddy rice. Most agricultural production is carried out on a family small holder 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. Other significant edible crops are maize, root crops and vegetables. Coffee, tobacco and cotton 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. Outputs, planted areas and other significant data for major crops are as summarized below:

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. National statistics show that the planted area of rice 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 1970's, the country continues to import more than 20,000 tons of rice mainly from Thailand as shown below:

Imported Amount of Rice

Year	1978-1982	1983	1984	1985	1986	1987
(ton)	72,300	26,500	38,000	23,000	20,000	29,300

Source: FAO Trade Yearbook, 1983, 1985, 1987

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.

Industrial crops

The main industrial crops in Lao PDR are coffee, tobacco, and cotton. They are planted in areas of about 15,500, 7,100 and 6,600 ha in 1988. 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.

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.

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

After foundation of Lao People's Democratic Republic, the Government of Lao PDR launched an Interim Three Year Development Plan (1978-1980) in order to restore the deteriorated economy and to increase production. During this period, the Lao economy achieved a substantial recovery and self-sufficiency in food was greatly 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. However, the recovery was limited to certain areas, and the economic infrastructure was still insufficient.

In view of the continuing deficiencies, the Government planned to continue the priorities of the previous three years, and formulated the 1st Five Year Plan (1981-1985). This Plan focussed on the construction of infrastructure (roads, electricity and irrigation) in order to remove the perceived constraints to growth in the productive sectors such as agriculture and industry. During this period too, the Lao economy grew steadily, and GDP increased by 5.4% per annum in real terms. 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. This may be due mainly to the inefficiency of state industry and discouragement of the private sector. In succession to the 1st Five Year Plan, the Government commenced the 2nd Five Year Plan (1986-1990), outline of which is summarized below:

2nd Five Year Plan

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

(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

This Plan gives priority to crop diversification and development of cash crops, livestock and forest products, while the 1st Five Year Plan focuses 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.

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.

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:

- 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.

2.4 Foreign Aid

The Government of Lao PDR has long been suffering from severe budgetary deficits, corresponding to 7 to 8% of GDP. Consequently, a larger part of the investment for economic development has been dependent on foreign aids. During the period from 1984 to 1987, the Government received the following amounts of loans and grants from DAC countries and international organization:

(Million US dollars)

	Sources	1984	1985	1986	1987
(1)	Bilateral	15.0	16.8	21.6	33.7
	Japan	2.4	8.2	6.7	15.3
	Sweden	6.8	5.2	9.1	12.5
	Australia	2.8	2.6	3.5	4.2
	Other DAC countries	3.0	0.8	2.3	1.7
(2)	Multilateral	20.5	21.9	29.4	29.0
	IDA	7.3	5.0	7.0	5.0
	UNDP	5.1	7.4	10.3	13.7
	Other organizations	8.1	9.5	12.1	10.3
Total		35.5	38.7	51.0	62.7

Source: Geographical Distribution of Financial Flows to Developing Countries 1984/1987, OECD 1989

Whereas all the bilateral aids were in the form of grant, the multi-lateral aid included loans, resulting in a relatively low grant element of 86.4% (1987). Among DAC countries, Japan was the biggest donor country in 1985 and 1987, followed by Sweden.

2.5 Background and Contents of the Request

The Lao economy is largely dependent on the agricultural sector, which produces about 65% of GDP and employs more than 80% of work force. Thus, development of the agricultural sector is a key to the economic development of the country and to the improvements of the living standard of its populace. With this background, the Government of Lao PDR launched the 2nd Five Year Plan (1986-1990) with great emphasis on i) attainment of self-sufficiency in rice, ii) securement of adequate security stocks of foodstuffs and iii) diversification of agriculture by expanding production of non-rice crops, livestock and fishery products for domestic consumption and exports. As one of the strategic projects to attain the above objectives, the Government took up "the Agricultural and Rural Development Project in the Suburbs of Vientiane". Feasibility investigations and study for the Project were carried out in 1989 under the technical cooperation of the Government of Japan.

Encouraged with the favourable results of the feasibility study and also owing to the urgent necessity of increase of rice production to ease a serious rice shortage caused by the recent droughts, the Government of Lao PDR requested the Government of Japan to extend a

grant aid for the implementation of the Project. This request covered whole of the Project works, comprising irrigation development of 2,700 ha area, establishment of a demonstration farm, improvement of rural infrastructures for all the villages located in the Project area and provision of operation and maintenance equipment and farm machinery.

Since the above requested works were judged too large in scale to implement under a grant aid due to various constraints, the JICA Basic Design Study Team had discussions with concerned officials of the Government of Lao PDR on the possible reduction of the scope of the works. In reducing the scope of the works, a careful consideration was given to the following:

i) Increase of rice production through irrigation development is the most urgent and important target of the Project.

ii) High priority should be given to the development of the area, where the development benefits will quickly accrue in view of soils, topography and socio-economic conditions.

iii) Improvement of rural infrastructures should be limited to villages, which are located within the selected priority area.

iv) Assuming that the Tha Ngon Project, located adjacent to this Project, will function as a demonstration farm, implementation of the demonstration farm planned under the Project is excluded from the Project works.

Based on the above, the revised scope fo the Project works was determined as follows:

i) Irrigation development will be executed for a net area of 1,200 ha, which mostly extends along the national roads of routes 10 and 13 and will be commanded by Headreach and No. 1 West Main Canal.

ii) Main Pump Station, Headreach and Regulation Pond will be designed with a capacity sufficient to irrigate a net area of 1,700 ha. Except installation of pumping equipment, all the works related to these facilities will be implemented as designed. Of five sets of pumping equipment planned to be provided, four sets will be installed to secure irrigation water for 1,200 ha area.

iii) All irrigation canals, drains and farm roads for 1,200 ha area will be implemented.

iv) Rural infrastructures for five villages, i.e. B. Pha Khao, B. Sa Phang Muk, B. Don Noun, B. Xai and B. Na Khe, will be improved.

v) A Project Office building and a warehouse will be provided.

vi) Equipment necessary for operation and maintenance of the Project will be provided.

Through the discussions, it was confirmed that the scope of the Project works revised as above was acceptable to the Government of Lao PDR and that the development of 500 ha-area, which was excluded from the revised scope of the works, will be carried out under the arrangement and responsibility of the Government of Lao PDR.

Discussions were also made on the possible changes of locations of the headreach and regulation pond, parts of which are planned to be located within forest reserves recently established by the Forest Department. As the results, it was agreed that the headreach route will be partially changed and the regulation pond site will be relocated to minimize damages to the forest reserves.

CHAPTER III THE PROJECT AREA

CHAPTER III THE PROJECT AREA

3.1 Location

The Project area is located in the central part of the Vientiane Plain. It extends southward from the Nam Ngum river to the Bueng Khat Kao swamp along the national roads routes 10 and 13, covering an area of 2,940 ha gross. The latitude north and longitude east of the Project area are 18°00' to 18°08' and 102°39' to 102°41', respectively. The area is located in close proximity of Vientiane city, the southern boundary of the area being only 6 km far from the city center. 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 middle portion of the Project area has extremely flat topography with a slope of less than 1/2,000. The elevation of the area ranges from EL171.0 m to EL164.00 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 1,617 mm, of which 1,470 mm or about 90% falls in the rainy season. The average rainfall observed by the Vientiane meteorological station during 23 years from 1967 to 1989 is as follows:

(Unit: mm)

J	F	M	A	M	J	J	A	S	O	N	D	Total
6.4	12.0	35.8	80.3	243.4	271.3	285.2	303.0	282.5	84.4	9.6	3.5	1,617.3

The mean temperature at Vientiane varies from 22.3°C in December to 29.0°C in April and the maximum temperature reaches to 40.0°C in April. The mean relative humidity is 71.7% over the course of a year with a maximum of 79.6% in August and a minimum of 63.7% in March. The mean evaporation from Class-A pan is 4.3 mm/day with a maximum of 5.2 mm/day in April and a minimum of 3.7 mm/day in January and August. Daily sunshine hours average 6.7 hours, ranging from 4.2 hours in August to 8.4 hours in January.

The meteorological data of the Vientiane meteorological station are shown in Tables-1 to -6.

3.4 Hydrology

The Nam Ngum river is one of the larger tributaries of the Mekong river. The catchment area of the river at Ban Tha Ngon is 16,500 km^2. The monthly mean discharge of the Nam Ngum river at Ban Tha Ngon ranges from 215 m^3/sec in April to 1,790 m^3/sec in September.

The hydrological data of the Nam Ngum river at Ban Tha Ngon station are shown in Table-7 and -8.

3.5 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. The baserock is called "Xaysomboune formation" or "$K2^{xb}$".

The talux 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 most unconsolidated clay, sand and gravel, extends in very low-lying land of the Bueng Khat Khao and the Houei Gnang rivers.

3.6 Soils

The soils in the Project area are classified into three groups in conformity with the FAO/UNESCO soil classification system.

(1) Acrisols (Ferric Acrisols)

The terric acrisols extend broadly over the Project area (area covered: 2,940 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 loan to clay.

(2) Fluvisols

The fluvisols distribute to the lower area along the Bueng Khat Khao swamp. This soil has developed from recent alluvial deposits on a narrow riverine depression. Drainability of the soil is poor and ground water table is high even in the dry season. At present this area is used mainly for the cultivation of floating rice.

(3) Gleysols (Humic Gleysols)

The area of this soil group is 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.

A soil map of the Project area is given in Fig.-1. The extent of each soil unit is summarized as follows:

Soil Unit	Texture	Area (ha)
Acrisols	Sandy loam	436
	Silty loam	1,991
	Silty clay	387
Fluvisols	Silty clay	68
Gleysols	Silty clay	58
Total		2,940

There is no salinity problem for cultivation of crop in the Project area except in a very limited area around the salt-pits located in the Project area. The salt is contained in The 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.

3.7 Land Use

The land use of the Project area is classified into several categories. They are paddy field, grass land, forest, villages, and others. Present land use of the Project area is illustrated in Fig.-2.

Category	Area (ha)
Paddy field	2,259
Grass land	34
Forest	435
Village	179
Others (road, pond, river)	33
Total	2,940

3.8 Population and Administration

(1) Population

The Project area covers 7 villages, of which six are in Saythany District and one in Saysetha District. The total population of the 7 villages was 8,577 in 1988. This population is regarded as being identical to that of the Project area. According to the

population census in 1985, the economically active population from 15 to 60 years old is about 50% of the total population.

Population, total household, farm household of each village in the Project area are summarized as follows:

Village	Population	Nos. of Household	Average Family Size	Nos. of Farm Household
B. Pha Khao	1,925	311	6.2	75
B. Sa Phang Muk	710	149	4.8	101
B. Don Noun	1,263	206	6.1	199
B. Xai	1,326	170	7.8	149
B. Na Khe	655	101	6.5	101
B. Dan Xang	1,318	198	6.7	162
B. Na	1,380	303	4.6	88
Total	8,577	1,438	6.1	875

Source: Saythany and Saysetha District Offices

(2) Administration

The Vientiane Municipality is an administrative unit separated from the Vientiane Prefecture in 1983, which consists of eight administrative districts i.e., Saysetha, Sysathanak, Chanthabouly, Sykhothabong, Saythany, Naxaythong, Hatxayfong and Phyalat. The Vientiane city is being called generically putting together of Saysetha, Sysathanak, Chanthabouly and Sykhothabong districts. The Project area belongs to Saythany and Saysetha districts.

The population of the Vientiane Municipality and the Vientiane city was approximately 404,000 and 212,000 in 1987, respectively.

3.9 Social Infrastructures

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 quantity.

The Vientiane city is mostly served 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 Don Xang (so-called KM-14 point) from the Vientiane city along the national road route 13. 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.

Electricity for inhabitants of the Project area is supplied by the existing 22 kV electric power line of the Lao Electricity Company (Electricite Du Lao), which branches off from the transmission line conveyed from the Nam Ngum hydropower station.

3.10 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 take water from the Mekong river. One (1) project of the remaining seven (7) projects takes water from the Nam Ngum river. This is the Tha Ngon irrigation project, which was completed in 1974 and rehabilitated under a grant aid from the Government of Japan in March 1989. The remaining six (6) projects take water from other rivers or swamps.

All the existing projects are shown in Fig.-3.

3.11 Agriculture in Project Area

(1) Cropping pattern

The Project area is characterized as being a paddy mono-culture area. Most of the paddy fields are generally cultivated under rainfed condition. 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. The present cropping pattern is shown in Fig.-4. Rainy season paddy is planted at the onset of the rainy season, from May to June, and harvested from October to December.

(2) Farming practices

Paddy cultivation is carried out as a labor intensive form of agriculture from seeding to harvesting. Animal power, mainly buffaloes, is used extensively for land preparation. 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.

(3) Yield and production

The paddy yield and production under the present conditions are estimated on the basis of a farm interview survey and a yield survey carried out at the time of the feasibility study. The present unit yield of paddy is estimated at 1.5 ton/ha for rainy season paddy and 2.5 ton/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 in the Project area is estimated as follows:

Crops	Cultivated Area (ha)	Unit Yield (ton/ha)	Production Amount (ton)
Rainy season paddy	2,259	1.5	3,388
Dry season paddy	139	2.5	348
Total	2,398	-	3,736

CHAPTER IV THE PROJECT

CHAPTER IV THE PROJECT

4.1 Objectives of the Project

In 1980, Lao PDR attained self-sufficiency in rice at the national level. However, there has been an imbalance between demand and supply of rice at the regional level, and the Vientiane Municipality, where more than 10% of the total population of the country is concentrated, has been suffering from a chronic shortage of rice. Further, the rice production is still vulnerable to varying climate since most of the paddy fields are rainfed. Under these circumstances, the Government of Lao PDR worked out an agricultural policy with emphasis on i) stable self-sufficiency of rice, ii) securement of adequate security stocks of foodstuffs and iii) diversification of agriculture. The Government took up the Project as one of development projects to be promoted in line with the above policy.

The objectives of the Project are i) to ease a shortage of rice in the Vientiane Municipality, ii) to increase production of non-rice crops for domestic consumption and export, iii) to improve living standard of farmers and to enhance their socio-economic activities through improvement of rural infrastructures, and iv) to save foreign exchange by reducing imports.

4.2 Assessment of the Request

4.2.1 Justification of the Project

An assessment was made on the Request received from the Government of Lao PDR, the content of which was already explained in Section 2.5, as to its suitability for implementation under a Japan's grant aid from the viewpoints of the national development plans, agricultural and rural development projects, supply and demand conditions for foodstuffs, conditions of the Project area, etc., which were clarified through the field investigations. The results of the assessment are summarized as follows:

(1) Significance of the Project in view of the national development plan and agricultural policy

The Government of Lao PDR has been implementing the 2nd Five Year Plan (1986-1990), 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. In the plan, major emphasis is placed on development of the agricultural sector with the following specific objectives;

- To secure self-sufficiency in rice and maintain adequate security stocks,
- To diversify agriculture by expanding production of non-rice crops, livestock and fishery products for domestic consumption and exports,
- To increase exploitation and improve conservation of forest resources by controlling and reducing slash and burn agriculture,
- To expand collectivization of agricultural production activities.

Among the above, the collectivization of agricultural activities was abandoned and, instead, agricultural production based on family farms has been promoted under a new economic policy adopted in 1987. In order to achieve the above-mentioned objectives, the Government of Lao PDR places emphasis on the introduction of intensive cultivation and the expansion of irrigated areas. Especially, irrigation development has been given a high priority, and the area irrigated is planned to be expanded to three times the size in 1985.

The proposed Project aims at the efficient agricultural and rural development with emphasis on irrigation development, and the agricultural production under the Project is planned to be based on family farms. Thus, the implementation of the Project exactly meets the intent and scope of the said national plan and agricultural policy.

(2) Significance of the Project in stabilized supply of foodstuffs

Though self-sufficiency in rice was attained at the national level in 1980, there has been still imbalance between supply and demand of rice at the regional level due to poor transportation facilities. Further, the rice production is vulnerable to climatic conditions since most of the paddy fields are rainfed. The statistics for the recent three years show that, whereas rice production was 1,450,000 tons in 1986, it fell to 1,210,000 tons in 1987 and further to 1,000,000 tons in 1988 due mainly to severe droughts. In these circumstances, the Government of Lao PDR has been forced to import 20,000 to 30,000 tons of rice every year from abroad to ease rice shortage especially in the densely-populated Vientiane Municipality.

The main objective of the Project is to increase and stabilize production of rice through introduction of improved farming practices, including double cropping of rice a year. Located in the proximity of the Vientiane city, the Project is expected to contribute much to easement of rice shortage in the Vientiane Municipality.

(3) Saving of foreign exchange

Balance of foreign trade in Lao PDR has been chronically in deficit, providing a heavy burden on the national budget. The imports of agricultural products and foodstuffs have a significant share of the total imports, amounting to US$7.7 million equivalent in 1987. With implementation of the Project, the rice production in the Project area is expected to increase by about 13,000 tons per annum, which corresponds to about 40% of average annual amount of rice imported for the past three years from 1985 to 1987, and thereby to contribute to the saving of foreign exchanges, equivalent to about US$4 million.

