JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ROYAL IRRIGATION DEPARTMENT (RID), MOAC
THE KINGDOM OF THAILAND

THE MASTER PLAN STUDY
ON
THE INTEGRATED AGRICULTURE AND WATER RESOURCES DEVELOPMENT PROJECT
OF HUAI MONG, NAM SUAI AND HUAI LUANG RIVER BASINS
IN THE KINGDOM OF THAILAND

FINAL REPORT
VOLUME I
MAIN REPORT

AUGUST, 1996

SANYU CONSULTANTS INC.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
ROYAL IRRIGATION DEPARTMENT (RID), MOAC
THE KINGDOM OF THAILAND

THE MASTER PLAN STUDY
ON
THE INTEGRATED AGRICULTURE AND WATER RESOURCES DEVELOPMENT PROJECT
OF HUAI MONG, NAM SUAI AND HUAI LUANG RIVER BASINS
IN THE KINGDOM OF THAILAND

FINAL REPORT

VOLUME I

MAIN REPORT

AUGUST, 1996

SANYU CONSULTANTS INC.

PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct the Master Plan Study on the Integrated Agriculture and Water Resources Development Project of Huai Mong, Nam Suai and Huai Luang River Basins and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a study team headed by Mr. Hiroshi Moriyama, Sanyu Consultants INC., two times between August 1995 and August 1996.

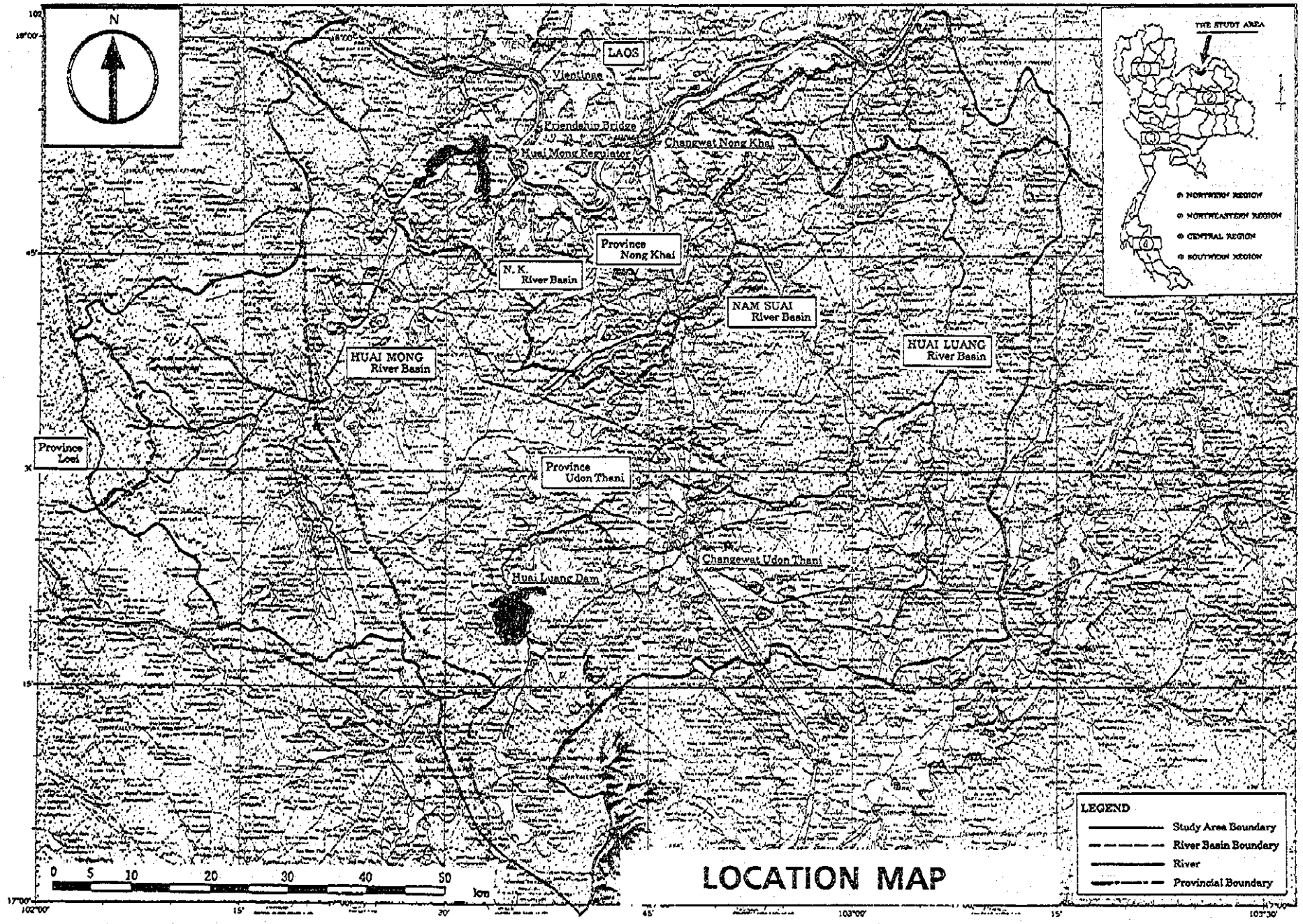
The team held discussions with the officials concerned of the Government of Thailand, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