(4) Improvement of living standard of farmers

Under the Project, both yield and production of rice are expected to increase significantly. As the results, annual farm income of an average farm (1.6 ha) is expected to increase from US$550 equivalent to US$2,070 equivalent and also disposable income from US$500 to US$1,600. This will contribute much to the improvement of farm budget and living standard of farmers.

Rural infrastructures such as village roads and potable water supply facilities will be improved under the Project. This will contribute to the enhancement of social and economic activities of villagers and to the improvement of sanitary conditions of villages.

(5) Increase of employment opportunities and demonstration effects

As a result of the Project, employment opportunities for local people will be greatly increased, making a favorable impact on the national economy through the multiplier effect. In addition, the Project is expected to function as a typical model for similar agricultural and rural development in other areas of the country.

Through the assessment explained above, it was clarified that the Project will not only contribute to the improvement of farmers' living standard and stabilization of public welfare in

the Project area but also make a favorable impact on the national economy. Based on these facts, implementation of the Project under a Japan's grant aid is judged practicable and appropriate. Detailed assessments of the Project works are as explained hereunder.

4.2.2 Irrigation and Drainage Facilities and Farm Roads

The purpose of the Project is to make possible double cropping of rice a year all over the Project area by providing efficient irrigation and drainage facilities and farm roads. These facilities are planned in line with the revised scope of the works mentioned in Section 2.5 as follows;

(1) Irrigation facilities

The source of irrigation water for the Project is the Nam Ngum river flowing through the northern part of the Project area. A pump station (Main Pump Station) will be provided at the right bank of the river, about 1 km downstream of the Tha Ngon village. The water lifted from the river at the pump station will be conveyed through a canal (Headreach) for a distance of about 11 km and stored in a regulation pond. The Headreach will run from north to south generally along the national road route 10, and its detailed alignment will be determined so as to minimize required earthworks, to avoid demolition of existing facilities and to minimize damages to forest reserves as far as possible. The inner sections of the Headreach will be lined with concrete in order to reduce seepage losses of canal water, to secure stability of canal banks and to make canal maintenance easier. The regulation pond will be of earthen structure, and its capacity will be determined so as to store an amount of water equivalent to irrigation requirements for six hours. The regulation pond will be sited outside the forest reserves.

Starting from the regulation pond, a main canal (West Main Canal No. 1) will be provided and, branching off from the main canal, secondary, tertiary and field canals will be constructed to distribute canal water to fields. All these canals will be of earth type. Alignments of the canals along the national roads routes 10 and 13 will be made, taking into account the urbanization plan for the Vientiane city.

(2) Drainage facilities

For the drainage system, the Project area is broadly divided into two areas, namely the northern area located north of the national road route 13 and the southern area. In the

northern area, excess water will be drained to the Nam Ngum river through the Houei Gnang and the Nam Kho rivers, while in the southern area water will be drained into the Mekong river through the Houei Ma Hiao river.

The proposed drainage canals consist of main, secondary, tertiary and field drains. All these drains will be unlined earth canals. In the northern area, drainage canals will have relatively steep longitudinal slopes and therefore have relatively small flow areas owing to the steep topography of the area. The southern area has generally flat topography, resulting in gentle longitudinal slopes and larger flow areas of drains. There exist several drains in the southern area at present, but the drainage conditions are very poor because these existing drains do not function as a drainage system. Under the Project, most of the existing drains will be improved and incorporated into a drainage system to be newly constructed. Alignments of drainage canals will be made, avoiding demolition of existing facilities as far as possible and also taking into account future urbanization of the area.

(3) Farm roads

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 irrigation canals. The farm road along the headreach will be utilized mainly for operation and maintenance of the headreach since the national road route 10, running in parallel with the headreach, could be utilized as a trunk farm road. The roads along main and secondary canals will be both for operation and maintenance and for general traffic. The roads along tertiary and field canals will be exclusively for operation and maintenance of canals and for farm operation. In addition, connecting roads will be provided to connect the above roads with each other and to national roads in order to form an efficient road network. The farm roads along the headreach and the main and secondary canals will be provided with laterite pavement to facilitate traffic during the rainy season.

4.2.3 Rural Infrastructures

The Request from the Government of Lao PDR also covers improvements of rural infrastructures for 12 villages located in the irrigation area of 2,700 ha originally proposed by the feasibility study. Since such rural infrastructures are considered to function efficiently only by combining them with irrigation development, however, improvements of rural infrastructures will be limited to five villages located in or around the 1,200 ha area selected

for irrigation development under the Project. The outlines of the improvement works are as follows;

(1) Village roads

The existing village roads in the Project area are poor in quality and insufficient in density, hindering social and economic activities of villagers. Under the rural development plan, improvements of part of village roads will be carried out to secure smooth access to nearby national roads by providing laterite pavement and drainage facilities.

(2) Potable water supply facilities

Villagers in the Project area rely mainly on groundwater from shallow wells for daily use. The field survey shows that three villages have been suffering from shortage of potable water and need to be provided with new water supply facilities under the Project. Since the three villages are located near an existing water pipeline running along the national road route 13, water supply to these villages will be made by providing distribution pipelines, branching off from the said existing pipeline.

4.2.4 Operation and Maintenance Office

After completion of the construction works, all the Project facilities will be transferred to the Vientiane Municipality for their operation and maintenance (O&M). In order to help the Vientiane Municipality in executing the O&M works, an office building will be provided under the Project. The building will be furnished with electric and water supply facilities and other necessary appurtenants, and its floor space will be determined so that all staff and technicians to be assigned will be able to work efficiently.

The above building will be constructed in the early stage of the Project construction and will be utilized as a construction office throughout the construction period. The building will be located near the junction of the national road route 13 with route 10, taking into account availability of electricity and water supply as well as convenience for transport and communication.

4.2.5 Warehouse

A warehouse will be provided for the storage of i) maintenance materials for the Project, ii) O&M equipment and spare parts, and iii) agricultural materials such as seeds, fertilizers and chemicals. The warehouse will be located in the same compound for the said office building and managed by the O&M office.

4.2.6 Supply of Operation and Maintenance Equipment

The Vientiane Municipality has been executing operation and maintenance of a number of existing irrigation projects located within the administrative area of the Municipality, including the Tha Ngon Project completed in 1989 under the Japan's grant aid. In addition, the Municipality will be responsible for operation and maintenance of this Project after the construction as afore-mentioned. Since the equipment presently owned by the Municipality are limited and insufficient for operation and maintenance of the above projects, equipment and tools will be supplied to the Municipality under the Project for smooth and efficient operation and maintenance of the Project facilities.

4.2.7 Organization

The Ministry of Agriculture and Forestry of the Government of Lao PDR will be responsible for implementation of the Project. The Ministry will establish a Project Office and entrust it with design, construction supervision, etc. of the Project. The proposed organization chart for the Project implementation is given in Fig. 8.

After completion of the construction works, the Project Office will be transferred to the Vientiane Municipality and reorganized as an O&M office under the governor. The Office will be directly responsible for operation and maintenance of major facilities such as the main pump station, headreach, main and secondary canals, etc. The operation and maintenance of on-farm facilities will be entrusted to water users' associations to be organized on a tertiary canal basis. The proposed organization for the operation and maintenance is illustrated in Fig. 9.

4.2.8 Necessity of Technical Assistance

In the discussions held with the JICA Basic Design Study Team, the Government of Lao PDR expressed that a Japan's technical assistance of various forms will be needed for operation and management of the Project after the construction.

It is obvious that the objectives of the Project will be attained only through a systematic and efficient management of the Project facilities combined with intensified agricultural extension services to farmers. Although the Government of Lao PDR has long managed similar projects, experience and knowhow in these fields are still limited. To cope with this situation and in view of the fact that the Project is one of sophisticated projects in the country, it is considered essential to extend a Japan's technical assistance to the Government of Lao PDR in the following forms;

- Technical assistance by JICA experts (irrigation, agronomy, agricultural extension and agro-machinery)
- Overseas training of local staff

4.2.9 Basic Plan of the Project Facilities

Through the assessments made in the preceding Sections, it was clarified that the aims and expected effects of the Project meet the intent of the Japan's grant aid program. For the implementation of the Project under a Japan's grant aid, a basic design of the Project facilities will be made in line with the design policy summarized in Table 4.1.

Table 4.1 Outline of Request, Examination of Request and Policy for Basic Design (1/9)

Facilities	Outline of Request	Study & Examination on Request	Policy for Basic Design
a) Main Pump Station			
- Location	- Right bank of the Nam Ngum	- To be located on the river bank with a slope of 30°	- To be determined based on supplementary topo. surveys
- Design discharge	- 4.86 m3/sec (0.81 m3/sec x 6)	- To be based on the revised scope of the works	- To have a capacity for irrigation of 1,700 ha
- Pump type & size	- Inclined pump, 600 mm dia.	- As per F/S design	- As per the request
- No. of pump	- 7 units, including 1-standby	- To be based on the revised scope of the works	- To have a total capacity for irrigation of 1,200 ha. One standby unit be added.
- Pump house	- Operation house only	- To be based on the revised scope of the works. Facilities required for O/M of equipment be provided	- A repairshop and a gantry crane be added for maintenance of pumping equipment
- Design high water level	- 167.20 m (10-year probable high water level of the Nam Ngum)	- To confirm the maximum flood level of the Nam Ngum in the past	- To be safe even against the maximum flood level of 167.62 m occurred in Sept. 1981
- Discharge pipe	- 1,200 mm dia. x 1 & 1,000 mm dia. x 1	- To be designed based on the revised design discharge Safe and economical operation be considered	- To have a capacity for irrigation of 1,700 ha. Provision of double pipelines be considered from viewpoints of operation, maintenance and economy.
- Power distribution line	- 1.0 km long	- To be constructed by Lao side	- Construction costs to be born by Lao side be estimated based on the survey results

Table 4.1 Outline of Request, Examination of Request and Policy for Basic Design (2/9)

Facilities	Outline of Request	Study & Examination on Request	Policy for Basic Design
b) Booster Pump Station No. 1	- 1 station	- To be based on the revised scope of the works	- To be deleted from the Project works, because it is not required for irrigation of 1,700 ha
c) Booster Pump Station No. 2	- 1 station	- Same as above	- Same as above
d) Regulation Pond			
- Location	- At EP of headreach (11.4 km from BP)	- Forest reserve be taken into account in locating	To be shifted to 10.9 km point so as not to damage forest reserve
- Storage capacity	- 110,000 m3	- To be based on the revised scope of the works	To have a capacity for storing 6-hour irrigation requirements for 1,700 ha
- Type	- Earth construction	- Soils at the relocated site consist of laterite and silty clay, having relatively high permeabilities	Earth construction. Pond bottom and inside slopes be coated with clayey materials to reduce seepage losses.
- Pond area at HWL	- 11 ha	- To be determined based on required capacity and effective depth	To be determined so as to avoid excessive pond area and large fluctuation of water levels
- Related structures	Inlet, outlet & spillway	- Locations of structures be re-examined. Outlet be of type suitable for releasing constant discharge	- Spillway be located near existing streams. Provision of an automatic control gate and a distributor for outlet be considered so as to facilitate water management

Table 4.1 Outline of Request, Examination of Request and Policy for Basic Design (3/9)

Facilities	Outline of Request	Study & Examination on Request	Policy for Basic Design
e) Headreach			
- Length & route	- 11.4 km from outlet of Pump Station to Regulation Pond	- Measures be taken to avoid damages to forest reserve, through which part of headreach will run	- Route change be made for 400 m portion of headreach and location of regulation pond be shifted about 500 m upstream of the original to minimize damages to forest reserve
- Design discharge	- 4.86 m3/sec	- To be based on the revised scope of the works	- Design discharge be based on peak irrigation requirements of 1,700 ha and for 24-hr per day operation
- Canal type	- In-situ concrete lined canal	- Lining method be determined in consideration of past experiences in lining works and construction period	- Precast concrete block lining be adopted, taking into account experience in Tha Ngon Project and easiness of quality control
- Related structures	- Turnout, syphon, cross drain, foot path, check, culvert, spillway	- Future plan for widening National road route 10 be considered	- National road route 10 is assumed to be widened to 20 m
		- Locations and numbers of structures be reviewed	- Locations and numbers of structures be determined in consideration of topography and distribution of irrigation areas
		- Additional structures be provided to facilitate farm operation	- Foot paths and culverts be additionally provided where considered necessary
		- Additional structures be provided for convenience of villagers and for desilting works	- Steps be provided in canal
		- Slope protection be considered especially for deep cut portion of canal	- Berms and drainage ditches be provided at some interval of slopes

Table 4.1 Outline of Request, Examination of Request and Policy for Basic Design (4/9)

Facilities	Outline of Request	Study & Examination on Request	Policy for Basic Design
f) Main Canal			
- No. & length	- 3 routes (19.3 km)	- To be based on the revised scope of the works	- West Main Canal No.1 only be provided to irrigate 1,200 ha
- Design discharge	- 2.94 ~ 0.44 m3/sec	- To be based on the revised scope of the works	- To be determined based on irrigation areas and unit requirements of 2.4 lit/sec/ha
- Canal type	- Earth canal	- As per F/S design	- As per Request
- Related structures	- Turnout, syphon, cross drain, foot path, check, culvert, spillway	- Future plan for widening National road route 13 be considered - Locations and numbers of structures be reviewed - Additional structures be provided to facilitate farm operation - Types of structures crossing roads or streams be reviewed	- National road route 13 is assumed to be widened to 25 m - Locations and numbers of structures be determined in consideration of topography and distribution of irrigation areas - Foot paths and culverts be additionally provided where considered necessary - Syphons crossing National road route 13 be changed to culverts. Arrangements and alignments of structures be suitable for prevailing topography.

Table 4.1 Outline of Request, Examination of Request and Policy for Basic Design (5/9)

Facilities	Outline of Request	Study & Examination on Request	Policy for Basic Design
g) Secondary Canal			
- No. & length	- 8 routes (20.8 km)	- To be based on the revised scope of the works	- Only 4 routes be provided to irrigate 1,200 ha
		- Routes be located in consideration of urbanization	- Routes be located 100 ~ 200 m apart from National road route 13
		- BP & EP of canals be re-examined	- BP of SCW1-1 be shifted downstream by 1 km, and EP of SCW1-2 shifted upstream by 900 m
		- Use of existing canals be considered	- Use of existing canals is not considered because their water levels are too low to irrigate the Project area
- Design discharge	- 0.69 ~ 0.12 m3/sec	- To be based on the revised scope of the works	- To be calculated based on irrigation areas and unit requirements of 2.4 lit/sec/ha
- Canal type	- Earth canal	- As per F/S design	- As per request
- Related structures	- Turnout, syphon, cross drain, foot path, check, culvert, spillway, drop	- Future plan for widening National road route 13 be considered	- National road route 13 is assumed to be widened to 25 m
		- Locations and numbers of structures be reviewed	- Locations and numbers of structures be determined in consideration of topography and distribution of irrigation areas
		- Additional structures be provided to facilitate farm operation	- Foot paths and culverts be additionally provided where considered necessary
		- Function of spillways be re-examined	- Spillways be deleted
		- Types of gates be studied	- Steel gates be used

Table 4.1 Outline of Request, Examination of Request and Policy for Basic Design (6/9)

Facilities	Outline of Request	Study & Examination on Request	Policy for Basic Design
h) Drainage Canal			
- Main drain	- 3 routes (8.9 km)	- To be based on the revised scope of the works	- BP of MD3 be changed to the crossing point with National road route 10
- Secondary drain	- 12 routes (30.5 km)	- Same as above - Existing structure of national road route 13 be utilized as a crossing structure of SD2-1	- Only 6 routes be provided - BP of SD2-1 be changed so that the existing structure can be used
- Related structures	- Culvert, drop	- Types of structures be reviewed	- Corrugated iron pipes be used for culverts - Locations and numbers of drops be determined based on survey results
i) Farm Road			
- Main road	- 4 routes (31.0 km)	- To be based on the revised scope of the works	- Only 2 routes be provided
- Secondary road	- 12 routes (21.0 km)	- Same as above	- Classification be changed to Main road, since there is no difference in functions between the two
		- Road along headreach be used for O&M of headreach - Access from National roads be considered	- Road along headreach be changed to one-lane road - Additional connecting roads be provided

Table 4.1 Outline of Request, Examination of Request and Policy for Basic Design (7/9)

Facilities	Outline of Request	Study & Examination on Request	Policy for Basic Design
j) On-farm Facilities			
- Tertiary & field canals	- 256.7 km	- To be based on the revised scope of the works	- To be provided for irrigation of 1,200 ha
		- Alignments be made in consideration of urbanization	- Canals be located 100 ~ 200 m away from National roads
		- Field canals be aligned to facilitate plot-to-plot irrigation	- Field canals be aligned generally along existing field ridges
		- Fill materials for canal embankments be secured economically	- Drains be provided along canals so that excavated materials in drains can be used as filling materials for canals
		- Suitable types of turnouts be adopted for smooth water management	- Steel gates be provided for turnouts of tertiary canals
		- Provision of access structures to fields over canals be considered	- Pipe culverts be provided on canals to secure farm access
			- Work quantities for tertiary and field canals be estimated based on typical designs for selected sample areas
- Tertiary & field drains	- 235.3 km	- To be based on the revised scope of the works	- To be provided for 1,200 ha area
		- Suitable alignments of drains be considered	- In principle, drains be aligned along canals so that excavated materials in drains can be used economically
- Tertiary & field roads	- 270.0 km along tertiary and field canals	- To be based on the revised scope of the works	- To be provided for 1,200 ha area - The roads are to be classified as secondary roads

Table 4.1 Outline of Request, Examination of Request and Policy for Basic Design (8/9)

Facilities	Outline of Request	Study & Examination on Request	Policy for Basic Design
- Land clearing and reclamation	- 880 ha	- To be based on the revised scope of the works	- To be deleted, because the proposed irrigation area (1,200 ha) is covered with existing paddy fields
k) Demonstration Farm - Area	- 64 ha	- Necessity be reviewed	- To be deleted since the Tha Ngon Project could function as a demonstration farm
- Tractor	- 3 units	- Same as above	- Same as above
l) Operation & maintenance office	- To be located near the office of Saythany District	- To be located at a site, where communication is easy and water & electricity are easily available	- To be located at the site along National road route 13, about 150 m away from the junction with National road route 10 - The office be provided with a space sufficient to accommodate 54 staff
m) Warehouse	- 1 unit (700 m2)	- To be located near the O/M office - Not only O/M equipment and parts but also agricultural materials be stored	- To be located within the same premises for O/M office - A store room for equipment and parts be provided. An office room be also provided for efficient store keeping

Table 4.1 Outline of Request, Examination of Request and Policy for Basic Design (9/9)

Facilities	Outline of Request	Study & Examination on Request	Policy for Basic Design
n) Rural Infrastructure			
- Tubewell	- 2 nos.	- To be based on the revised scope of the works	- To be deleted.
- Pipelines	- 8.5 km	- Same as above	- Three pipelines be provided for B. Don Noun, B. Xai and B. Na Khe
- Communal tap	- 43 nos.	- Same as above	- Taps be uniformly distributed for the above three villages
- Village roads	- 6 routes (6.7 km)	- To be based on the revised scope of the works	- Improvements be made on village roads for five villages located along National road route 13
		- Scope of improvement works be reviewed	- Road embankments be hightened, and surface be paved with laterite
- Drainage culverts	- 14 nos.	- To be based on the revised scope of the works	- Nos. of culverts be decreased by revising alignments
o) Operation & Maintenance Equipment	- See Table 4.2	- Equipment be supplied for efficient operation and maintenance of the Project facilities	- As per request

4.3 Outline of the Project

4.3.1 General

The Project to be implemented under the grant aid covers an area of about 2,940 ha (gross), which extends from the right bank of the Nam Ngum river to a place about 6 km north of the center of Vientiane city along the national roads routes 10 and 13. The Project comprises the following development plans:

i) Irrigation development plan, aimed to make year-round irrigation possible in the Project area. Main facilities will have capacities sufficient to irrigate a net area of 1,700 ha, while water distribution systems will be provided only for 1,200 ha.

ii) Agricultural development plan, aimed to make possible double cropping of rice a year under improved farming practices.

iii) Rural development plan, aimed at improvements of village roads and potable water supply facilities.

4.3.2 Executing Agency and Organization

The Ministry of Agriculture and Forestry of the Government of Lao PDR (MAF) will be the executing agency of the Project. An office called "the Project Office" will be established under the minister and will take part of day-to-day operations relating to the implementation of the Project. A coordination committee will also be formed under the minister of MAF in order to coordinate, guide and assist the Project Office in the implementation. The committee will consist of representatives of authorities concerned, including the Vientiane Municipality, Saysetha and Saythany District Offices, etc.

The Project Office will have five sections; i) design section, ii) construction section, iii) equipment section, iv) accounting section and v) administrative section, the total number of office staff being around 25. The organization chart is given in Fig. 9.

4.3.3 Operation and Maintenance Plan

After completion of the Project construction, the Project facilities will be transferred to the governor of the Vientiane Municipality, and both the Project Office and the coordination committee will be put under the authority of the governor. The Ministry of Agriculture and

Forestry will be a member of the coordination committee, and will assist and collaborate with the Project Office in the operation and maintenance of the Project facilities.

The Project Office will be responsible for the operation and maintenance of the major Project facilities, including operation of irrigation water supply, maintenance and repair of facilities, technical guidance and training for farmers in water management, etc. In order to carry out efficiently these works, the Project Office will be organized into four sections, namely i) operation section, ii) maintenance section, iii) accounting section and iv) administration section. The total number of office staff required is estimated at 54. The organization chart is given in Fig. 8.

At the farmers' level, irrigation water users' associations will be organized on a tertiary canal basis to manage water supply and maintain the on-farm facilities under the technical guidance of the Project Office.

The annual operation and maintenance expenditures, which will incur in running the Project Office, are roughly estimated as shown in the following table.

Annual O&M Expenditures

	Items	Quantity	Unit rate (Kip)	Amount (1,000 Kips)
1.	Personnel cost			
	Salaries for staff	54 man-years	-	35,461
	Labor	2,500 man-days	2,100	5,250
2.	Operation cost			
	Electric charge	3,758,000 kWH	7	26,306
	Fuel and lubricant	L.S.		7,092
3.	Office expenses	L.S.		2,837
4.	Maintenance cost	L.S.		11,500
5.	Materials and sundry	L.S.		884
	Total			89,330

4.3.4 Principal Features of the Project Facilities and Equipment

The principal features of the Project facilities and equipment to be provided under the grant aid are as follows:

(1) Main Pump Station

Rated capacity	:	2.295 m^3/sec (0.765 m^3/s x 3)
Pump type	:	Inclined pump (mixed flow pump)
Pump dia.	:	600 mm
Numbers	:	4 units, including standby
Rated head	:	28.0 m
Output of motor	:	300 kW
Discharge pipeline	:	900 mm dia. x 2 lines x 80 m

(2) Headreach

Design discharge	:	3.06 m^3/s
Canal type	:	Open canal with concrete block lining
Length	:	10.96 km
Related structures	:	64 nos.

(3) Regulation Pond

Storage capacity	:	66,100 m^3
Pond area	:	5.6 ha

(4) No. 1 West Main Canal

Design discharge	:	2.19 - 1.44 m^3/s
Canal type	:	Earth canal
Length	:	4.83 km
Related structures	:	26 nos.

(5) Secondary Irrigation Canals

Design discharge	:	0.82 - 0.18 m^3/s
Canal type	:	Earth canal
Length	:	12.13 km
Related structures	:	54 nos.

(6) Main Drains

Design discharge	:	14.63 - 5.35 m^3/s
Canal type	:	Earth canal
Length	:	9.18 km
Related structures	:	8 nos.

(7) Secondary Drains

Design discharge	:	10.24 - 1.61 m^3/s
Canal type	:	Earth canal
Length	:	8.83 km
Related structures	:	15 nos.

(8) On-farm Canals

Tertiary and field canals	:	54.54 km
Tertiary and field drains	:	45.79 km

(9) Farm Roads

Main farm roads	:	28.39 km
Secondary farm roads	:	56.02 km

(10) Rural Infrastructures

Village roads	:	1.70 km
Distribution pipeline	:	4.05 km
Communal tap	:	28 nos.

(11) Project Office : 1 unit (floor area: 832 m^2)

(12) Warehouse : 1 unit (floor area: 700 m^2)

(13) Operation and Maintenance Equipment : See Table 4.2

Table 4.2 Operation & Maintenance Equipment

Equipment	No. of unit
1. Bulldozer, swamp type, 10 tons	1
2. Backhoe, 0.1 m^3	1
3. Wheel loader, 1.7 m^3	1
4. Dump truck, 6 tons	2
5. Cargo truck, 6 tons, w/crane	1
6. Pickup truck 4WD, double cabin	3
7. Motor grader, 9 tons	1
8. Plate compactor, 100 kg	2
9. Concrete mixer, 0.2 m^3	2
10. Submerged motor pump, 50 mm dia.	2
11. Diesel generator, 10 kVA	2
12. Motor cycle, 90 cc	6

CHAPTER V BASIC DESIGN

CHAPTER V BASIC DESIGN

5.1 Irrigation and Drainage Works

5.1.1 Design Policy

The irrigation and drainage works are the main component of the Project works, consisting of the construction of a pump station, a regulation pond, irrigation and drainage canals, farm roads and their related structures. These facilities will be in principle planned so as i) to have appropriate scales for their respective purposes from both technical and economic viewpoints and ii) to effectively function to facilitate social and economic activities of farmers. In preparing basic designs of the facilities, due consideration will be given to simplification of design and maximum use of locally available materials for construction so that the facilities will be easily and efficiently operated, maintained and repaired by local technicians. The basic design policies for respective facilities are as explained below:

Irrigation facilities

1) The total area to be irrigated under the Project shall be 1,200 ha net.

2) A high irrigation efficiency shall be attained for the effective use of expensive pumped water.

3) Types of irrigation facilities to be adopted shall be determined mainly in view of easier operation, maintenance and water management, taking also into account present irrigation practices in existing projects.

4) Alignments of facilities shall be made so as not to conflict with the urbanization plan for Vientiane city.

5) Design of facilities shall be made, taking collectively into account natural conditions of the construction sites, availability of construction materials, and easiness of construction works.

Drainage facilities

1) Improvements of existing drains and natural streams, and their incorporation into the Project drainage system shall be considered to reduce construction costs.

2) Alignments of drains shall be made so as not to conflict with the urbanization plan for Vientiane city.

Farm roads

1) Maximum utilization of existing roads shall be considered.

2) In order to enhance the social and agricultural activities of farmers, emphasis shall be put on smooth connection of farm roads with the national roads routes 10 and 13.

3) Major farm roads shall be given with embankments and surface pavements to facilitate traffic even during the rainy season.

5.1.2 Study and Examination on Design Criterion

(1) Nam Ngum river

The monthly mean discharges of the Nam Ngum river at Ban Tha Ngon located about 1 km upstream of the main pump station site are 215 m^3/sec in minimum (April), 1,790 m^3/sec in maximum (September) and 667 m^3/sec in average. The minimum discharge of the river at Ban Tha Ngon observed was 39 m^3/sec in May 1960. The monthly mean discharge of the Nam Ngum river at Ban Tha Ngon for 1973 to 1989 was as follows;

(Unit: m^3/sec)

J	F	M	A	M	J	J	A	S	O	N	D	Average
263	240	234	215	275	532	1,081	1,646	1,790	951	466	305	667

The low flow analysis was made on the basis of annual minimum daily discharge records at Ban Tha Ngon. The frequency analysis was 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	153.6	152.9	152.7	152.6

The flood discharge was estimated on the basis of annual maximum daily discharge record at Ban Tha Ngon. 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	166.6	167.2	168.4	168.6

Based on the results of the above analyses, the Design Low Water Level and Flood Water Level for the main pump station were determined as follows;

Design Low Water Level (LWL) : 152.00 m
Design Flood Water Level (FWL) : 167.20 m

Though the design FWL was determined as above, the design of the main pump station will be made so that no serious damages to pumping equipment will occur even for the flood level of 167.62 m (September 1981), which was the highest flood level observed from 1972 through 1988.

(2) Irrigation water requirements

The crop proposed to be grown in the Project area is paddy rice. The irrigation water requirement for paddy rice was estimated on the following conditions;

1) The potential evapotranspiration is calculated by the modified Penman method recommended in "Crop Water Requirement, FAO Irrigation and Drainage Paper No. 24, 1977 (FAO paper)". The crop coefficient (Kc) was also based on the

FAO paper. The climatic data observed at Vientiane meteorological station are used.

2) 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 results of percolation in existing paddy fields.

3) The puddling water requirement was estimated at 180 mm, considering such factors as soil properties, pudding method and period, groundwater table in the paddy field, etc. The nursery water requirement was estimated at 420 mm, considering actual measurement results of evapotranspiration and percolation, and prevailing nursery method.

4) The design rainfall 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 Mekong Committee.

5) The unit diversion water requirement was estimated by adding the irrigation losses, which consist of application loss, operation and conveyance loss, to the farm water requirement. The efficiencies taken into account are as follows:

Item	Efficiency
Application efficiency	85%
Operation efficiency	80%
Conveyance efficiency	90%
Overall irrigation efficiency	61%

The peak unit diversion requirement was thus estimated as follows:

Crop	Peak Time	Peak Unit Diversion Requirement
Dry season paddy	February	1.80 lit/sec/ha
Rainy season paddy	July	1.05 lit/sec/ha

The detailed calculations of the above requirements are given in Tables 9 and 10.

(3) Drainage water requirements

The Project area will consist of paddy field and upland field. In the estimation of drainage water requirements the upland field is defined as non-paddy field such as upland field, fallow land, forests, etc. The estimated daily maximum rainfall with a 10-year return period is employed as design rainfall, namely 164 mm.

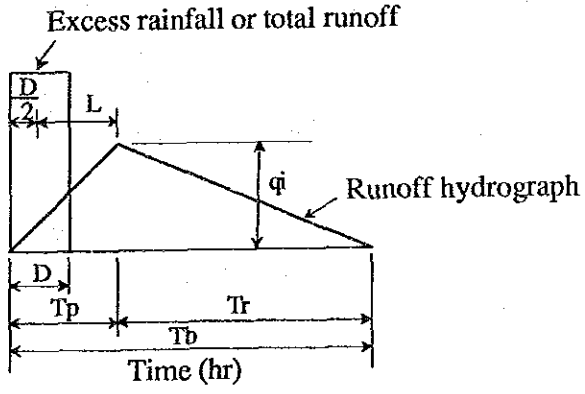
1) Drainage water requirement for paddy field

$$Qp = q \times A$$
$$q = RE24 \times 10^4/60 \times 60 \times T = 94 \times 0.058 = 5.4 \text{ lit/sec/ha}$$
$$RE24 = R24 - (D1 - D2)$$

where; Qp = Design drainage water requirement for paddy field (lit/sec)
q = Unit drainage water requirement (lit/sec/ha)
A = Drainage area (ha)
R24 = Design rainfall (164 mm)
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)
T = Duration of drain from paddy field (48 hr)

2) Drainage water requirement for upland field

The drainage water requirement for the upland field is considered to be the peak runoff from the upland field, considering no storage function in the area. The peak runoff is estimated by applying a triangular unit hydrograph.



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

where; Q = Total runoff in mm, 65.6 mm (40% of design rainfall)
qi = Peak rate (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 (2 x Tp)
Tb = Total time of hydrograph (hr)
D = Rainfall period (12 hrs by referring to the hourly rainfall data at Vientiane)
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".

$$Qh = qh \times A$$
$$qh = qi \times 10^4/60 \times 60$$

where, Qh = Design drainage water requirement for upland field (lit/sec)
qh = Unit drainage water requirement (lit/sec/ha)
A = Drainage area (ha)

(4) Cropping pattern

The double cropping of rice is adopted for the Project taking into consideration (i) suitability of land and climate, (ii) profitability of crop for both farmers and nation, (iii) marketability of products, (iv) acceptability to farmers and (v) agricultural policy of the Government. The proposed cropping calender was established in consideration of the following;

1) Both maturity and harvesting of paddy should take place in the dry season.

2) A low temperature of less than 15°C, which may cause severe damage to paddy yield, should be avoided during the generative growth period.

The proposed cropping pattern is shown in Fig. 5. The fallow period of about one and half months was given in the proposed cropping pattern for maintenance and repair of the Project facilities.

5.1.3 Basic Plan

(1) Main pump station

Although the Nam Ngum river has abundant water throughout the year, the river water level is too low for the gravity irrigation of the Project area. Hence, the use of pumps is essential for the irrigation system of the Project. The proposed pump station (the main pump station) will be located on the right bank of the Nam Ngum river, about 1.0 km downstream of Ban Tha Ngon or about 1.5 km upstream of an existing pump station of the Tha Ngon Project.

For design of the main pump station, selection of pump type was made from economic and technical viewpoints. Based on the required pumping discharge and head, three pump types were selected for comparison, namely i) horizontal shaft volute pump, ii) inclined mixed flow pump and iii) vertical shaft mixed flow pump. Generally horizontal shaft volute pump is economically superior to other pumps. Since allowable suction head is limited for volute pump, however, it has to be installed below the water levels of the Nam Ngum river, requiring construction of a costly water tight pump house. Inclined pump is comparable to vertical shaft mixed flow pump in easiness of operation and maintenance but is somewhat superior in required initial costs. The inclined pump is one of the most popular pump types adopted in existing projects in Laos and local technicians are well accustomed to operation and maintenance of this type of pump. Further, pump house and related facilities required for installation of inclined pump are of relatively simple and small in scale. Taking collectively into account the above factors, the inclined pump was selected as the most appropriate type for the main pump station.