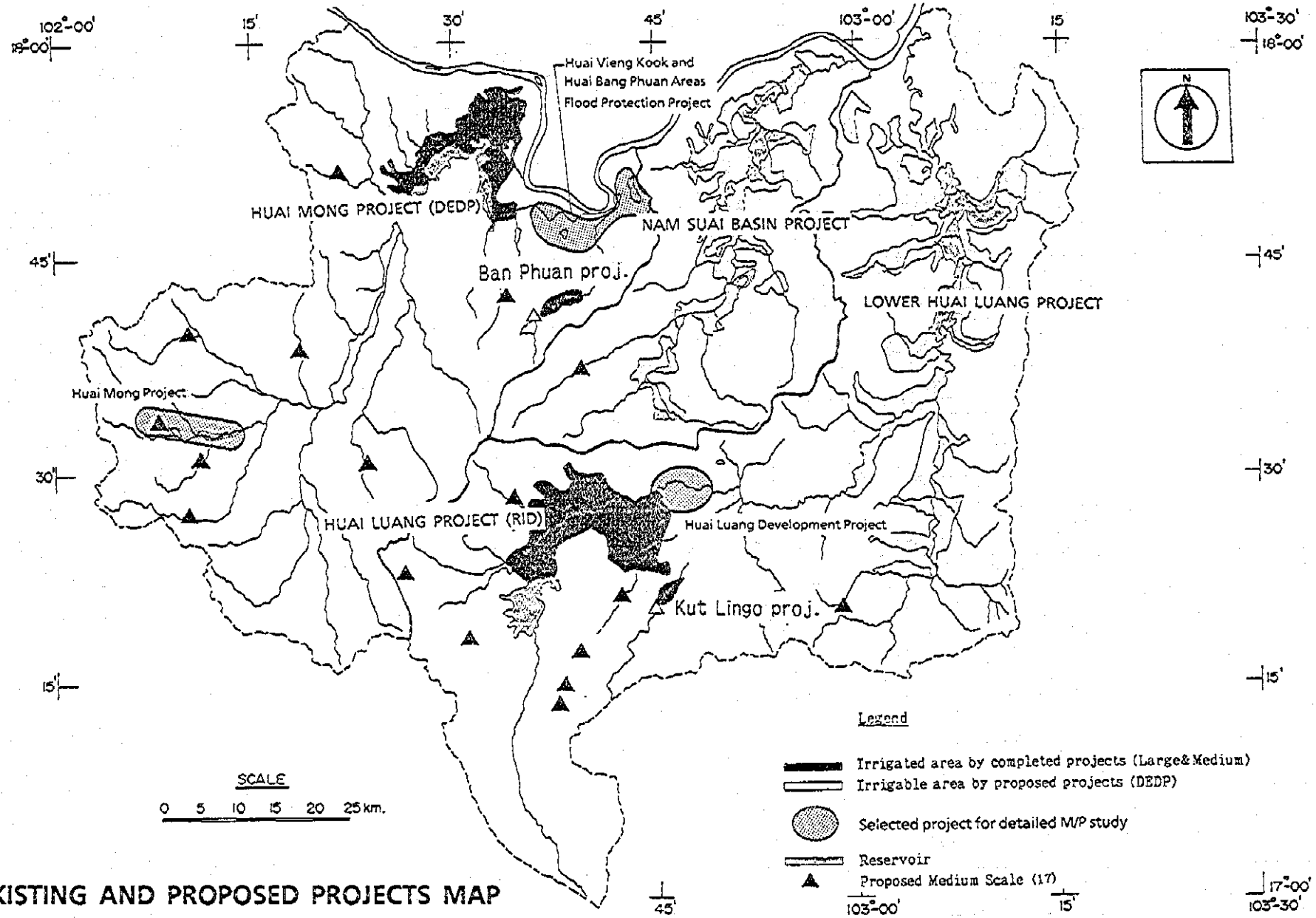
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

August 1996

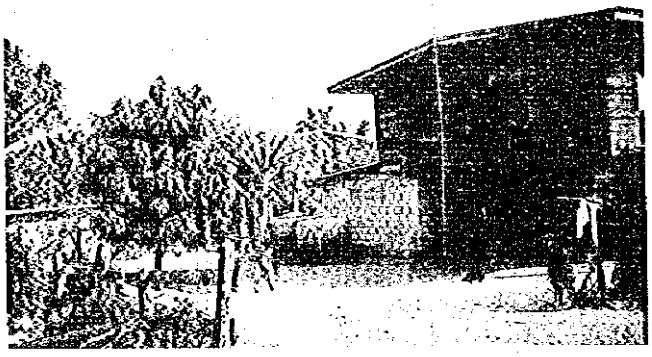
Kimio Fujita
President
Japan International Cooperation Agency


N
LAOS
Vientiane
Friendship Bridge
Changwat Nong Khai
Huai Mong Regulator
Province Nong Khai
N. K. River Basin
NAM SUAI River Basin
HUAI LUANG River Basin
HUAI MONG River Basin
Province Loei
Province Udon Thani
Changwat Udon Thani
Huai Luang Dam
THE STUDY AREA
① NORTHERN REGION
② NORTHEASTERN REGION
③ CENTRAL REGION
④ SOUTHERN REGION
LEGEND
Study Area Boundary
River Basin Boundary
River
Provincial Boundary
0 5 10 20 30 40 50
km
LOCATION MAP