The facilities related to the pump station will consist of a repairshop, an operation house and a gantry crane. The repairshop is to make maintenance and repair of pumping equipment and will have a space sufficient for dismantling and repairing a complete set of pumping equipment. It will be also provided with a room for storage of equipment, tools and spare parts. A gantry crane will be installed to facilitate dismantling of pumping equipment and transporting them to the repairshop. The operation house will be designed to have a sufficient space for installation of switch boards, control boards and ancillary apparatus and for operation of these equipment. It will be also provided with an office room cum resting room for pump operators and a storage room for tools and spare parts of pumping equipment.

Two alternative plans were conceived on design of pump discharge pipelines, namely provision of two lanes of pipelines and that of one pipeline with larger diameter. Comparison of these plans shows that, although the construction cost of one pipeline is somewhat less than that of two pipelines, the provision of two pipelines is far superior to the one pipeline in view of operation, maintenance and repairing. Accordingly, two pipelines will be adopted to the main pump station.

The principal features of the main pump station thus designed are as summarized below;

1) Pumping discharge : For irrigation of 1,700 ha ; 3.06 m^3/s (0.765 m^3/s x 4)
For irrigation of 1,200 ha ; 2.29 m^3/s (0.765 m^3/s x 3)

2) Pump, Type : Inclined pump (mixed flow pump)
Dia. : 600 mm
Numbers : For irrigation of 1,700 ha ; 5 units (incl. 1-standby)
For irrigation of 1,200 ha ; 4 units (incl. 1-standby)

3) Rated head : 28.0 m

4) Output of motor : 300 kW each

5) Discharge pipeline : 900 mm dia. x 2 lanes x 80 m

Durability of pumping equipment depends upon timely maintenance and repairs of the equipment. To prolong the durability, therefore, an appropriate amount of spare parts and consumables, and gunine tools for repairing will be supplied under the Project.

(2) *Irrigation canals*

The proposed irrigation canals for the Project consist of a headreach, and main, secondary, tertiary and field canals. All these canals will be designed to be trapezoidal open canals. In order to minimize seepage loss of canal water and to secure stability of canal banks, it is most preferable to provide all the canals with lining. In view of the Project economy, however, only the headreach, which is the largest and the most important canal, is proposed to be lined. In selecting a suitable lining material and method, a comparative study was made on the following;

i) Rubber sheet lining

ii) In-situ concrete lining

iii) Precast concrete block lining

Taking into account the characteristics of lining methods given in the table in the next page, advantages and disadvantages of the above three lining methods are examined as follows;

Rubber sheet lining; This method requires relatively high technical skill for implementation,especially for jointing rubber sheets. Moreover, the rubber sheets are liable to damages by cattles and buffaloes as well as by maintenance works such as desilting, weeding, etc. Since this type of lining has never been adopted in Lao PDR and there are some foreseeable problems in implementation and maintenance of this lining as above-mentioned, the rubber sheet lining cannot be adopted for the Project.

In-situ concrete lining; This type of lining for a long canal like the headreach has never been implemented in Lao PDR, and therefore local technicians have no experiences on this lining. Generally, this method requires very precise technics in placing, finishing and curing concrete and, even if well implemented, losses of concrete by about 30% will inevitably occur.

Precast-concrete block lining; This type of lining was successfully implemented in the Tha Ngon Project completed in 1989. This lining method has generally advantages that i) quality control of concrete blocks can be easily made because they are manufactured in a central plant, ii) concrete blocks can be manufactured even during the rainy season, in which most of works have to be suspended, and iii) repairing of damaged lining can be easily made by simply replacing damaged ones with new ones.

Through the above examinations, the precast concrete block lining was clarified to be technically most advantageous. Further, a cost comparison shows that the precast concrete block lining is the most economical among the three, the unit cost being about US$20/m^2. Accordingly, the precast concrete block lining was adopted for the Project.

Study on Construction Method of Lining Canal

Item	Precast Concrete Block Lining	Concrete Lining	Rubber Sheet Lining
I. Construction			
(1) Treatment of foundation	Unsuitable soils should be replaced with sands and be followed by compaction. Even suitable soils, concrete should be placed immediately after excavation to minimize the change of moisture ratio.	Same as for precast concrete block lining. Special attention is required to concrete lining to a canal with high canal banks.	Same as for concrete lining. Grasses and stones under the sheet should be removed.
(2) Treatment of groundwater	Weep holes or drains should be provided to release groundwater pressure. Flap valves should also be provided for under drains.	Same as for precast concrete block lining.	Same as for concrete lining. The connection between flap valves and the sheet is difficult.
(3) Stability of canal	The stability of canal depends on the inside slope of canal. The inside slope of canal is required to be 1 to 1.5 or 1.0.	Same as for precast concrete block lining.	Same as for concrete lining.
(4) Availability of materials	Concrete materials are available in Laos.	Same as for precast concrete block lining.	The rubber sheet is not available in Loas.
(5) Placing	Since the concrete block is manufactured in a factory, the quality control and curing are easy. Extra concrete is not necessary. Comparing with the concrete lining, the speedy progress of works is expected.	Extra concrete of 30% is expected for placing concrete. The treatment of surface requires much time. Since the construction will be carried out in the dry season, the careful curing of concrete is necessary.	Careful placing of the sheet is necessary. Special adhesive and experienced person are required for placing. Consequently, the rubber sheet lining cannot be done by the local contractor.
II. Operation and maintenance	The precast concrete block lining canal is strong against the scouring by water flow and the damage by person and animals. The damages by the undifferential settlement are easily repaired by replacing concrete block. The maintenance for weeding and deposited silts and sands is easy.	Same as for precast concrete block lining. The canal is relatively weak against undifferential settlement.	The rubber sheet lining is very weak against damage by person and animals. The repairing of damaged parts is very difficult, because of availability of materials and experienced person.

Hydraulic designs of the headreach and other irrigation canals are carried out on the following conditions:

Design discharges, which are determined by the following formula;

$$Q = q \times A \times 1/1,000$$

where, Q; Design discharge in m^3/sec
q; Unit design discharge in lit/sec/ha
For headreach; q = 1.8 lit/sec/ha
For other canals; q = 2.4 lit/sec/ha
A; Command area in ha

Design discharges for respective canals thus calculated are shown in Fig. 6 (Irrigation Diagram).

Allowable water velocity

Items	Max. velocity	Min. velocity
Lined canal	1.2 m/sec	0.3 m/sec
Earth canal	0.6 m/sec	0.3 m/sec
Structures	2.0 m/sec	0.3 m/sec

Roughness coefficient for Manning's Formula

Lined canal & concrete structures ; 0.015
Earth canal ; 0.027

Minimum free board

Lined canal ; 0.30 m
Earth canal ; Design water depth x 1/3

Inside slope of canal bank

Lined canal ; 1:1.50
Earth canal, main & secondary canal ; 1:1.50
Tertiary & field canal ; 1:1.00

(3) Related structures of irrigation canals

In conjunction with irrigation canals, a number of structures of various types will be constructed in order i) to divert and distribute canal water, ii) to regulate canal water levels, iii) to pass canal water across roads or rivers and iv) to protect canals from failure.. Kinds and numbers of canal structures to be provided under the Project are as tabulated below;

Items	Numbers of Structures		
	Headreach	Main canal	Secondary canal
Nos. of canals	1	1	4
Canal length (km)	11.0	4.8	12.1
Turnout	5	7	15
Check	4	5	10
Syphon	3	-	2
Culvert	11	4	8
Drop	-	-	3
Spillway	2	1	-
Cross drain	15	2	5
Foot path	7	7	11
Washing steps	12	-	-
Slope protection	5	-	-

(4) Regulation pond

Irrigation water will be conveyed by the headreach from the main pump station on a 24-hour per day basis to minimize the construction costs. However, irrigation operation at the fields is planned to be 18 hours per day in view of a fact that existing irrigation projects, in which 24-hour irrigation is practiced, face some water management problems. In order to store the water for the balance of six hours, a regulation pond will be provided at the tail of the headreach. The principal features of the regulation pond designed are as summarized below;

Storage capacity (active)	:	66,100 m^3
High water level (HWL)	:	El.171.74 m
Low water level (LWL)	:	El.170.54 m
Pond bottom (average)	:	El.170.04 m
Water surface area at HWL	:	56,133 m^2

Total pond area	:	59,996 m^2
Side slope of embankment	:	1:2.0
Earth lining to slopes & bottom	:	t = 50 cm
appurtenant structures	:	Inlet, outlet and spillway

The side slopes and bottom of the regulating pond will be lined with impermeable clayey materials, since the natural ground has a relatively high seepage rate of 20 to 30 mm/day. The outlet structure of the pond will be designed so as to release accurately the stored water according to irrigation requirements. For this purpose, the structure will be equipped with an automatic water level control gate and a calibrated water distributor.

(5) Drainage canals and related structures

The proposed drainage canals consist of main, secondary, tertiary and field drains. All these drains are designed to be trapezoidal open canals of unlined type. Designs of these drains are carried out in the following manner;

Design discharges, which are determined by the following formula;

For paddy fields : $Qp = q_p \times A$
For non-paddy fields : $Qh = q_h \times A$

where, Qp, Qh ; Design discharge in m^3/sec
q_p, q_h ; Unit design discharge in $m^3/sec/ha$
A ; Drainage area in ha

Design discharges thus calculated for respective drains are shown in Fig. 7 (Drainage Diagram).

Maximum water level of drains ; 10 cm below neighbouring ground level

Roughness coefficient for Manning's formula;

Earth canal	:	0.035
Concrete structure	:	0.015
Corrugated iron pipe	:	0.022

Side slope;

For drains with bottom width of more than 50 cm : 1:1.5
For drains with bottom width of less than 50 cm : 1:1.0

Culverts and drops will be provided at respective points, where drainage canals run across roads or irrigation canals and drainage canals have excessive longitudinal slopes. Numbers of these structures to be constructed are as follows;

Items	Numbers of structures	
	Main drain	Secondary drain
Nos. of drains	3	6
Canal length (km)	9.2	8.8
Drainage culvert	8	12
Drainage drop	-	3

(6) Farm roads

In principle, farm roads will be provided alongside all the irrigation canals. The farm roads are broadly divided into two types, namely main roads and secondary roads. Although the road along the headreach is classified as a main road, it will be given with less road width than other main roads. This is because the road along the headreach is not expected to function as a social road due to existence of the national road, route 10. The main roads along main and secondary canals are the important roads both for the operation and maintenance of the Project facilities and for general traffic. The secondary roads will be provided along tertiary and field canals for farm operations. Numbers and length of farm roads to be constructed under the Project are as follows;

Road type	Canal, along which road is provided	Total width	Numbers	Total length
Main road	Headreach	3.50 m	1	11.1 km
	Main canal	4.50 m	1	4.8 km
	Secondary canal	4.50 m	4	2.4 km
Secondary road	Tertiary canal	3.00 m	-	9.2 km
	Field canal	3.00 m	-	46.9 km

The features of the respective farm roads are as summarized below;

Road type	Canal, along which road is provided	Total width	Laterite pavement		Minimum embankment height
			Width	Thickness	
		(m)	(m)	(m)	(m)
Main road	Headreach	3.50	2.50	0.15	0.50
	Main canal	4.50	3.50	0.15	0.50
	Secondary canal	4.50	3.50	0.15	0.50
Secondary road	Tertiary canal	3.00	-	-	0.30
	Field canal	3.00	-	-	0.30

Structures related to farm roads will be culverts for crossing irrigation canals or drains, which are already counted as irrigation culverts or drainage culverts.

(7) On-farm facilities

The proposed on-farm facilities comprise tertiary canals and drains, field canals and drains, secondary farm roads and their related structures. For estimation of work quantities and construction costs, design of the on-farm facilities was made for two sample areas as follows;

Irrigation canals; Alignments of tertiary and field canals are to be made in due consideration of i) efficient utilization of irrigation water, ii) equitable distribution of water to fields, iii) easier water management and iv) efficient farming operations. In this view, the maximum length of one field canal is set at around 600 m, and its command area is determined to be about 18 ha (600 m x 300 m). Six division boxes will be provided on one field canal. Generally, field canals will be aligned along contour lines, while tertiary canals will be at right angle to contour lines. Alignments of these canals for the selected sample areas are given in the attached drawings, and their lengths are estimated as follows;

Items	Sample area - A	Sample area - B
Command area (ha)	71	84
Tertiary canals (m)	830	300
Field canals (m)	3,080	2,710
Division boxes (nos.)	27	36

Drainage canals; Tertiary and field drains will be provided in principle along tertiary and field canals, and excavated materials from the drains will be used as filling materials for canal embankments. Lengths of tertiary and field drains for the sample areas are as follows;

Items	Sample area - A	Sample area - B
Drainage area (ha)	71	84
Tertiary drains (m)	1,000	450
Field drains (m)	820	3,740
Drainage culverts (nos.)	2	3

Secondary farm roads; Alignments of secondary farm roads will generally follow those of tertiary and field canals as shown in the attached drawings. Total lengths of secondary roads for the sample areas A and B are 3,350 m and 3,880 m, respectively.

Principal Features of Irrigation & Drainage Facilities and Farm Roads (1/3)

Facilities			Description
1.	Irrigation facilities		
(1)	Main pump station		
	Pumping capacity	;	2.295 m^3/sec (0.765 m^3/sec x 3)
	Pump type	;	Inclined pump (mixed flow pump)
	Pump size	;	600 mm dia.
	Number of unit	;	4 units (including 1-standby)
	Rated pump head	;	28.0 m
	Output of motor	;	300 kW
	Discharge pipeline	;	900 mm dia x 2 x 80 m
	Control house	;	15 m x 6 m x 3.8 m
	Repairshop	;	9.6 m x 8.4 m
	Gantry crane	;	1 set, 8.0 m x 3.6 m
	Switchyard	;	12.5 m x 6.0 m
(2)	Headreach		
	Design discharge	;	3.06 m^3/sec
	Canal type	:	Precast concrete block lined canal
	Length	;	10.96 km
	Related structures	;	Turnout, check, syphon, culvert, spillway, cross drain, foot path, washing step, slope protection
(3)	Regulation pond		
	Storage capacity	;	66,100 m^3
	HWL	;	El.171.74 m
	LWL	;	El.170.54 m
	Pond bottom	;	El.170.04 m
	Water surface area	;	5.6 ha at HWL
	Related structures	;	Spillway, inlet, outlet
(4)	Main irrigation canal (No. 1 West Main Canal)		
	Design discharge	;	2.19 m^3/sec ~ 1.44 m^3/sec
	Canal type	;	Earth canal
	Length	;	4.83 km
	Related structures	;	Turnout, check, culvert, foot path, cross drain

Principal Features of Irrigation & Drainage Facilities and Farm Roads (2/3)

Facilities		Description
(5) Secondary irrigation canal		
Design discharge	;	0.82 m^3/sec ~ 0.18 m^3/sec
Canal type	;	Earth canal
Numbers of canal	;	4
Total length	;	12.13 km
Related structures	;	Turnout, check, culvert, cross drain
(6) Tertiary irrigation canal		
Design discharge	;	0.18 m^3/sec ~ 0.043 m^3/sec
Canal type	;	Earth canal
Numbers of canal	;	19
Total length	;	9.2 km
Related structures	;	Division boxes
(7) Field canals		
Design discharge	;	0.043 m^3/sec
Canal type	;	Earth canal
Total length	;	45.4 km
Related structures	;	Division boxes
2. Drainage facilities		
(1) Main drains		
Design discharge	;	14.63 m^3/sec ~ 5.35 m^3/sec
Canal type	;	Earth canal
Numbers of drain	;	3
Total length	;	9.18 km
Related structures	;	Drainage culvert
(2) Secondary drains		
Design discharge	;	10.24 m^3/sec ~ 1.61 m^3/sec
Canal type	;	Earth canal
Numbers of drain	;	6
Total length	;	8.83 km
Related structures	;	Drainage culvert, drop

Principal Features of Irrigation & Drainage Facilities and Farm Roads (3/3)

Facilities			Description
(3)	Tertiary drains		
	Design discharge	;	2.89 m^3/sec ~ 0.04 m^3/sec
	Canal type	;	Earth canal
	Numbers of drain	;	15
	Total length	;	2.2 km
	Related structure	;	Drainage culvert
(4)	Field drains		
	Design discharge	;	0.097 m^3/sec ~ 0.016 m^3/sec
	Canal type	;	Earth canal
	Total length	;	33.6 km
	Related structure	;	Drainage culvert
3.	Farm roads		
(1)	Main farm road		
	Total width	;	3.5 m for the road along headreach
			4.5 m for others
	Type	;	Laterite-paved road
	Numbers of road	;	6
	Total length	;	28.3 km
(2)	Secondary road		
	Total width	;	3.0 m
	Type	;	Dirt road
	Total length	;	56.0 km

5.2 Rural Infrastructures

5.2.1 Design Policy

Villages, for which rural infrastructures are proposed to be improved under the Project, are Ban Don Noun, Ban Xai, Ban Na Khe, Ban Pha Khao and Ban Sa Phang Muk, which are located in or near the irrigation development area of the Project. These villages have been suffering from poor conditions of existing roads and/or shortage of potable water supply, both hindering social and economic activities of villagers. The rural infrastructures to be improved under the Project are as follows;

i) Improvement of village roads, connecting villages with the national road, route 13, for three villages.

ii) Provision of potable water supply systems for three villages by extending an existing municipal water pipeline.

5.2.2 Study and Examination on Design Criterion

(1) Village roads

In order to secure smooth access between the national road, route 13 and villages and/or among villages, the following existing roads will be rehabilitated and improved under the Project.

Roads	Present conditions		
	Length	Width approx.	Road conditions
- NR route 13 ~ B. Pha Khao	500 m	7.0 m	Poor drainage conditions due to insufficient road embankment
- NR route 13 ~ B. Sa Phang Muk	500 m	6.0 m	Same as above
- NR route 13 ~ B. Don Noun ~ B. Xai ~ B. Na Khe	1,700 m	5.0 m	Irregular road surface & insufficient road embankment

Note: NR = National road

(2) Potable water supply facilities

Three villages, namely Ban Don Noun, Ban Xai and Ban Na Khe have been suffering from a serious shortage of potable water. To solve this problem, these villages will be

provided with potable water supply facilities under the Project. The source of potable water supply will be the existing municipal water supply pipeline (pipe; 200 mm dia., capacity; 3,480 m^3/day, water pressure; 4 kg/cm^2) recently constructed by the Lao Water Supply Company along the national road, route 13. The design concepts for the water supply facilities are as follows;

i) Design capacity of the facilities will be determined, following a standard applied to those in neighbouring areas.

ii) The facilities should be of types and construction, comparable to those constructed and being operated by the Lao Water Supply Company.

iii) In designing the facilities, maximum use of locally available materials should be considered to facilitate maintenance works after the implementation.

5.2.3 Basic Plan

(1) Village roads

Improvements of the village roads will be made by hightening road embankments and providing laterite pavement. The proposed dimensions of respective village roads after improvement are as follows;

Road	Length (m)	Emb. height (m)	Total width (m)	Effective width (m)	Pavement thickness (m)
NR route 13 ~ B. Pha Khao	500	0.1	7.00	6.00	0.15
NR route 13 ~ B. Sa Phang Muk	500	0.1	6.00	5.00	0.15
NR route 13 ~ B. Don Noun ~ B. Xai ~ B. Na Khe	1,700	0.2	5.00	4.50	0.15

The NR route 13 ~ B. Don Noun ~ B. Xai ~ B. Na Khe road will be provided with side ditches and culverts for drainage of rain water and for smooth connection to other village roads.

(2) Potable water supply facilities

Total demand for potable water for three villages is estimated based on projected population in 2000 (population growth rate applied: 2.9% per annum) and per capita consumption of 60 liters/day. The net water demand is determined by deducting available amount of potable water of existing wells from the above total demand as follows;

Items	Ban Don Noun	Ban Xai	Ban Na Khe	Total
1) Present conditions				
- Population	1,263	1,326	655	3,244
- Existing wells (nos.)	2	3	5	10
- Estimated water supply (m^3/d)	5	7	12	24
2) Plan				
- Population in 2000	1,780	1,868	923	4,571
- Total water demand (m^3/d)	107	112	55	274
- Net water demand (m^3/d)	102	105	43	250

As seen in the above table, the total net water demand for three villages is estimated at 250 m^3/day, which can be supplied from the existing pipeline of the Lao Water Supply Company with a capacity of 3,480 m^3/day. Water supply to villagers will be made through communal taps, which will be provided at an approximate rate of one tap per 20 households. Total numbers of communal taps required in each village are estimated as follows;

Items	Ban Don Noun	Ban Xai	Ban Na Khe	Total
1) Present conditions				
- Nos. of households	206	170	101	477
- Existing wells (nos.)	2	3	5	10
2) Plan				
- Nos. of households in 2000	290	240	142	672
- Required nos. of taps	15	10	3	28

Branching off from the existing pipeline of the Lao Water Supply Company, three systems of water distribution pipelines will be constructed, one for Ban Xai and Ban

Na Khe and two for Ban Don Noun. The distribution pipelines will be made of PVC pipes of 100 mm to 50 mm diameters, and will be provided with such facilities as control valves and water measuring devices. The principal features of the proposed water supply systems are as follows;

Items	Quantity
- Branching works from existing pipeline	3 places
- Distribution pipelines	
100 mm dia. pipes	650 m
75 mm dia. pipes	1,450 m
50 m dia. pipes	1,950 m
- Control valves	
100 mm dia. valves	2 nos.
75 mm dia. valves	4 nos.
25 mm dia. valves	28 nos.
- Water measuring devices, 25 mm dia.	28 sets
- Communal taps	28 sets

5.3 Building Works

5.3.1 Design Policy

Buildings to be constructed under the Project are an office building and a warehouse. The office building will be primarily for the use of operation and maintenance staff of the Project, but it will be used temporarily as a construction office during the Project construction. The warehouse will be for storage of i) maintenance materials, ii) equipment and tools for operation and maintenance and their spare parts, and iii) seeds, fertilizers, chemicals and other agricultural inputs. The design policy for these buildings is worked out as follows;

i) The buildings shall be so designed that they are convenient for use and less expensive in maintenance. Types and construction of the buildings will generally follow those normally adopted in Lao PDR. Spaces of the buildings will be determined based on Japanese standards, since no such standards are available in the country.

ii) In the design of the buildings, maximum use of locally available building materials shall be considered. However, use of local materials that are poor in quality or limited in quantity will not be considered.

iii) The buildings shall be designed, taking into account the facts that i) prevailing climate is characterized by distinct dry and rainy seasons, and ii) there are little possibilities of occurrence of earthquakes in Lao PDR.

5.3.2 Study and Examination on Design Criterion

The operation and maintenance office will comprise four sections, namely the operation section, the maintenance section, the accounting section and the administrative section as shown on the attached Fig. 8, and 54 staff in total are expected to be assigned to the office. As for the warehouse, storage of such equipment and materials as operation and maintenance equipment, spare parts, seeds and other agricultural materials are expected. The design conditions for these buildings are determined in consideration of the above-mentioned functions and purposes as follows;

Operation and maintenance office

- The office will consist of one director room and seven office rooms. As annexes to these, a meeting room, a secondary room, two store rooms and a kitchen will be provided.

- A conference room will also be provided for discussions and conferences on operation and maintenance. The size of this conference room will be determined on the assumptions that not only the project staff but also representatives of water users' associations will participate in the conferences.

Warehouse

- The warehouse will be provided with two entrances so that cargo trucks can enter and go out without difficulties.

- The warehouse will have a space sufficient to store agricultural materials required for farm operations for 1,700 ha.

- A store room separated from the main store floor with partition walls will be provided for storage of equipment spare parts.

- An office room will be provided for proper store keeping.

5.3.3 Basic Plan

(1) Building site

The proposed site of the buildings is located along the national road route 13, about 150 m away from the junction with the national road route 10. The site is of rectangular shape and covers an area of 7,680 m^2. The land is owned by the Saythany District of the Vientiane Municipality.

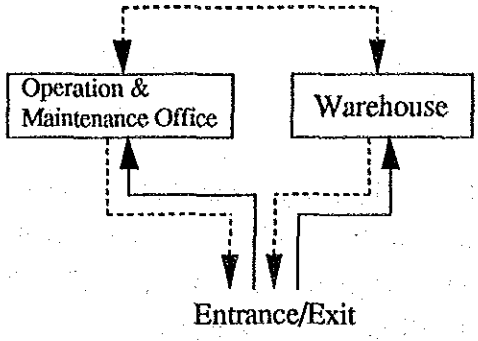
The total floor area of the proposed buildings is estimated at 1,373 m^2, which correspond to about 18% of the site area. For access to the site from the national road, an access road with a width of 8 m will be provided. Electricity for the buildings will be supplied from an existing power distribution line running along the national road route 13. Potable water will be supplied by extending an existing pipeline of the Lao Water Supply Company. Sewerage will be treated within the site by providing septic tanks and soak pits, since no public facilities are available.

(2) Layout plan

In making a layout plan, due considerations will be given to the following;

- The building layouts should be made so that respective buildings can function efficiently.
- The office building should be laid so that its longer side faces south.
- An open yard should be provided in front of the warehouse for parking vehicles and heavy equipment. The yard and warehouse should be provided with a fencing.
- The buildings should be sited at as much distance as possible from the national road to avoid noise.
- The plans and building heights should be suitable for purposes and functions of the respective buildings.

The proposed building layout and its functional flow are schematically shown below;



The detailed layouts of the buildings are shown in the attached drawings.

(3) Floor plan

The floor areas of the proposed buildings are determined as given in the attached tables (see page 67 and 68), reference being made to Japanese guidelines and standards. The floor plan for each building is as follows;

Operation and Maintenance Office

Possible patterns of floor planning for this building are; finger plan, box plan, center corridor plan, side corridor plan and cluster plan. Among these, the center corridor plan is adopted to this building because the plan is suitable for a medium scale building like this office and can attain a relatively high occupation ratio of office room areas to the total floor area. Each room of this building will be arranged to face outside so as to enable it to receive natural light and natural ventilation.

Warehouse

The warehouse will be used for storing various kinds of equipment and materials. The store room for equipment spare parts will be separated from the main storage floor with a partition wall. An office room will be provided at a corner of the building for efficient store keeping.

Operation & Maintenance Office and Warehouse
Determination of Optimum Floor Areas (1/2)

1. Operation & Maintenance Office (832 m^2)

Rooms	Floor Size (m^2)		No. of Personnel	Reference	Remarks
	Designed	Required			
Manager's Room (1)	32.0	33.3	1	P.154 of HBRP for division chief of A-class local government	3.7 m^2 x 9 = 33.3 m^2
Secretary Room (1)	32.0	32.1	3	P.154 of HBRP for normal officer of A-class local government	3.7 m^2 x 1 x 3 persons + waiting persons 4 m x 4 m + store 5 m^2 = 32.1 m^2
Office Equipment Room (1)	20.0	18.2	2		Copying machine 5 m^2 + documents space 4 m^2 + working desk 5 m^2 + common use space 30% = 18.2 m^2
Kettle Room (1)	20.0	13.0 ~21.0		P.157 of HBRP	Office with more than 500 m^2 of effective floor size requires 13 m^2 of kettle room
Office Room (7)	328.0	318.0	53	P.249 of HRI Vol. II	Medium of required floor of 5 - 7 m^2/person, 6 m^2 x 53 = 318 m^2
Meeting Room (1)	40.0	40.3	23	Do	Medium of required floor of 1.5 - 2.0 m^2/person, 1.75 m^2 x 23 = 40.3 m^2 Manager 1 Section chief 4 Staff 16 Committee member 2 Total 23
O/M Conference Room (1)	104.0	104.9	57	CMAD	Required floor of 1.6 m^2/person, 1.6 m^2 x 57 = 91.2 m^2 Common space, 15%; 13.7 m^2 Operation section 13 Maintenance section 8 Admin. section 5 Villages 21 Others 10 Total 57
Store room (1)	24.0	17.7		P.156 of HBRP	17% of O/M room 104 m^2 x 0.17 = 17.7 m^2

Operation & Maintenance Office and Warehouse
Determination of Optimum Floor Areas (2/2)

2. Warehouse (700 m^2)

(1)	Storage of agricultural materials (550 m^2)		
	1) Materials;	Seeds 40 kg/ha x 1,700 ha =	68,000 kg
		Fertilizer 350 kg/ha x 1,700 ha =	595,000 kg
		Chemicals 10 kg/ha x 1,700 ha =	17,000 kg
		Sub-total	680,000 kg
	2) Weight/m^3		0.6 ton
	3) Average piling height		2.5 m
	4) Stored amount/m^2		1.5 tons/m^2
	5) Required floor area;	Seeds	45.3 m^2
		Fertilizer	396.6 m^2
		Chemicals	11.3 m^2
		Sub-total	453.2 m^2
		Access & allowance	
		2.5 m x 20 m + 10% of 453.2 =	95.3 m^2
		Total (required)	548.5 m^2
		(designed)	550.0 m^2
(2)	Storage of equipment and spare parts (100 m^2)		
	1) Plate compactor	1.5 m x 0.8 m x 2 units =	2.4 m^2
	2) Concrete mixer	3.0 m x 2.2 m x 2 units =	13.2 m^2
	3) Pump & generator	2.5 m x 1.3 m x 2 + 3.0 m x 2.0 m x 2 =	18.5 m^2
	4) Spare parts and tools,	L.S.	50.0 m^2
		Sub-total	84.1 m^2
	5) Access & allowance,	30% of above sub-total	25.2 m^2
		Total (required)	109.3 m^2
		(designed)	100.0 m^2
(3)	Office room (50 m^2)		
	10 ~ 15% of storage floor		50.0 m^2
3.	Lavatory;	5.1 m x 2.3 m =	11.7 m^2

Note: - Japan Association of Building and Repairs, *Eizen Keikaku Yoran (Handbook for Building and Repairs Planning)* referred to as "HBRP".
- Japan Society of Architectural Engineering, *Kenchiku Sekkei Shiryou Shuusei (Collection of Materials for Architectural Design)* referred to as "CMAD"
- Japan Association of Research for Rural Improvement, *Nouson Seibi Handbook (Handbook for Rural Improvement)* referred to as "HRI"

(4) Section and elevation plan

Operation and maintenance office

The building is planned to be of single storey type as it is a medium scale building. The building will be designed with emphasis on its functional aspect, and no special treatment or decorations will be considered.

Warehouse

The warehouse will also be a single storey building similar to those found in and around the Vientiane city. The building design will be made with emphasis on the functional aspect, and no special treatment considered. Windows and other openings will be arranged regularly.

(5) Structural design

Taking collectively into account strength of structure, durability, availability of construction materials and their prices as well as traditional types of buildings in Lao PDR, the structures of the buildings are determined as follows;

- Frame : Reinforced concrete beams
- Roofing : Corrugated asbestos sheets
- Column : Reinforced concrete columns
- Walls : Concrete blocks with cement mortar plastering
- Ceiling : Plywood for the office building. No ceiling is provided for the warehouse.
- Floor : Plain concrete

Structural calculations for the buildings are made generally based on Japanese standards and guidelines, since no standards are established in Lao PDR.

a) Earthquake loads:

No earthquake loads are considered.

b) Wind force

$F = c \times f \times q \times Ae$

Where, F ; Horizontal wind pressure
c, f ; Wind force coefficient
q ; Velocity
Ae ; Area

c) Bearing capacity:

Bearing capacity of foundation is estimated at about 20 tons/m^2.

d) Design loads:

- Dead loads

Reinforced concrete	;	2.4 tons/m^3
Structural steel	;	7.85 tons/m^3
Concrete block	;	1.9 tons/m^3
Cement mortar	;	2.0 tons/m^2
Timber	;	0.8 ton/m^3

- Live loads

Roof		;	50 kg/m^2
Floor	(Office)	;	300 kg/m^2
	(Warehouse)	;	Actual loads

e) Structural materials

Allowable strength and quality of structural materials shall be as follows;

Reinforcement bar	;	Deformed bar SD30 (JIS) or equivalent
Concrete	;	210 kg/cm^2 (4 weeks strength)
Cement	;	Portland cement
Structural steel	;	SS41 (JIS) or equivalent

(6) Building facility plan

a) Electric supply system

- Power supply	;	3 phase, 4 wires, 380/220V, 50 Hz
- Power source	;	22 kV line
- Power receiving	;	Transformer 22 kV/380/220V
- Distribution line	;	Overhead line system
- Electrical facilities		
Indoor lighting	;	Fluorescent lamps as required
Electric outlets	;	As required
Outdoor lighting	;	Fluorescent or mercury lamps as required

b) Plumbing system

- Water supply to site	;	From municipal water supply pipeline, (Capacity: 3,480 m^3/day, 4 kg/cm^2)
- Water supply system	;	Gravity supply, water taps as required
- Sewerage	;	To be treated in septic tanks and drained through soak pits
- Sanitary facility	;	Lavatory to be provided near office

c) Airconditioning and ventilation system

- Air conditioning	;	Office rooms (except store rooms and kitchen) shall be provided with air coolers because of hot climate

(7) Main building material plan

a) Finishing schedule

- Floor	;	Concrete, trowel finish
- Base	;	Cement mortar
- Wall for office building		
Outside	;	Lower part; brick masonry
	;	Upper part; concrete block w/plastering
Inside	;	Plywood, oil paint finish
- Wall for warehouse	;	concrete block w/cement mortar plastering

- Column ; Reinforced concrete
- Ceiling ; Plywood, oil paint finish (for office only)
- Roofing ; Corrugated asbestos sheet
- Windows and doors ; Wood or steel made

b) Pavement of service roads

Service roads and parking areas shall be provided with laterite pavement.