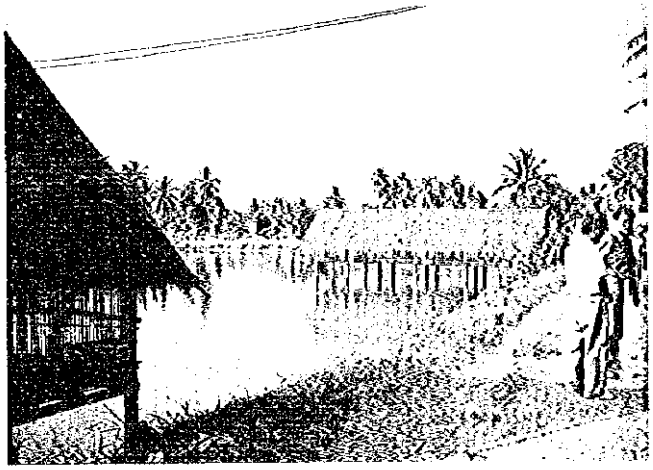


EXISTING AND PROPOSED PROJECTS MAP

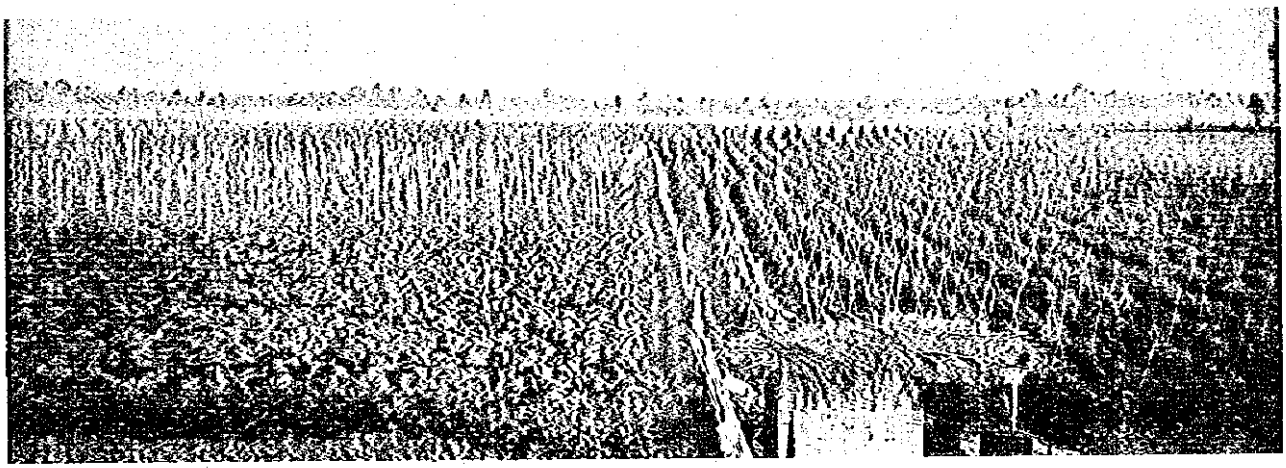
PHOTOGRAPH OF THE STUDY AREA



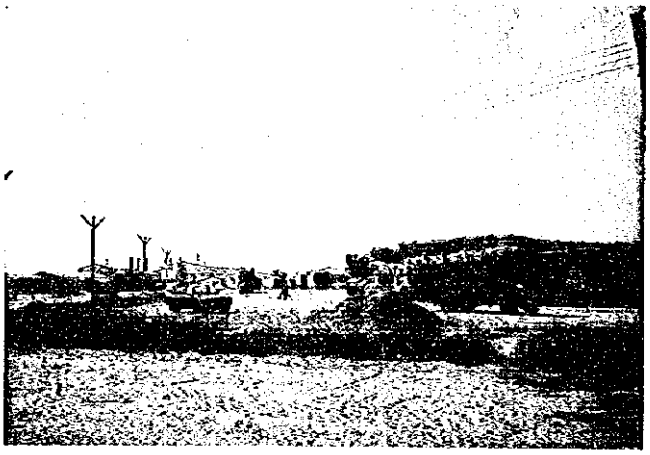
A Typical Farmhouse



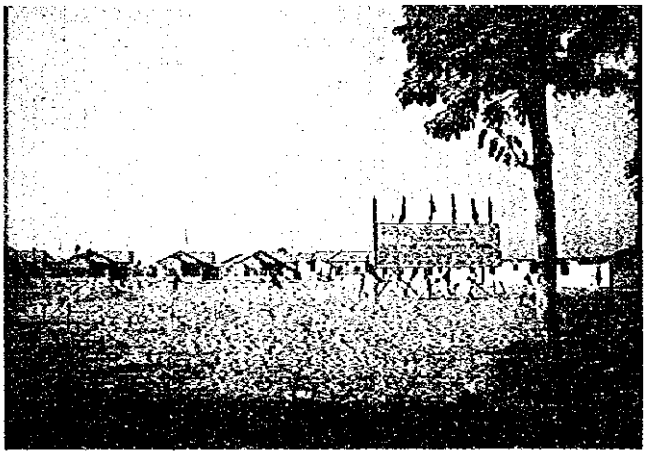
A typical Fish Pond



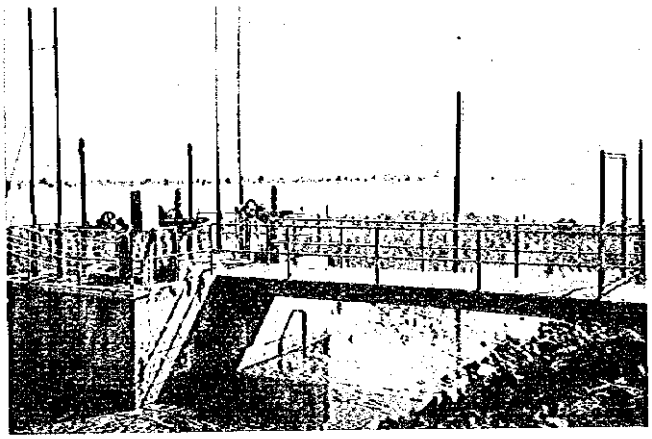
A Dry Season Farmland along the Mekong River



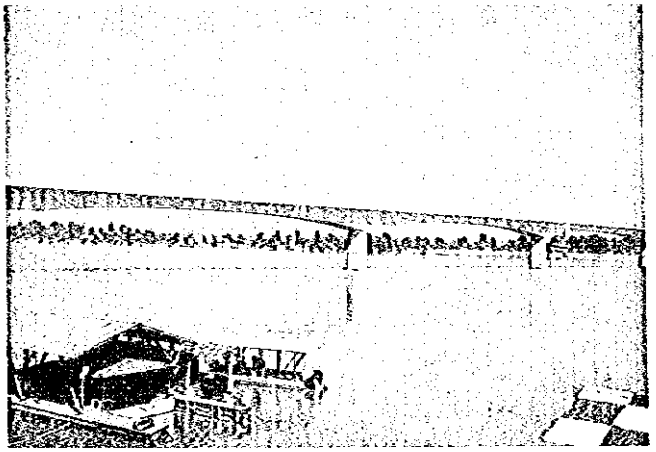
A Sugar Mill



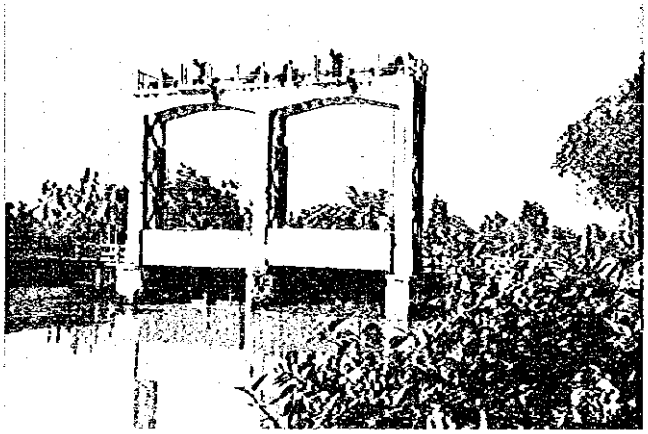
An on-going Housing Project



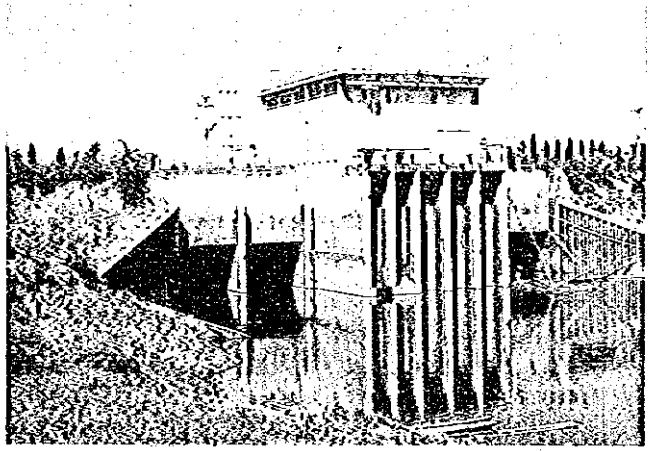
The Huai Luang Dam/Reservoir(Huai Luang Project:RID)