5.4 Operation and Maintenance Equipment

5.4.1 General

The effectiveness and durabilities of the Project facilities are greatly dependent on their operation and maintenance. In this view and also taking into account the shortage of equipment in the Vientiane Municipality as mentioned in Section 4.2.6, equipment and tools required for the operation and maintenance will be supplied under the Project.

5.4.2 Basic Criterion

The operation and maintenance equipment to be supplied will be selected based on the following criteria;

i) Since equipment locally available are limited, most equipment will be of the Japanese made and of types, makes and models that are manufactured based on Japanese standards and are normally available in markets.

ii) Selection of sophisticated equipment shall be avoided. Equipment to be selected shall be easy in operation and maintenance,high in reliability and economical.

iii) Equipment shall be of models and types, for which spare parts will be easily obtained in local markets or from neighbouring countries.

5.4.3 Equipment to be Supplied

The operation and maintenance equipment selected and their usage are given in the following table. These equipment will be assembled and tested at site, and local operators will be provided with a brief training on operation and maintenance of the equipment.

	Equipment	Type & make	No. of unit	Main usage
1)	Bulldozer	Swamp type, 10t	1	For large scale maintenance and repair of roads and canals
2)	Backhoe	0.1 m^3	1	For repair of canals and drains
3)	Wheel loader	1.7 m^3	1	For loading materials to trucks
4)	Dump truck	6 tons	2	For transportation of maintenance materials
5)	Cargo truck	6 tons, w/s-ton crane	1	For transportation of materials and labors
6)	Pickup truck	Double cabin, 4WD	3	For facility operation
7)	Motor grader	9 tons, w = 3.1 m	1	For maintenance of roads
8)	Plate compactor	100 kg	2	For compaction of earthfill
9)	Concrete mixer	0.2 m^3	2	For repairing concrete structures
10)	Submersible motor pump	50 mm dia.	2	For drying construction sites
11)	Diesel generator	10 kVA	2	For driving pumps
12)	Motorcycle	90 cc	6	For water management
13)	Spare parts		L.S.	

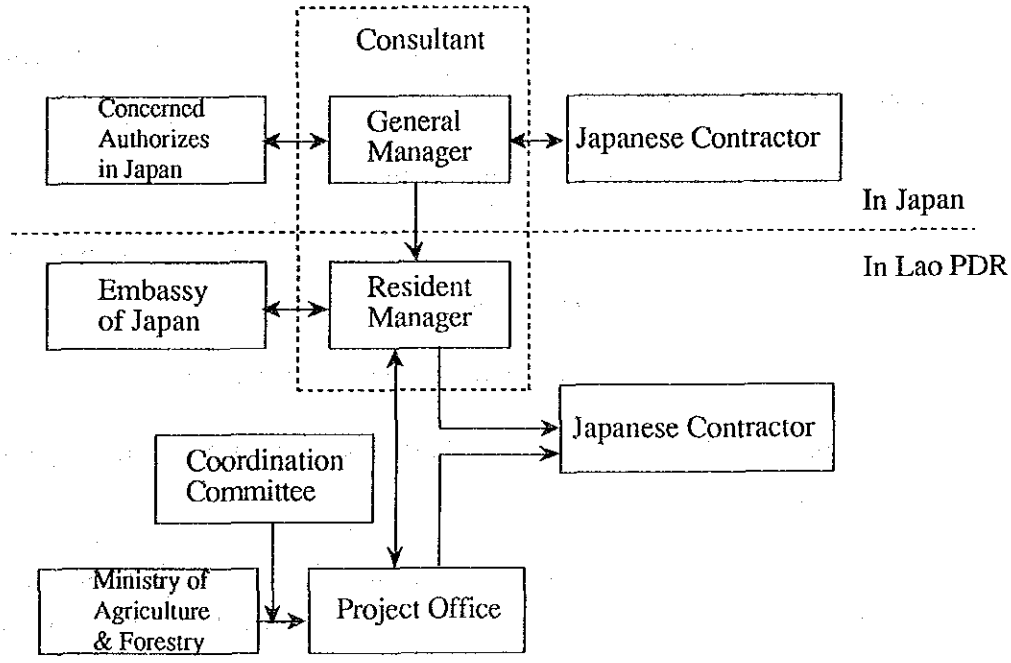
CHAPTER VI IMPLEMENTATION PLAN

CHAPTER VI IMPLEMENTATION PLAN

6.1 Organization for Project Implementation

The executing agency of the Project is the Ministry of Agriculture and Forestry (MAF) of the Government of Lao PDR, whose organization is given in Fig. 9. For smooth implementation of the Project, an office called "the Project Office" will be established under MAF and will take charge of tendering, construction supervision and other works related to the Project implementation. To assist, advice and supervise the Project Office, a coordination committee will be formed under the chairmanship of the Minister of MAF. The committee will comprise representatives of relevant ministries, departments and offices.

The overall organizational structure for the Project implementation is outlined as follows;



6.2 Scope of the Project Works

The scope of the Project works to be implement is summarized as follows;

1) Construction of complete irrigation and drainage systems and farm roads for a net area of 1,200 ha.

2) Construction of a pump station (except pumping equipment), headreach and regulation pond, all with capacities sufficient to irrigate a net area of 1,700 ha, and installation of pumping equipment with a total capacity just sufficient to irrigate a net area of 1,200 ha.

3) Improvements of rural infrastructures for five villages located in or around the irrigation area.

4) Construction of an office building and a warehouse.

5) Supply of operation and maintenance equipment and spare parts.

In connection with the implementation of the Project, the Government of Lao PDR is required to undertake the following;

1) Provision of data, drawings and documents required for preparation of detailed design.

2) Acquisition of lands required for the construction of the Project facilities, including lands for borrow pits and soil disposal.

3) Extension of a high tension power line to the pump station.

4) Provision of a fencing for the premises of the Project Office, and extension of a water supply pipeline to the premises.

5) Provision of a reasonably furnished office room to the Consultant.

6) Execution of banking arrangement and establishment of A/P at the expense of the Government of Lao PDR.

7) Arrangements on customs clearance and inland transportation for imported materials, and exemption of taxes and duties to be imposed on those materials.

8) Arrangements on tax exemption on the incomes of the Japanese consultant and contractor.

9) Issuance of visas, work permits and others to the Japanese consultant and contractor.

10) Arrangements on payment to the Japanese consultant and contractor.

11) Operation and maintenance of the Project facilities after the construction.

12) Assistance to the Japanese consultant and contractor in hiring equipment and labor.

13) Arrangements necessary for purchase of fuel and lubricant for vehicles and equipment.

6.3 Construction Plan

(1) Detailed design works

Prior to the commencement of the Project implementation, the following works will be executed;

a) Field surveys

- Longitudinal and cross section surveys for irrigation and drainage canals based on the Basic Design
- Establishment of additional benchmarks
- Supplementary foundation surveys for the main pump station

b) Detailed design

- Confirmation of the Basic Design based on the results of the field surveys
- Preparation of detailed designs and confirmation of the Project costs based on the detailed designs

c) Tender documents

- Preparation of tender drawings
- Preparation of tender documents for construction works and supply of equipment

(2) Construction method

a) Construction roads

Equipment and materials shipped from Japan will be transported to the Thanaleng port through Thailand and, after the customs clearance there, they will be transported to the Project site through the Tha Dua road and the national roads routes 13 and 10. Materials procured in Vientiane will be transported to the site through the said national roads routes 13 and 10. Within the Project area, construction roads will be newly constructed or existing roads will be improved and utilized as construction roads.

b) Earthworks

Earthworks for canals and roads will be in principle carried out by heavy equipment, since a considerable amount of earthworks will have to be carried out for a limited period. For examples, excavation will be executed by bulldozers or backhoes, earthfilling for embankments by a combination of bulldozers, motor graders, tyre rollers and water tankers, and finishing of bank slopes by motor graders supplemented by manual labor. Transportation of fill materials from borrow pits will be made by dump trucks. In general, excavated materials, if suitable for filling, will be used as filling materials to minimize construction costs. Laterite materials for road pavement are assumed to be transported for about 2.0 km.

c) Concrete works

Concrete works will be required mainly for the main pump station, headreach, regulation pond, canal structures and buildings. Concrete will be manufactured in a central batching and mixing plant to be installed in a construction camp, and will be transported to construction sites by agitator trucks. Concrete aggregates will be purchased from a corporation belonging to the Ministry of Construction. Concrete blocks for lining the headreach will also be manufactured in a block making plant to be installed near the concrete plant and, after curing, they will be transported to construction sites.

(3) Construction plan

The construction works are proposed to be carried out in three stages, taking into account the scale of the Project works, allowable construction periods under the Japan's grant aid system, climate in the Project area, etc. The main works to be implemented in each stage are as follows:

Stage-1 :
- Construction of the main pump station (civil works)
- Construction of the headreach (earthworks)
- Construction of the regulation pond
- Construction of canals, drains and roads for Area-A (348 ha net)
- Construction of the operation and maintenance office
- Installation of one set of pumping equipment

Stage-2 :
- Lining works to the headreach
- Construction of canals, drains and roads for Area-B (441 ha net)
- Installation of one set of pumping equipment

Stage-3 :
- Construction of canals, drains and roads for Area-C (411 ha net)
- Improvements of rural infrastructures
- Construction of the warehouse
- Supply of the operation and maintenance equipment
- Installation of two sets of pumping equipment

The above stagewise construction of the Project facilities is determined on the following conditions:

1) The facilities to be constructed in each stage shall function as designed and shall be serviceable.

2) The civil works, power receiving facilities and other related facilities for the main pump station shall be constructed in full scale in Stage-1, but number of pumping equipment to be installed in this Stage be limited to one unit.

3) The operation and maintenance office to be constructed in Stage-1 shall be used as a construction office throughout the construction period for whole the Project facilities.

4) Construction of the warehouse and supply of the operation and maintenance equipment shall be made in Stage-3. Although earlier execution of the improvement works for rural infrastructures is preferable, they are scheduled to be made in Stage-3 in order to make the work volume in that Stage sizable.

6.4 Procurement and Transportation Plan

6.4.1 Procurement Plan

Equipment and materials locally available will be in principle procured in local markets. However, such equipment and materials that are locally available but are short in supply or poor in quality will be imported from Japan. Equipment and materials that are not available in Lao PDR will be totally procured from Japan.

Since the adoption of a new economic policy by the Government of Lao PDR in 1987, a number of construction projects have been going on especially in and around the Vientiane city. Under these circumstances, both quantities and kinds of locally available construction materials have been increased.

6.4.2 Transportation Plan

Since Lao PDR is a land-locked country, imports and exports of all commodities are made through neighbouring countries, mainly Thailand. Equipment and materials shipped from Japan will be unloaded in Bangkok port and transported by trucks to Nong Kai (Thailand side) located on the right bank of the Mekong river. Then, they will be transported by ferry boats to Thanaleng (Lao side) across the Mekong. Customs clearance of the equipment and materials will be needed at both Nong Kai and Thanaleng. All the roads from Bangkok to Nong Kai and from Thanaleng to the Project site are paved roads of all weather type.

The period necessary for transportation from Japan to the Project site is estimated to be about 2 months in total, including the periods required for ocean transport, unloading and transshipment at Bangkok, transportation across the Mekong and customs clearance.

6.5 Supervisory Plan and Implementation Schedule

6.5.1 Detailed Design and Tendering

Immediately after signing the Exchange of Notes (E/N) between the Government of Japan and the Government of Lao PDR, a contract for consulting servers will be concluded between the Ministry of Agriculture and Forestry (MAF) and a Japanese consultant. This will be immediately followed by field surveys and preparation of detailed designs by the consultant. At the same time, land acquisition and establishment of a construction office will be executed by MAF. The detailed design works will be executed in Lao PDR and Japan.

In order to select qualified tenderers, prequalification of prospective tenderers will be made. A prequalification notice will be issued in the name of MAF on major construction or economic newspapers of Japan, and prequalification documents will be distributed to applicants by the consultant. Tender documents will be distributed only to the prequalified tenderers, and tenders will be opened in the presence of representatives of MAF, tenderers and other concerned authorities. Evaluation of the tenders will be made jointly by MAF and the consultant. All the documents and procedures will be subject to the approval of MAF.

6.5.2 Construction Supervision

After conclusion of the construction contract, the general manager of the consultant will have discussions with the contractor on construction schedules, construction methods, etc. After the commencement of the construction works, a resident manager of the consultant will be stationed at the Project site and will supervise the construction works. The resident manager will periodically report the work progress attained to MAF and the Embassy of Japan in Vientiane. In addition to the resident manager, short term experts of the consultant will be assigned to the Project to supervise specific parts of the construction works.

In executing the construction supervision works, the consultant will duly take into account the social structure of Lao PDR, tradition and custom of local people, etc. so that the works will proceed without difficulties and will be completed as scheduled. The construction supervision works to be executed are outlined as follows;

1) Assistance and advice in contracting

Assistance and advice in prequalification of tenderers, evaluation of tenders, selection of a successful tenderer and contract preparation.

2) Examination and approval of construction drawings, etc.

Examination and approval of construction drawings, applications for construction, samples of construction materials, detailed specifications and shop drawings of machinery, etc., which will be submitted by the contractor from time to time.

3) Progress control and test of works

Examination and adjustment of construction schedules and methods proposed by the contractor, check and control of construction progress, and execution of various tests required for quality control of the works.

4) Approval of payment to the contractor

Measurements and tests of the completed works for issuance of interim certificates and completion certificate to the contractor.

5) Reporting on construction progress

Periodical reporting to MAF, the Embassy of Japan and other concerned authorities on construction progress and others relating to the implementation of the Project.

6) Handing over of completed works

After the completion of the construction works and also after confirming that the completed works satisfy the contract specifications, whole the completed facilities and equipment will be handed over to MAF in the presence of the consultant. Brief technical trainings will be given to local technicians on operation and maintenance of some facilities and equipment before their handing over. The contract works will be completed upon the issuance of a receipt by MAF.

6.5.3 Implementation Schedule

As mentioned in Section 6.3(3), the Project will be implemented in three stages. For Stage-1, a contract for the consulting services will be signed immediately after conclusion of

the E/N, and the detailed design will then be carried out for about 4 months. This will be followed by preparation of tender documents, tendering, tender evaluation and contract negotiations. The construction period required is estimated to be about 12 months after the construction preparatory work of 1.5 months.

For Stage-2, the same procedures as for Stage-1 will be executed. The detailed design work will take about 4 months. The periods required for the construction preparatory work and the construction are estimated to be about 1.5 months and 12 months respectively. For Stage-3, the detailed design work will take about 3 months, while the construction preparatory work 1 month and the construction 9.5 months. The operation and maintenance equipment will be procured in this Stage. After placing an order, they will be procured, packed, shipped and transported to the Project site in about 3 months.

The proposed implementation schedule is given in the attached Fig. 10.

The extension of a high tension power line to the pump station, construction of a fence around the project office, etc. shown below, whose costs were estimated at about Kip.9,634,000 (equivalent to Yen 2,370,000: Kip.1 = Yen 0.246), shall be undertaken by the Government of Lao PDR.

Work Items	Cost (Kip.)
Extending high tension power line to the pump station	6,296,000
Fencing around the project office	2,028,000
Extending water supply pipeline to the project office	1,310,000
Total	9,634,000

CHAPTER VII PROJECT EVALUATION

CHAPTER VII PROJECT EVALUATION

It is anticipated that various direct and indirect benefits will accrue from the implementation of the Project. The major direct benefits will be the substantial increase of agricultural production, saving of foreign exchange by reduction of rice import, and improvement of living standard of farmers through increase of farm incomes and provision of rural infrastructures. Among the indirect benefits will be the increase of employment opportunities, stabilization of foodstuff supply and enhancement of socio-economic activities of inhabitants in the Project area.

(1) Increase of rice production and saving of foreign exchange

Single cropping of rice a year is practiced under rainfed conditions almost all over the Project area. Since the cultivation method employed is of premitive and the production is unstable due to varying climatic conditions, average unit yields of rice are extremely low. With the implementation of the Project, double cropping of rice will be made possible in the fields equipped with irrigation and drainage facilities, and the rice production will increase greatly as shown below:

	Present Condition (2,259 ha)	With Project (1,700 ha)
Unit yield of paddy		
Rainy season	1.5 t/ha	4.5 t/ha
Dry season	2.5 t/ha	5.5 t/ha
Production		
Rainy season	3,388 tons	7,650 tons
Dry season	348 tons	9,350 tons
Total production	3,736 tons	17,000 tons
(average yield	1.65 tons	10 tons)

Expected yields of rice under with-project condition are estimated in the feasibility study, due reference being made to the information from the Salakham Rice Research Station, Agricultural Research and Experiment Station at Hat Dok Keo and Agricultural Research Center at Napok as well as yields in other similar projects in the world. Attainment of these yields also premise improved farming practices such as

introduction of a cropping pattern proposed in Section 5.1.2, high yielding varieties of rice, etc.