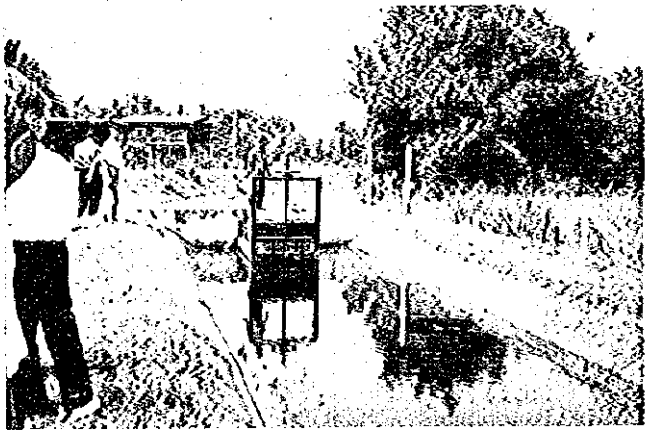
The Friendship Bridge over the Mekong River



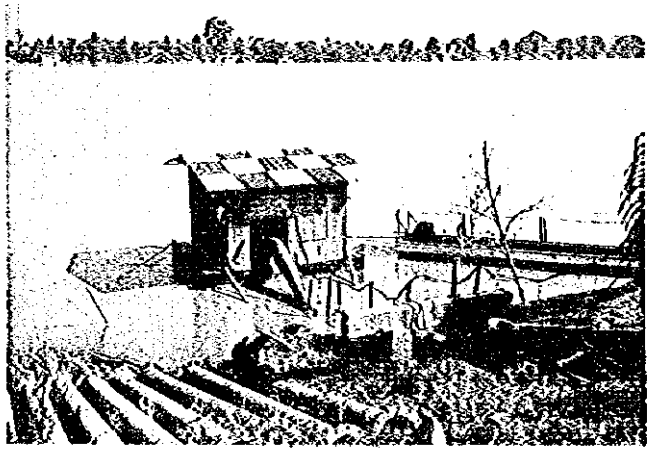
The Huai Luang Diversion Dam (Old Dam: RID)



Regulator of the Huai Mong Project (DEDP)



An Irrigation Canal(Huai Luang Project)



A Floating Pump on Mekong River(DEDP)

CONTENTS

CHAPTER 4. SELECTION OF PROJECTS FOR DETAILED M/P STUDY

PART-2 DETAILED MASTER PLAN STUDY

CHAPTER 5. HUAI MONG PROJECT

CHAPTER 7. HUAI LUANG DEVELOPMENT PROJECT

PART-3 RECORDS OF SEMINAR AND RECOMMENDATION

CHAPTER 8. RECORDS OF SEMINAR

CHAPTER 9. RECOMMENDATION

LIST OF TABLES

LIST OF FIGURES

ABBREVIATION AND GLOSSARY

1) Agencies

ALRO	Agricultural Land Reform Office, MOAC
ARD	Accelerated Rural Development Office, MOI
BAAC	Bank for Agriculture and Agricultural Cooperatives
CDD	Community Development Department, MOI
CPD	Cooperative Promotion Department
DLD	Department of Land Development, MOAC
DEDP	Department of Energy Development and Promotion, MOSTE
DMR	Department of Mineral Resources
DOA	Department of Agriculture, MOAC
DOAE	Department of Agricultural Extension, MOAC
DOF	Department of Fisheries
DOH	Department of Health
DOL	Department of Livestock, MOAC
DOLA	Department of Local Administration, MOI
EGAT	Electricity Generating Authority of Thailand
FAO	Food and Agriculture Organization of the United States
JICA	Japan International Cooperation Agency
MD	Meteorological Department
MI	Ministry of Industry
MOAC	Ministry of Agriculture and Cooperatives
MOE	Ministry of Education
MOF	Marketing Organization of Farmers
MOI	Ministry of Interior
MOSTE	Ministry of Science, Technology and Energy
MPH	Ministry of Public Health
MTC	Ministry of Transport and Communication
NEB	National Environmental Board
NESDB	Office of National Economic and Social Development Board, PMO
NSO	National Statistic Office
OAE	Office of Agriculture Economics
ONEB	Office of the National Environmental Board
PAEO	Provincial Agricultural Extension Office
PEA	Provincial Electric Authority
PMO	Prime Minister's Office

PWA	Provincial Waterworks Authority
PWD	Public Works Department
RFD	Royal Forestry Department, MOAC
RID	Royal Irrigation Department, MOAC
TDRI	Thai Development Research Institute

2) Other Abbreviations

GDP	Gross Domestic Product
GRP	Gross Regional Product
GPP	Gross Provincial Product
HYV	High Yield Variety
LV	Local Variety
EIRR	Economic Internal Rate of Return
B/C	Benefit Cost Ratio
NPV	Net Production Values
KWH	Kilowatt Hour
MW	Mega Watt
F.C	Foreign Cost
L.C	Local Cost
FY	Fiscal Year
C.I.F.	Cost, Insurance and Freight
F.O.B.	Free on Board
O/M	Operation and Maintenance
HWL	High Water Level
NWL	Normal Water Level
LWL	Low Water Level
EL	ELevation Above Mean Sea Level
MSL	Mean Sea Level
LSIP	Large-Scale Irrigation Project
MSIP	Medium-Scale Irrigation Project
SSIP	Small-Scale Irrigation Project
JICA Study Team	JICA Study Team assigned to the Study

3) Glossary

Phak	Region
Changwat	Province
Muang	Capital of Province
Amphoe	District
Tambon	Sub-District
Muban	Village
Mae Nam	Large River
Nam	A Medium-size river
Lam	A small river
Kwae	A tributary of a river
Huai	A rivulet

4) Units of Measurements

mm	millimeter
cm	centimeter
m	meter
km	kilometer
sq.cm	square centimeter
sq.m	square meter
sq.km	square kilometer
rai	unit of land measurement
l, lit	liter
cu.m	cubic meter
MCM	million cubic meter
lit/sec	liter per second
m/sec	meter per second
ppm	part per million
pH	Potential of hydrogen
EC	electric conductivity
g	gram
kg	kilogram
ton,t	metric ton
sec	second
min	minute
hr.	hour

min.	minimum
max.	maximum
%	percent
No.	number
C	degree centigrade
Cl	chlorine
HP	horse power
ET	evaportranspion
ppm	parts per million
N	nitrogen
P	phosphate
K	potassium
Baht	unit of Thai currency
US$	US Dollar

5) Conversion Factors

Unit of Length:	Millimeter (mm)	0.001	meter
	Centimeter (cm)	.01	meter
	Kilometer (km)	1,000	meter
Unit of Area:	Square centimeter (sq.m)	0.0001	sq.m
	Hectare (ha)	10,000	sq.m = 6.25 rai
	Square kilometer (sq.m)	1,000,000	sq.m
	Rai	0.16	ha
Unit of Volume:	Liter (lit)	0.001	cu.m
	Cubic meter (cu.m)	1,000	liters
Unit of Weight:	Kilogram (kg)	1,000	grams
	Metric Ton (t)	1,000	kg

SUMMARY AND RECOMMENDATION

CONTENTS

SUMMARY

INTRODUCTION

1. Objectives and Contents of the Study

1) Objectives

(a) To conduct the Master Plan Study on the Integrated Agriculture and Water Resources Development Project of Huai Mong, Nam Suai and Huai Luang River Basins, and

(b) To carry out technology transfer to the Thai counterpart personnel during the course of the Study.

2) Contents

(a) The overall agriculture and water resources development plan (basic concept for development), which is mainly composed of agricultural water resources development plans and flood protection plans, will be established. And the selection of a priority project area and project for the detailed master plan study will be made in each river basin.

(b) the detailed master plan will be formulated for the project selected in each river basin.

2. National Policy on Agricultural Development

The objectives of the 7th National Economic and Social Development Plan (1992-1996) can be summarized as follows:

- Efficient Use of Natural Resources
- Support Research, Development and Transfer of Technology.
- Restructure Agricultural Production to suit Local Condition and Market Demand
- Support Development of Agro-processing Industry
- Improve Agricultural and Cooperative Development System

3. National Policy on Water Resources Development

During the period of the 7th National Plan (1992-1996), the principal objectives of water resources development may be summarized as follows:

- Budgetary allocation to medium scale projects, formulated according to sound planning.
- Budgetary allocation to small scale projects, emphasizing areas which are less well developed.
- Encouragement of water user's organizations to participate in operation and maintenance of projects.

THE STUDY AREA

4. Study Area and River Runoff

The Study Area consists of three river basins of the Huai Mong, the Nam Suai and the Huai Luang covering a total area of approximately 8,600 sq.km. It is located in the Northern part of the Northeastern Region of Thailand. The Area is in one of the frontier regions of Thailand, and distributed three provinces of Nong Khai, Udon Thani and Nong Bua Lamphu. All three rivers are on the right bank of the Mekong, and the Study Area is facing Laos across the Mekong.

The Area is being in the Asian monsoon zone which is characterized by a clear classification of climate with a rainy season from May to October and a dry season. Annual rainfall amounts to approximately 1,350 mm, of which 90 percent falls in the rainy season, and the remainder falls in the dry season without any effect on crop growth. Even in the rainy season, dry days are frequent.

The river runoff at present is estimated at 2,414 MCM for a normal year and 1,725 MCM for a 1/5 drought year. The river runoff for a 1/5 drought year is shown below;

Season	River Runoff (1/5 Drought Year) in MCM		
	Potential	Existing	Aft. Develop.
Dry Season	175	156	144
Wet Season	1,738	1,569	1,483
Total	1,913	1,725	1,627

Potential : before implementation of existing water resources development projects
Existing : at present
Aft. Develop : after implementation of proposed water resources development projects

5. Population

Province	Population (1,000 persons)	Average Family Size (Persons/household)	Rural Population (% of total population)
Udon Thani	766	4.97	70
Nong Khai	313	5.00	86*
Nong Bua Lam Phu	103	5.12	78
Total	1,182		

Note is the information from 1990

6. Existing and On-going Project

1) RID Projects

The RID defines the large, medium and small scale projects. Large and medium-sized reservoirs are capable of supporting irrigated agriculture during the dry season, but small reservoirs with average storage capacity of 0.45 MCM will not serve the dry season irrigation in many cases. It is said that small scale projects are provided to serve the basic needs of rural people.

Within the Study Area, one (1) large scale project, nine (9) medium scale projects and 147 small scale projects exist, and the total irrigation area is 28,880 ha (180,490 rai) which includes 1,750 ha (10,940 rai) of swamp dredging and farm pond projects.

2) DEDP Projects

a) Pump Irrigation Projects

The objective of the pump irrigation project is to supply irrigation and domestic water for local people. Thirty two (32) pump stations were constructed in the Study Area and its irrigation area is 9,230 ha (57,700 rai).

b) Huai Mong Project

The Huai Mong project has been constructed in the area of Amphoe Sri Chiangmai and Tha Bo located at the lowest reach of the Huai Mong river. The project aims to eliminate flood and drought damage and consists of regulator, dikes,irrigation and drainage pumps, canal system, etc.. The irrigation area of the project is 3,170 ha (19,800 rai). Water user's cooperative was organized and farmers pay about 50 percent of the running costs (80 Baht/rai/crop season).

c) Lower Haui Luang project

Lower Huai Luang project with the same objectives as Huai Mong project is being conducted by the DEDP. The regulator which is one of the main project facilities is being constructed at Amphoe Phon Phisai in Nong Khai province. The irrigation area of the project is 19,200 ha (120,000 rai), and will be irrigated by water pumped up from reservoir with a storage capacity of 155 MCM.

7. Soil and Land Classification

The most of the soil in paddy field in the Study Area is low humic gray soil, and soil in upland field is red-yellow podzolic soil with loam or sandy loam in texture. The contents of soil organic matter are generally insufficient, available phosphate and potassium are also low or moderately low, and soil pH ranges from 5 to 6.