As seen above, the average yield and the production of rice after the completion of the Project is expected to increase to about six times and about five times respectively of the present ones. Though self-sufficiency in rice was attained in Lao PDR at the national level, there has been imbalance between supply and demand of rice at a regional level. Vientiane Municipality, where more than 10% of the total population is concentrated, has been suffering from a chronic shortage of rice and, to compensate this, about 20,000 tons of rice have been imported every year mainly from Thailand. With the implementation of the Project, the rice importation is expected to be reduced by about 40%, a foreign exchange of around US$4 million equivalent being saved.

(2) Increase of farmers' incomes

With the implementation of the Project works combined with the introduction of improved irrigation farming, farmers' incomes are expected to increase significantly. In order to clarify the effects of the Project to farm economy, farm budget analyses were made for a standard farm (paddy field: 1.6 ha) under without- and with-project conditions as summarized below:

(US$)

Items	Without Project	With Project
Farm income	287.1	1,798.2
Other income	268.0	268.0
Total income	555.1	2,066.2
Farm expense	51.1	462.2
Disposable income	504.0	1,604.0

As seen above, farm income after the implementation of the Project is estimated to be about 6 times larger than under the without-project condition. Disposable income is also expected to increase by 3 times, contributing much to improvement of farm budget.

(3) Enhancement of economic and social activities

Local transportation will be much improved by the construction of both village roads and operation and maintenance roads along the irrigation canals. At present, the road

network is not sufficient and existing rural roads are of poor quality. They impede the economic and social activities of villagers particularly in the rainy season. The improved road system will contribute to the improvement of economic activities by enhancing inter- and intra-regional accessibility and communication.

(4) *Satisfaction of basic human needs*

Potable water supply facilities will be developed in villages where at the moment there are problems because of shortage of water. The sanitary conditions of villages will be improved through expansion of potable water supply.

(5) Stable food supply

The Project will help to ensure self-sufficiency in rice, one of the main objectives of the national development plans. Adequate supply of food will be an important contribution to establishing the economic independence of Lao PDR.

(6) Increase of employment opportunities

There will be increased employment opportunities for local people as a result of the Project and a favorable impact will be made on the national economy through the multiplier effect. Furthermore, employees will be able to gain experience, technical know-how, and skills in various fields of work. This experience can be applied to future development in the region.

CHAPTER VIII CONCLUSION AND RECOMMENDATIONS

CHAPTER VIII CONCLUSION AND RECOMMENDATIONS

Through the field investigations in Lao PDR and the subsequent analyses and studies, it was clarified that implementation of the Project will generate various direct and indirect benefits as explained in the preceding Chapter, and will make favorable socio-economic impacts on the country as well as on the Vientiane Municipality.

It was confirmed that implementation of the Project will be made under the supervision and responsibility of the Ministry of Agriculture and Forestry of the Government of Lao PDR. After the completion, the Project facilities will be transferred to the Vientiane Municipality for operation and maintenance. Since both the Ministry and the Municipality have experiences in implementing similar projects (e.g. Tha Ngon Project), there are no foreseeable problems in respect of implementation, operation and maintenance of the Project.

From the above facts, implementation of the Project requested by the Government of Lao PDR is considered practicable and justifiable. Located in close proximity of Vientiane, the capital of the country, the Project is assessed to be one of the most urgent and efficient projects for socio-economic development of the Vientiane Municipality. Taking collectively into consideration these factors, the implementation of the Project under a Japanese grant aid is judged very significant and appropriate.

For the smooth implementation, operation and maintenance of the Project, the following recommendations are made to the Government of Lao PDR.

(1) To complete as scheduled the works to be executed by the Government of Lao PDR,

(2) To establish an organization for the Project implementation such as a Project Office, a coordination committee, etc.,

(3) To establish an organization for operation and maintenance of the Project after the implementation,

(4) To make necessary budgetary arrangements for the Project implementation and operation/maintenance, and to provide the Project staff with technical training,

(5) To execute periodical maintenance and repairs of the Project facilities and equipment,

(6) To strengthen the present agricultural support organization and to intensify the agricultural extension services, inclusive of training of farmers and supply of agricultural inputs, and

(7) To receive a technical assistance from the Government of Japan such as acceptance of JICA experts (irrigation, agronomy, agricultural extension and agro-machinery) and training of local staff in Japan.

TABLES

Table-1 Monthly Rainfall (1/3)

at Vientiane (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1967	2.3	12.6	6.0	94.2	159.9	221.8	327.3	209.8	488.9	N	21.2	N	1,544.0
1968	0.9	N	100.6	88.8	301.8	243.5	258.2	206.8	272.0	27.7	T	N	1,500.3
1969	19.6	N	42.4	40.9	204.3	295.9	402.1	128.9	247.9	49.9	14.3	N	1,446.2
1970	0.5	N	31.2	56.9	306.4	377.2	215.8	624.9	420.5	53.8	T	0.1	2,087.3
1971	N	7.3	13.9	34.1	294.0	274.8	289.4	226.4	163.4	103.5	0.8	18.2	1,425.8
1972	N	6.8	36.8	167.6	115.6	312.8	246.1	306.7	166.3	148.4	8.2	5.8	1,521.1
1973	N	N	37.0	36.4	308.3	200.7	298.6	263.9	361.3	25.7	T	N	1,531.9
1974	T	1.6	36.7	97.4	100.5	159.2	255.7	368.4	187.1	92.6	29.7	0.2	1,329.1
1975	23.5	26.3	13.2	21.8	347.0	473.9	177.5	430.4	289.7	194.4	8.5	N	2,006.2
1976	N	23.0	111.9	126.9	121.7	167.3	167.6	403.1	416.7	76.7	N	N	1,614.9
1977	15.2	N	35.1	69.0	151.9	231.0	211.1	174.8	190.3	26.5	16.5	22.8	1,144.2
1978	1.6	17.8	51.1	145.9	328.4	254.9	354.6	293.6	381.4	128.9	28.5	N	1,986.7
1979	N	21.0	0.1	61.8	344.7	333.3	150.1	117.8	253.1	19.2	N	N	1,301.1
1980	N	18.6	68.8	61.0	319.5	611.0	461.5	342.9	353.4	54.7	T	N	2,291.4
1981	N	0.3	19.6	124.2	311.1	238.5	635.0	210.0	224.8	117.8	40.5	T	1,921.8
1982	N	6.1	60.8	69.6	239.3	95.4	253.8	484.0	319.5	90.2	22.2	0.6	1,641.5
1983	53.1	5.7	9.0	58.1	97.6	243.8	217.9	360.8	247.1	67.9	N	7.2	1,368.2
1984	N	10.6	3.4	88.9	148.3	148.1	421.0	388.9	267.1	142.1	17.3	N	1,635.7
1985	24.8	64.7	4.9	10.8	135.3	223.5	257.4	191.9	258.8	81.4	N	N	1,253.5
1986	N	3.2	1.5	118.8	383.4	256.2	308.9	318.3	275.3	66.7	N	21.0	1,753.3
1987	T	13.9	100.6	127.0	63.6	473.8	175.0	356.0	260.7	93.4	3.2	N	1,667.2
1988	T	23.4	2.8	66.0	573.2	131.5	188.9	257.6	170.4	194.6	T	T	1,608.4
1989	23.6	T	63.0	85.6	200.8	165.1	132.5	421.4	459.7	-	-	-	-
AVE.	6.4	12.0	35.8	80.3	243.4	271.3	285.2	303.0	282.5	84.4	9.6	3.5	1,617.3
%	0.4%	0.7%	2.2%	5.0%	15.1%	16.8%	17.6%	18.7%	17.5%	5.2%	0.6%	0.2%	100.0%

Table-1 Monthly Rainfall (2/3)

at Salakham (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1972	N	N	13.0	83.5	72.4	332.2	196.8	223.8	93.8	125.5	23.2	5.6	1,169.8
1973	N	N	11.8	32.3	160.9	128.5	275.2	221.3	398.9	15.6	N	6.4	1,250.9
1974	N	5.4	62.8	59.3	86.9	160.4	276.6	419.5	71.8	18.4	25.7	N	1,186.8
1975	10.7	16.6	14.0	1.0	285.6	357.7	245.6	233.8	216.8	82.6	N	N	1,464.4
1976	N	26.0	N	130.3	152.6	163.7	198.2	269.8	305.3	43.0	3.3	N	1,292.2
1977	12.6	N	17.7	82.8	145.3	188.6	216.8	207.3	161.1	30.0	10.3	11.9	1,084.4
1978	3.9	9.6	48.5	127.7	274.2	204.0	313.1	222.1	253.6	74.4	22.6	N	1,553.7
1979	N	13.5	0.5	53.9	136.2	156.4	123.3	178.4	177.2	3.0	N	N	842.4
1980	N	3.0	10.4	63.0	282.5	467.0	392.4	420.8	292.9	56.1	3.0	N	1,991.1
1981	N	N	24.3	75.4	257.5	237.2	445.7	224.8	223.0	160.8	23.2	N	1,671.9
1982	N	1.2	39.2	69.0	167.7	114.0	357.2	403.6	330.2	75.6	6.6	3.6	1,567.9
1983	42.4	6.5	9.7	36.0	66.4	217.7	185.9	302.8	214.3	58.3	N	5.2	1,145.2
1984	N	19.5	3.5	49.9	197.7	137.2	327.6	345.2	184.9	112.9	11.4	N	1,389.8
1985	37.0	84.0	2.0	32.8	94.5	199.4	255.4	232.8	182.0	94.0	N	N	1,213.9
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	T	22.6	57.5	117.4	72.7	365.2	77.4	342.6	253.8	89.0	18.4	T	1,416.6
1988	T	26.4	16.6	128.7	371.6	194.2	273.8	162.0	152.4	141.2	T	T	1,466.9
1989	5.4	T	37.3	58.4	225.6	198.8	115.9	319.6	322.2	-	-	-	-
AVE.	6.7	14.6	20.7	71.4	176.5	226.5	260.1	275.7	219.5	73.8	9.2	2.0	1,356.7
%	0.5%	1.1%	1.5%	5.3%	13.0%	16.7%	19.2%	20.3%	16.2%	5.4%	0.7%	0.2%	100.0%

Remarks :
N : Nill, T : Trace, - : Not available

Table-1 Monthly Rainfall (3/3)

at Tha Ngon (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1967	5.2	30.2	17.4	49.6	170.0	210.2	150.8	210.6	544.2	8.0	6.0	N	1,402.2
1968	T	N	31.6	144.8	499.0	383.4	330.4	273.4	407.4	31.2	7.8	N	2,109.0
1969	47.8	N	118.2	34.0	271.8	396.2	596.4	239.0	310.0	27.8	N	N	2,041.2
1970	0.6	N	34.6	63.1	340.0	629.9	289.9	617.8	408.1	58.0	T	0.2	2,442.2
1971	N	2.3	10.7	20.5	254.2	343.9	255.8	236.2	234.1	123.6	3.0	12.4	1,496.7
1972	N	11.2	93.2	74.1	125.6	216.0	180.4	317.9	120.5	233.9	12.9	2.6	1,388.3
1973	N	N	66.8	61.7	242.7	276.6	321.5	310.8	309.6	21.1	N	4.2	1,615.0
1974	T	0.1	57.0	60.3	121.9	304.9	280.5	453.9	157.3	59.5	39.5	0.8	1,535.7
1975	29.5	17.1	57.4	30.6	417.7	402.9	224.5	494.7	325.0	187.3	7.1	6.4	2,200.2
1976	N	31.8	83.0	106.6	268.4	247.0	337.8	265.9	344.6	28.6	8.7	N	1,722.4
1977	16.4	N	7.8	142.2	215.6	242.2	338.8	354.0	214.7	50.0	9.0	6.2	1,596.9
1978	8.5	5.6	71.4	175.5	360.4	256.4	434.0	261.1	247.1	53.6	28.2	N	1,901.8
1979	N	12.4	1.2	74.0	470.6	240.6	172.9	220.4	192.4	7.9	N	N	1,392.4
1980	N	3.0	97.4	74.5	289.4	543.2	442.5	341.5	430.4	71.2	N	N	2,293.1
1981	N	N	17.4	125.7	347.6	227.2	707.7	249.4	362.7	146.8	18.1	N	2,202.6
1982	N	6.4	36.2	105.1	177.8	204.0	369.5	548.3	450.5	91.2	6.4	N	1,995.4
1983	53.2	10.8	15.6	30.8	67.3	304.9	249.5	399.9	292.2	78.7	N	5.7	1,508.6
1984	N	39.8	5.4	33.3	358.0	198.4	398.6	480.9	192.4	140.6	10.9	N	1,858.3
1985	20.4	31.9	31.0	56.5	191.2	490.8	359.8	214.2	249.5	170.3	2.2	N	1,817.8
1986	T	T	T	173.8	T	300.3	T	T	T	T	T	T	474.1
1987	T	42.4	132.7	58.4	63.6	385.5	327.9	382.0	329.3	64.7	83.0	T	1,869.5
1988	T	22.9	32.0	85.0	288.4	153.6	183.1	403.1	105.4	-	-	-	-
AVE.	8.6	11.7	47.0	80.7	250.1	324.0	322.3	327.2	291.5	78.8	11.6	1.8	1,755.4
%	0.5%	0.7%	2.7%	4.6%	14.2%	18.5%	18.4%	18.6%	16.6%	4.5%	0.7%	0.1%	100.0%

Remarks ; N : Nill, T : Trace, - : Not available

Table-2 Monthly Mean Temperature at Vientiane

(Unit : celsius)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1968	21.5	22.6	27.0	27.2	27.7	27.4	28.4	28.0	28.0	26.7	25.8	24.2	26.2
1969	24.5	25.3	27.9	29.5	28.9	28.3	28.1	28.0	27.2	27.0	23.6	20.8	26.6
1970	22.5	24.9	27.8	28.0	28.5	27.4	27.8	27.1	27.2	26.6	24.7	23.9	26.4
1971	21.0	23.4	26.7	29.4	28.5	27.7	27.4	26.9	27.5	25.5	22.9	22.5	25.8
1972	21.1	24.8	25.8	27.6	29.6	28.7	28.5	27.5	28.0	27.4	26.1	23.9	26.6
1973	22.9	26.3	28.2	30.6	28.8	28.9	27.9	27.3	27.1	27.2	23.8	20.5	26.6
1974	21.4	22.4	26.1	27.6	28.6	28.4	27.9	27.5	27.7	27.1	24.9	23.4	26.1
1975	23.0	25.2	28.0	30.9	27.6	28.1	27.9	27.6	27.6	27.3	24.3	19.8	26.4
1976	20.9	24.6	26.7	28.0	27.8	28.3	27.9	27.4	27.7	27.3	23.8	22.9	26.1
1977	22.5	22.8	26.8	28.7	29.1	30.2	28.3	28.4	27.7	27.6	24.0	23.6	26.6
1978	23.4	24.0	28.2	29.0	28.5	28.7	28.3	27.8	27.3	27.0	25.3	23.1	26.7
1979	24.6	25.8	28.5	29.3	28.6	28.0	27.4	28.0	28.1	26.4	24.0	22.7	26.8
1980	23.2	24.3	28.2	29.8	28.9	28.0	29.4	28.3	27.3	27.8	25.9	23.8	27.1
1981	22.2	26.2	28.3	28.7	28.5	28.2	28.4	28.2	28.3	27.3	25.9	21.4	26.8
1982	22.7	25.2	28.8	27.9	29.7	29.2	27.7	27.5	27.2	27.4	26.4	20.9	26.7
1983	20.9	25.5	27.0	31.0	29.4	28.9	28.4	28.0	27.0	27.2	23.4	21.1	26.5
1984	21.6	25.4	27.6	30.0	28.3	28.6	28.9	27.6	27.4	25.8	25.2	22.8	26.6
1985	23.0	25.2	26.4	28.9	28.9	28.0	27.4	27.9	27.5	26.9	26.1	22.3	26.5
1986	21.5	24.8	26.4	29.5	28.3	28.8	27.7	25.6	27.6	27.3	24.8	22.8	26.3
1987	23.0	25.0	27.0	28.8	29.9	28.8	27.9	28.0	27.9	27.6	27.0	20.4	26.8
1988	23.6	25.6	27.6	29.2	28.4	28.1	28.9	27.4	27.9	26.3	23.0	21.6	26.5
1989	22.7	23.9	25.4	29.5	28.4	27.7	27.9	27.3	27.5	-	-	-	-
AVE.	22.4	24.7	27.4	29.0	28.7	28.4	28.1	27.6	27.6	27.0	24.8	22.3	26.5