Besides low soil fertility, there are some saline soil. Saline soil which is classified into Grade 1 to 2 (Very severely and severely salt-affected soil) are very little, and is distributed in two areas. Saline soil which is classified into

Grade 3 to 4(Moderately and Slightly salt affected soil) is very widely distributed in the Study Area.

On the land classification, DLD has classified the whole provincial land according to soil suitability for paddy(wetland) rice and land capability for upland crops. According to this land classification, the most suitable field for paddy and upland crops are scarcely distributed in the Study Area. The most of the fields have some constraints such as drought, flood, infertile, soil acidity,etc., but there is no serious problem regarding the soil and land in developing the Study Area.

8. Existing Land Use

The agricultural land occupies about 53 % of the whole Study Area or 460,500 ha (2,878,000 rai), and its land uses are as follows.

Agricultural Land Use

Paddy field	335,200 ha	(2,095,000 rai)	72.8 %
Upland field	98,200 ha	(614,700 rai)	21.3 %
Fruit and perennial crops	16,000 ha	(100,000 rai)	3.5 %
Vegetables	5,700 ha	(35,600 rai)	1.2 %
Others	5,400 ha	(33,400 rai)	1.2 %

9. Land Ownership

In the whole province, about 87% of total farm holding land in Nong Khai, and about 92% of farm holding land in Udon Thani was owned by farmers in 1991; 96.5% (Nong Khai) and 92.1% (Udon Thani) of the owned farm land was utilized by holding farmers themselves.

Only 3.0% in Nong Khai and 7.9% in Udon Thani of owned land is mortgaged out to the tenant farmers, and most of this land does not have specified periods of tenancy.

10. Crop Productivity

The average yields of major rice in the Study Area are 1,550 to 1,750 kg/ha in recent years by Thai Agricultural Statistics. Of course, yields vary by

Amphoe and year, but these are about 75 to 92 % of the those of the whole Kingdom. The average yields of cassava and sugarcane are almost equal of those of whole Kingdom.

On the cultivation of crops, some farmers are practicing the plowing and puddling and leveling of paddy field before transplanting the rice by farming machines. However, the most of the works such as transplanting, weeds control, harvesting and threshing of rice and upland crops are done by man power.

11. Livestock and Inland Fishery

There are so many heads of buffaloes, beef cattle, swine, chicken and duck in the Study Area. Under one-half of the farm households are breeding 1 to 10 heads of buffaloes or beef cattle. The number of buffaloes are now decreasing, on the contrary, number of beef cattle and chicken are increasing.

The area of fish ponds in the Study Area is almost 10,000 rai (1,600 ha), and the number of fish ponds are 7,330. The number and area of fish ponds are now increasing in the area, by the prosperous demand of the fish. The most of the capture fish are consumed by farmers themselves, and the remains are selling in local markets.

12. Supply and Demand of Products

On the glutinous rice, vegetables and fish, the amounts of supplies to inhabitants in the area were calculated by the total production and the population in each Amphoe. Average amounts of supply of glutinous rice (milled rice) are 203 to 379 kg/person/year, those of vegetables are 3.9 to 16.3 kg/person/year, and those of fishes are 1.8 to 10.0 kg/person/year. The amount of demands of glutinous rice, vegetables and fishes are estimated at 270 kg, 50 to 70 kg, and 20 kg respectively. So, it is necessary to increase the area of vegetables and fish pond in the Study Area.

13. Agro-Economic Characteristics

Some 8,600 km^2 of the Study Area accounts for 5.1 % of the North-eastern region and 1.7 % of the total national land. Number of farm households

has been increasing slightly excluding Udon Thani for which administrative separation was taken place in 1993.

Paddy lands in the three province are 65 % in Udon Thani and Nong Bua Lamphu, 59 % in Nong Khai, respectively. Ratio of irrigable area very low, that is, 6.1 % in Nong Khai, 3.9 % in Udon Thani. Despite its small farm holding areas, Nong Khai province produces higher value in agricultural production per ha of farm holding area.

In comparison of net farm household income including off-farm in comes, farmers in the three provinces are considered being living on lower annual income level, rainging from 32,500 Baht to 34,400 Baht which are equivalent to about 40% of the averaged family income of Thailand. This is resulting in dependence on off-farm income to meet annual expenditure. According to the farm economic survey, 30% of the farmers interviewed go outside of their village to get off-farm incomes.

14. Profitability of Crops

Crops budgets planted in the Study Area were estimated based on the farm economic survey to compare the profitability. As a result, profitability of the traditional crops shows lower profits compared to fruit and vegetables. Farmers in the Study Area are apt to save farm input because of their poor farming capital and dependence on the rainfall. The break-even point of wet season paddy in Udon Thani was estimated at 3,085 Baht/ha which is equivalent to about 60% of 5,103 Baht/ha of the whole country.

15. Marketing System for the Farm Products

Individual bargaining is prevailing in the Study Area because of the weakness of the cooperatives in marketing activities. At present, marketing paddy can be said being a buyer's market. On the basis of the farm economic survey, amount of paddy marketed was estimated at 38.4 % of the total production. Some 30% of which is glutinous rice and 79.4% is non-glutinous rice, respectively, supposing that glutinous rice for home consumption and non-glutinous rice for selling. Tomatoes mainly planted in Nong Khai are sold to processing factory with which farmers make contract farming. Sugarcane is transported to the sugarmill at Khumphawapi in Udon Thani.

16. Farm Household Income and Poverty Conditions

NESDB estimates poverty threshold at 6,500 Baht per capita per year, which is equivalent to about 33,800 Baht/family/year. Net farm incomes in the Study Area are 10,682 Baht in Nong Khai, 11,050 Baht in Udon Thani and 11,789 Baht in Nong Bua Lamphu, respectively, which implies that off-farm incomes are now indispensable to meet family expenditures.

17. Agricultural Supporting Services

The provincial agricultural extension office and district agricultural extension office are responsible to implement extension services in line with the head office of the Department of Agricultural Extension.

Private sector is the main supplier of fertilizer and chemicals. Most of seed is obtained by retaining crop grain from farm production.

There are also Sericulture Research Institute and Fishery Experimental Station in Udon Thani, and Rice Temperate Cereals Experimental Station in Nong Khai.

18. Agricultural Credit Services

BAAC has 10 branch offices in Udon Thani, 3 branches in Nong Bua Lamphu and 4 branches in Nong Khai to offer agricultural crediting services, which are composed of short, medium and long-term credits. BAAC also provides loan in line with the government policy on the restructure of agricultural production in lower interest rate (5% and 15 years repayment)than usual one. Some 80 % of the loan disbursed to farmers is the short-term loan, and 77% of the total amount of loan is occupied by Nong Khai province in which crop diversification has been promoting more than other two provinces.

19. Rural Infrastructure

Compared to three national highways, Route 2, Route 210 and Route 22, feeder roads and rural roads are, in general not paved and flooded sometimes during wet season, resulting in causing problems of marketing agricultural crops and daily life of the village people.

More than 97 % of the villages are electrified through the Provincial Power Office, but domestic water supply systems in the rural areas are very poor because of giving priority to the municipal areas. Rural people depend on rainfall, groundwater and rivers for domestic water.

20. Result of the Farm Economic Survey

Some 200 farmers were interviewed to know the agroeconomic conditions in the Study Area. Average family size and farm labour per family are estimated at 4.69 and 3.09. Men and women are involved in all agricultural activities such as planting, weeding, harvesting and threshing etc. Men mainly work hard physical works, while women play a substantial role in livestock and acquacultural sectors. Fetching water is also the main task of women and children, spending about 15 hours per month.

Average farm size in the Study Area is estimated at 4.08 ha. Land use in the Area is concentrated to wet season paddy, however, dry season crops such as tomato and tobacco are widely planted in Nong Khai.

Some 30 % of farmers or their family member go outside temporary or permanently to get off-farm incomes. Farmer's intention to the integrated farming in the future is not so high, accounting 41.5 %.

The major problems in the Study Area can be summarized as water and poverty. Some 63 % of farmers answers that irrigation project should be given the highest priority. As to the Basic Minimum Needs(BMN), quality of life in the Huai Mong and Nam Suai basins are generally low as compared to that of Huai Luang river basin.

21. Irrigation and Drainage

Irrigation efficiency varies from project to project. For example Huai Luang Project has 45% efficiency. But in the same province, in case of medium scale projects it varies from 56-64%. However, an average of 50% efficiency would be an ideal.

The existing irrigation area are summarized as shown below.

Project Type	Agency	Mong Basin (ha)	Suai Basin (ha)	Luang Basin (ha)	Total (ha)	Total (Rai)
Large	RID	0	0	13,760	13,760	85,970
Medium	RID	0	2,050	1,640	3,690	23,080
Small	RID	2,552	2,848	4,280	9,680	60,500
H.M Proj	DEDP	3,170	0	0	3,170	19,820
Pumping	DEDP	3,075	4,305	1,850	9,230	57,700
Swamp Dradging & Farm Pond Proj. (RID)					1,750	10,940
Total (existing)		8,797	9,203	21,530	41,280	258,010

In the Study Area, drainage is performed through natural stream/canals.

OVERALL AGRICULTURE AND WATER RESOURCES DEVELOPMENT PLAN

22. Target Year

The main objective of this Study is to conduct a master plan study on integrated agriculture and water resources development. Taking into consideration the limited number of proposed projects in the Study Area and the period of National Economic and Social Development Plan, the target year of the development is set to be the year 2006 or the end of the 9th National Plan period (2001-2006).

23. Provincial Development Plan

Provincial development plans conform with the regional development plan of the NESDB and other government policies related to the provincial development. Considering the geographical location, natural resources and potential of the province, the provincial development strategies of three provinces in the Study Area may be summarized as follows:

a) Udon Thani

- Develop Udon Thani as a trading center for commercial business and as a financial service center for Upper Northeastern Region linked with Indochinese countries.

- Develop Udon Thani as an agro-industry province for export to the sub-region and the import of raw materials from Indochinese countries.

b) Nong Khai

- Nong Khai was set to be a border trade point with linkages to Udon Thani which is a trading center of the Upper Northeastern Region.
- Nong Khai links the Northeastern Region to Indochina and South China, and will serve as tourism center along the Mekong river.

c) Nong Bua Lamphu

- Develop Nong Bua Lamphu to be an important satellite town with the major role in agricultural and agro-industry products.
- Develop Nong Bua Lamphu to be an attractive town for tourists together with Loei, Udon Thani, Nong Khai and Khon Kaen.

24. Water Demand and Available Storage Capacity

The irrigated area and rainfed area in the Study Area after implementation of proposed water resources development projects are estimated and presented below:

Agricultural Land in the Study Area after Development

	Wet Season	Dry Season
Irrigated Area	109,000 ha (684,000 rai)	22,000 ha (137,000 rai)
Rainfed Area	351,000 ha (2,186,000 rai)	-
Total	460,000 ha (2,870,000 rai)	22,000 ha (137,000 rai)

Based on the results of farm economic/inquiry survey, assuming about 80% of the farmers will irrigate 100% of their land during the wet season and 15% during the dry season, then the irrigation water demand for the Study Area is estimated at 2,180 MCM.

From the different water demands and its availability, a balance of water resources can be made.

A. Water demand

i)	Agricultural water demand	=2,180 MCM
ii)	Industrial water demand	= 10 MCM
iii)	Domestic water demand	= 50 MCM
	Total	2,240 MCM
	Required Storage Capacity = (assuming 15 % reservoir loss)	2,640MCM.....(1)

B. Available Storage Capacity

From existing projects	= 213 MCM
From on-going & proposed projects	= 519 MCM
Total	= 732 =730MCM.....(2)
Balance (2)-(1)	=(-)1,910 MCM

Which means the Study Area has a serious water shortage problem due to only a few effective storage damsites. And available water can irrigate only 23% of the total agricultural land in the Study Area.

25. Constraints against Development

In the Study Area, there are some constraints on the agricultural development, as listed below:

1) Natural Constraints

a) Low run-off during the dry season and flooding during rainy season.

b) Lack of water resources for assured irrigation due to storage damsites.

c) High cost of groundwater drawl for irrigation.

2) Agro-Economic Constraints

a) Low productivity of crops.

b) Declining farmgate prices for traditional crops.

c) Higher income obtainable in urban employment.

d) Low farm household income and income disparity.

3) Institutional Constraints

a) Insufficient integrating activities between RID and other agencies, such as DEDP in planning and constructing the irrigation projects.

b) Insufficient participation by farmers in water allocation and in on-farm water management.

c) Insufficient information on demand of agricultural products in Changwat level.