Remarks ; - : Not available

Table-3 Monthly Mean Relative Humidity at Vientiane

(Unit : %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1968	65.0	64.0	64.0	65.0	76.0	81.0	78.0	81.0	80.0	74.0	72.0	69.0	72.4
1969	71.0	64.0	70.0	66.0	74.0	81.0	81.0	80.0	79.0	74.0	70.0	71.0	73.4
1970	75.0	70.0	73.0	76.0	82.0	88.0	86.0	82.0	80.0	73.0	69.0	68.0	76.8
1971	64.0	64.0	61.0	64.0	72.0	78.0	79.0	80.0	75.0	71.0	65.0	67.0	70.0
1972	65.0	65.0	65.0	66.0	68.0	74.0	75.0	79.0	76.0	74.0	71.0	70.0	70.7
1973	65.0	62.0	60.0	59.0	68.0	75.0	75.0	80.0	80.0	72.0	67.0	66.0	69.1
1974	65.0	63.0	66.0	69.0	71.0	75.0	79.0	80.0	76.0	74.0	70.0	68.0	71.3
1975	72.0	64.0	64.0	57.0	74.0	74.0	73.0	76.0	76.0	71.0	68.0	63.0	69.3
1976	62.0	63.0	63.0	71.0	76.0	75.0	75.0	78.0	82.0	74.0	67.0	64.0	70.8
1977	69.0	60.0	60.0	67.0	70.0	69.0	76.0	76.0	76.0	72.0	66.0	68.0	69.1
1978	66.0	67.0	66.0	69.0	76.0	77.0	80.0	80.0	79.0	74.0	69.0	67.0	72.5
1979	67.0	66.0	61.0	65.0	74.0	79.0	75.0	79.0	77.0	68.0	62.0	65.0	69.8
1980	65.0	64.0	57.0	64.0	72.0	79.0	78.0	78.0	80.0	72.0	70.0	68.0	70.6
1981	66.0	65.0	62.0	69.0	74.0	76.0	79.0	77.0	75.0	74.0	69.0	66.0	71.0
1982	68.0	69.0	66.0	69.0	70.0	72.0	72.0	79.0	80.0	76.0	72.0	69.0	71.8
1983	72.0	68.0	63.0	64.0	73.0	78.0	80.0	82.0	81.0	79.0	69.0	70.0	73.3
1984	69.0	68.0	62.0	64.0	72.0	76.0	80.0	78.0	78.0	77.0	71.0	69.0	72.0
1985	72.0	70.0	64.0	65.0	74.0	80.0	80.0	82.0	81.0	79.0	72.0	70.0	74.1
1986	67.0	65.0	58.0	64.0	79.0	79.0	78.0	78.0	76.0	74.0	70.0	64.0	71.0
1987	68.0	67.0	66.0	67.0	70.0	77.0	74.0	81.0	80.0	77.0	74.0	63.0	72.0
1988	67.0	68.0	66.0	66.0	81.0	81.0	83.0	85.0	80.0	79.0	68.0	68.0	74.3
1989	69.0	65.0	71.0	68.0	76.0	80.0	79.0	84.0	78.0	-	-	-	-
AVE.	67.6	65.5	63.7	66.0	73.6	77.3	77.9	79.6	78.4	74.2	69.1	67.3	71.7

Table-4 Monthly Mean Wind Velocity at Vientiane

(Unit : m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1968	1.3	1.5	1.6	1.5	1.7	1.9	1.6	1.6	1.5	1.6	1.5	1.3	1.6
1969	1.5	1.7	1.8	1.5	1.9	1.6	1.6	1.4	1.3	1.3	1.6	1.6	1.6
1970	1.7	1.6	1.6	1.5	1.7	1.7	1.4	1.5	1.6	1.5	1.4	1.4	1.6
1971	1.5	1.4	1.6	1.6	2.1	1.3	1.5	1.5	1.5	1.2	1.6	1.5	1.5
1972	1.2	1.3	1.2	1.8	1.4	1.3	1.2	1.3	1.2	1.2	1.1	1.2	1.3
1973	1.1	1.1	1.4	1.5	1.5	1.3	1.5	1.4	1.2	1.2	1.5	1.8	1.4
1974	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	1.7	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	1.8	1.8	1.8	1.8	-
1978	-	-	-	2.2	2.2	1.8	2.0	2.4	-	1.9	1.2	-	-
1979	3.4	1.7	1.4	2.3	1.9	1.6	1.9	2.0	1.8	1.5	2.0	1.8	1.9
1980	1.6	1.7	1.8	3.3	3.6	1.7	1.8	1.6	1.9	1.4	1.3	1.4	1.9
1981	1.4	1.5	1.5	1.6	1.8	1.6	1.9	1.8	1.5	1.8	1.8	1.9	1.7
1982	1.3	1.7	1.6	1.7	1.8	1.7	2.0	1.8	2.0	1.5	1.6	1.8	1.7
1983	1.7	1.3	2.0	1.4	2.5	2.0	1.8	1.4	1.5	1.7	1.6	1.6	1.7
1984	1.8	2.2	1.8	2.2	2.3	2.8	2.3	2.5	1.7	1.6	1.7	1.5	2.0
1985	1.6	1.8	2.1	2.4	1.7	1.8	1.9	2.4	1.7	1.8	1.3	1.5	1.8
1986	1.5	1.9	1.7	2.2	2.2	2.1	2.0	2.2	1.9	1.8	1.7	1.3	1.9
1987	1.7	1.8	1.6	2.0	1.8	1.9	1.9	2.3	1.4	1.4	1.7	1.7	1.8
1988	1.0	1.4	1.4	1.7	1.2	1.3	1.3	1.2	1.1	1.1	1.6	1.0	1.3
1989	1.3	1.3	1.8	1.4	1.8	1.4	1.4	1.8	1.1	-	-	-	-
AVE.	1.6	1.6	1.6	1.9	1.9	1.7	1.7	1.7	1.6	1.5	1.6	1.5	1.7

Remarks ; - : Not available

Table-5 Monthly Mean Pan Evaporation at Vientiane

Class A-pan (Unit : mm/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1968	3.0	4.0	4.1	4.2	5.8	4.6	8.2	3.7	6.7	5.0	4.8	4.0	4.8
1969	3.6	5.0	4.8	5.2	3.7	4.1	5.1	5.1	3.6	4.6	4.2	4.0	4.4
1970	4.0	5.0	5.3	5.4	5.3	4.4	4.0	3.8	4.7	6.8	6.0	5.0	5.0
1971	5.0	4.9	6.5	6.8	7.0	4.9	4.1	4.6	4.5	4.4	4.6	3.8	5.1
1972	3.6	4.4	4.4	5.7	6.3	5.1	4.6	4.3	6.1	5.3	6.0	5.1	5.1
1973	4.7	5.9	6.3	6.8	5.5	4.3	3.5	3.5	3.3	4.1	4.0	4.2	4.7
1974	3.8	4.5	4.4	5.2	5.3	4.0	4.1	3.3	3.7	4.4	3.8	3.6	4.2
1975	3.1	4.3	4.2	6.4	3.2	3.3	3.6	3.3	3.9	4.2	4.0	3.5	3.9
1976	3.7	3.8	4.4	4.0	3.4	4.8	3.4	3.5	3.8	4.2	-	-	-
1977	3.2	4.0	4.2	4.7	4.9	5.2	4.1	3.3	4.7	4.0	4.1	3.5	4.2
1978	3.8	3.3	4.2	4.0	4.5	4.1	3.6	3.3	4.9	4.3	4.1	3.8	4.0
1979	3.7	3.8	4.3	5.2	4.1	4.0	4.6	3.7	3.6	4.3	4.5	4.0	4.2
1980	3.5	4.0	4.9	4.5	3.4	2.9	3.1	3.7	3.0	4.2	4.0	4.3	3.8
1981	4.2	4.3	4.9	5.0	4.4	3.7	3.4	4.2	3.6	4.0	3.9	4.1	4.1
1982	4.0	3.8	3.6	3.8	4.2	6.6	3.3	2.7	2.8	3.6	4.0	3.0	3.8
1983	3.1	3.6	4.0	6.0	4.8	3.5	3.6	2.7	3.1	3.3	3.4	3.0	3.7
1984	3.3	4.3	4.8	4.7	3.6	3.4	2.7	2.6	2.6	3.0	3.9	3.7	3.6
1985	3.4	3.7	4.4	5.0	3.9	3.1	3.4	3.2	3.7	3.8	3.9	3.6	3.8
1986	3.5	3.8	4.0	4.7	3.4	3.2	2.7	4.3	4.5	4.4	4.5	3.7	3.9
1987	4.0	4.0	4.6	5.0	6.2	4.9	5.1	4.6	4.4	5.1	4.7	4.2	4.7
1988	4.4	4.3	5.0	5.7	5.6	5.2	5.1	4.2	5.3	4.0	4.6	4.2	4.8
1989	4.1	4.6	4.9	5.9	5.5	4.9	4.9	4.2	4.1	-	-	-	-
AVE.	3.7	4.2	4.6	5.2	4.8	4.2	4.1	3.7	4.1	4.3	4.4	3.9	4.3

Table-6 Monthly Mean Sunshine Hours at Vientiane

(Unit : hours/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1968	8.6	6.6	6.4	6.4	7.4	3.3	6.6	4.2	6.2	7.6	8.8	8.9	6.8
1969	6.9	7.4	5.9	7.7	6.2	4.1	3.6	5.5	5.0	8.6	7.7	8.3	6.4
1970	7.2	7.7	5.6	6.3	6.4	3.6	3.6	3.8	4.2	6.9	6.9	7.4	5.8
1971	8.6	7.2	7.1	7.7	6.6	3.9	3.7	3.3	6.8	6.0	-	7.6	-
1972	8.2	6.7	8.4	8.0	7.6	6.4	4.6	3.3	7.4	7.1	7.2	7.8	6.9
1973	9.6	9.2	7.5	8.9	6.6	5.8	3.9	3.2	4.0	7.2	7.0	9.0	6.8
1974	8.3	7.4	6.2	6.8	7.2	4.7	5.0	3.9	6.7	7.0	7.5	7.8	6.5
1975	5.4	8.8	7.5	8.7	5.5	4.4	6.0	3.9	5.7	7.3	8.2	8.1	6.6
1976	9.6	8.7	7.6	8.1	5.7	7.2	4.3	4.7	5.8	7.8	8.9	8.3	7.2
1977	8.1	8.8	7.0	8.0	-	7.8	4.8	5.7	6.7	8.6	-	-	-
1978	-	-	7.8	8.0	6.4	5.6	4.1	4.0	4.8	8.3	8.8	8.5	-
1979	9.5	8.5	8.8	7.3	6.5	3.8	7.4	4.3	5.7	8.0	9.1	8.6	7.3
1980	8.4	6.7	5.4	7.2	7.3	4.2	3.8	4.6	4.1	7.6	8.3	8.7	6.4
1981	9.0	7.7	6.7	6.4	6.1	4.0	4.1	4.7	6.3	5.3	6.9	7.8	6.3
1982	8.6	6.8	5.7	7.3	7.6	5.3	3.9	2.9	4.2	7.5	8.3	8.4	6.4
1983	6.7	8.2	7.5	8.1	7.4	6.2	6.0	5.0	5.9	6.3	7.8	8.2	6.9
1984	8.4	7.5	6.7	7.6	7.0	5.3	5.1	4.6	7.0	6.5	7.8	8.8	6.9
1985	8.0	7.0	8.2	7.2	6.4	5.1	5.2	3.2	6.6	7.0	7.9	8.0	6.7
1986	9.9	4.9	5.3	6.7	4.7	4.6	3.6	6.0	6.6	7.1	8.1	7.7	6.3
1987	8.8	8.2	7.8	7.8	8.3	5.5	4.0	4.8	4.6	8.9	7.1	9.7	7.1
1988	9.3	7.4	6.8	7.8	6.6	5.1	5.8	3.8	7.2	4.9	7.4	8.3	6.7
1989	8.5	8.3	7.5	8.7	7.0	6.8	5.7	5.2	6.3	-	-	-	-
AVE.	8.4	7.5	6.9	7.5	6.7	4.9	4.8	4.2	5.7	7.1	7.8	8.3	6.7

Remarks ; - : Not available

Table-7 Monthly Mean Water Level in Nam Ngum River

River : River : Nam Ngum Station : Tha Ngon C.A. : 16,500km2 (Unit : m)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1972	3.74	3.37	3.27	3.24	3.06	4.26	7.20	12.93	11.49	8.02	5.48	4.21	5.86
1973	3.71	3.43	3.28	3.24	3.52	5.14	10.02	11.45	15.79	9.67	5.58	4.38	6.60
1974	3.63	3.34	3.44	3.31	3.62	4.74	6.73	10.25	11.58	7.91	5.64	4.04	5.69
1975	3.48	3.15	3.18	3.19	3.74	7.53	10.79	13.70	15.17	9.40	6.16	4.45	7.00
1976	3.84	3.52	5.77	3.76	3.68	5.77	7.28	10.91	10.97	9.89	7.29	4.54	6.44
1977	3.49	3.36	3.10	5.29	4.08	3.93	7.25	9.18	10.56	5.86	4.27	3.44	5.32
1978	3.23	2.94	4.89	3.19	4.84	8.15	12.34	15.26	13.26	7.46	4.39	3.33	6.94
1979	4.39	4.93	4.47	4.92	5.58	7.02	7.58	8.56	11.24	6.57	5.22	4.62	6.26
1980	4.11	4.43	4.97	4.68	5.18	7.69	9.19	12.45	13.61	7.73	5.62	5.14	7.07
1981	5.06	5.09	4.97	4.27	5.71	7.86	13.37	14.36	12.97	10.43	5.99	5.28	7.95
1982	4.93	4.72	4.94	5.17	5.14	6.02	8.11	11.11	11.17	10.52	5.89	5.23	6.91
1983	5.00	4.90	4.52	4.92	4.57	5.19	8.29	11.69	11.28	7.65	6.14	5.18	6.61
1984	5.04	4.95	5.34	4.37	5.28	6.24	10.53	10.90	10.21	8.14	5.91	5.65	6.88
1985	5.73	5.45	4.20	-	-	-	-	9.41	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	4.44	4.40	4.20	3.71	3.79	5.69	5.68	8.66	8.83	7.52	5.52	5.34	5.65
1988	5.14	5.12	4.63	4.67	5.25	6.13	7.69	10.33	8.50	6.01	4.12	3.38	5.91
AVE.	4.22	4.11	4.33	4.13	4.47	6.09	8.80	11.45	11.78	8.19	5.55	4.55	6.47

Table-8 Monthly Mean Discharge in Nam Ngum River

River : Nam Ngum Station : Tha Ngon C.A. : 16,500km2 (Unit : m3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1972	206	159	147	144	122	291	835	2260	1840	1000	525	329	655
1973	202	165	149	129	157	363	1280	1630	2960	1240	425	247	746
1974	168	139	130	136	168	331	647	1340	1770	835	431	216	526
1975	153	132	120	124	185	791	1500	2247	2790	1290	515	284	844
1976	191	157	135	93	174	465	705	1480	1524	1270	705	290	599
1977	155	142	450	380	235	216	728	1170	1400	469	260	149	480
1978	128	110	114	124	327	816	1910	2770	2010	793	278	138	793
1979	293	333	322	326	430	642	762	1060	1600	603	369	282	585
1980	256	261	267	274	365	799	1270	1910	2210	796	428	357	766
1981	347	351	333	259	450	835	2200	2470	2410	1410	514	378	996
1982	327	299	225	371	343	535	882	1600	1560	1410	471	370	699
1983	339	324	330	326	280	388	936	1670	1600	852	510	363	660
1984	343	330	257	255	379	526	1500	1490	1340	884	473	432	684
1985	445	404	390	113	166	596	1074	1170	2210	1052	808	485	743
1986	277	178	132	125	330	490	924	1460	1240	1011	562	308	586
1987	269	234	185	177	194	450	445	1012	1024	768	424	392	465
1988	365	360	295	299	375	513	785	1250	940	490	222	168	505
AVE.	263	240	234	215	275	532	1081	1646	1790	951	466	305	667

Remarks ; - : Not available

	J	J	A	S	O	N
	NURSERY				DRAIN	

(1) E To	(mm)	–	138	132	138	141	88
(2) KC		–	1.13	1.14	1.12	1.09	1.03
(3) =(1)x(2)	(mm)	–	156	151	155	154	91
(4) Percolation	(mm)	–	45	45	45	45	90
(5) Effective Rainfall	(mm)	–	185	195	185	50	–
(6) = (3) + (4) – (5)	(mm)	–	16	1	15	149	181
(7) Area Factor		–	0.5	1	1	0.78	0.06
(8) = (6) x (7)	(mm)	–	8	1	15	116	11
(9) Puddling Water	(mm)	30	150	–	–	–	–
(10) Nursery Water	(mm)	14	7	–	–	–	–
(11) NW(8)+(9)+(10)	(mm)	44	165	1	15	116	11
(12) DW(11)÷EF	(mm)	72	271	2	25	190	18
(lit/sec/ha)		0.28	1.05	0.02	0.09	0.74	0.07

Table-9 Irrigation Water Requirement (Rainy Season Paddy)