26. Planning Considerations

The items that should be considered in planning agricultural development and water resources development including irrigation and flood protection project will be derived from the constraints, the objectives of the development and the national policy, and are shown below:

1) for Agricultural Development Plan

- Diversified cropping on new and rehabilitated irrigation project.
- Optimum use of irrigation water.
- Rural industry based on the products of diversified cropping and integrated farming.
- Integrated farming, especially for rainfed areas.
- Sustainable farming to obtain the appropriate annual agricultural production.
- Strengthening agricultural extension services by introducing diversified cropping.
- Strengthening credit services and agricultural cooperatives.

2) for Water Resources Development Plan/Irrigation and Flood Protection Plan

- Promotion of large and medium scale projects to expand the areas of assured dry season irrigation.

- Promotion of a wide range of small scale projects to encourage poor rural areas.
- Improvement of irrigation efficiency.
- Encouragement of participation by farmers in water allocation and in on-farm water management.
- The national policy implies the following priorities for water use:
    1. Domestic water use.
    2. Industrial water use.
    3. Agricultural water use.

27. Environmental Aspects to the Development

A dam of the Huai Mong Project, which is selected for a detailed master plan study as described in item No. 34, will be constructed within the Forest Conservation Zone. Since the construction cost of the dam is estimated at 44 million baht, an Environmental Impact checklist must be prepared and submitted to the RFD/OEPP for land use permission.

As for Nam Suai Basin project which will be implemented by DEDP, its storage capacity, reservoir area and irrigation area are larger than the size indicated in a Ministerial Regulation of MOSTE, therefore the detailed EIA will be required.

28. Agricultural Development Plan

The land use plan in the Study Area, which aims to introduce diversified cropping, integrated farming, etc., is proposed as shown below:

LAND USE PLAN IN THE STUDY AREA (Unit : ha)

Crop	Rainy Season		Dry Season	
	Existing	Plan	Existing	Plan
Irrigated Rice	41,280	109,000	0	0
Rainfed Rice	258,539	193,262	0	
Second rice	0	0	3,053	1,359
Cassava	33,233	16,912	33,233	16,912
Sugarcane	9,218	10,500	9,218	10,500
Soy bean (paddy)	0	0	3,211	8,600
(Upland)	1,642	5,500	629	700
Mung bean (paddy)	0	0	437	1,000
Ground nut (paddy)	0	0	406	1,000
Maize (paddy)	0	0	3,271	3,560
(Upland)	7,552	7,500	0	0
Sweet corn (paddy)			336	1,500
(Upland)	834	1,200	0	0
Other upland crops	29,395	22,841	0	0
Baby corn (paddy)	0	0	2,531	3,000
Vegetables (paddy)	0	0	1,334	1,981
(vegetable field)	3,333	3,518	0	0
Industial Crops	0	0	1,667	2,457
Fruit Trees	15,976	21,793	15,976	21,793
Flower & ornamental	69	199	69	199
Fish pond	1,500	16,500	1,500	6,500
Bamboo	3,474	12,926	3,474	12,926
Fast Growing Trees	3,886	13,707	3,886	13,707
Grassland	6,125	11,270	6,125	11,270
Sub-total	416,056	446,628	90,356	118,964
Fallow & Others	44,462	13,890	370,162	341,554
Total	460,518	460,518	460,518	460,518

29. Water Resources Development Plan

1) Necessity for Development

The necessity for agricultural water resources development in the Study Area may be justified by the following reasons:

a) The result of the farm economic survey, revealed that about 80% of the farmers in the Study Area want to practice irrigated agriculture.

b) The Study Area is one of the less developed areas. In order to improve the income disparities between rural and urban areas and to stop migration from rural areas, agricultural development in the Northeastern Region including the Study Area has been given special priority in national development policy.

c) NESDB has a plan to develop the middle and northern parts of the Northeastern Region as a promotion zone for agro-industry, and some towns such as Nong Khai, Udon Thani, etc. as its center. In order to realize a plan, the stable supply of large amounts of diversified agricultural products for industry will be needed.

d) Agricultural water resources development in the Study Area also meets the national water resources development policy of the government as explained below.

- Budgetary allocation for medium scale projects, formulated according to sound planning.
- Budgetary allocation for small scale projects, emphasizing these areas which are less well developed.

2) Development Plan

Since there are very few damsites and on the other hand the agricultural water demand is very high, water resources will be developed as much as possible in the Study Area. The development strategy will consider the following points.

- Construction of medium scale projects considering sound planning.
- Construction of more small scale projects
- Rehabilitation/Improvement of existing Facilities
- Encourage the participation of farmers in on-farm water management emphasizing the improvement of irrigation efficiency.

Keeping in mind the problem of land acquisition and irrigation efficiency, introduction of a pineline water supply system should be examined.

Considering all the points that are explained above, the agricultural water resources development plan for the Study Area is formulated as presented below:

PROPOSED PROJECTS

Project	Mong Basin		Suai Basin		Luang Basin		Total Area	
	No.	Area	No.	Area	No.	Area	(ha)	(rai)
Nam Suai Basin			1	17,750			17,750	110,940
Lower Huai Luang					1	19,200	19,200	120,000
Medium (17 new)	7	4,290	2	2,910	8	3,810	11,010	68,810
Small (263 new)	86	6,070	50	3,628	127	10,450	20,148	125,930
Improve. large					1			
Improve. medium			2		5			
Improve. small	36		34		51			
Others (Dredging, River Improvement)								
Total(proposed)		10,360		24,288		33,460	68,108	425,680

As mentioned before, even if all the proposed water resources development projects are implemented, the irrigated area would not become more than 23% of the total agricultural land from its present share of 9%. Therefore, any increase in irrigated agriculture will depend on the use of Mekong river water.

A plan has been drawn up for the utilization of Mekong river water and the preliminary cost for the implementation of plans with different pump capacity has also been estimated.

30. Flood Protection Plan

Flood have taken place yearly and caused the people considerable losses in both their personal and social properties. As the possible countermeasures for flooding, the following can be considered.

- Reduction of peak flood discharge by reservoirs

There are hardly suitable damsite in the Study Area, making it difficult to construct flood control dams.

- Drainage improvement

Inundation are very common in the Area due to the lack of cross drain for roads and insufficient drainage capacity. The said situation has to be improved as soon as possible.

- River improvement and banking

Provision of rubber dam after the river improvement works will make it possible to store the water in the river course and to feed the river discharge to the neighboring storage facilities. It is considered necessary to include both flood control scheme and water utilization scheme in the river improvement project plan.

- Construction of regulator and drainage pump station

Lower reaches of the rivers in the Study Area used to be affected by the Mekong high water and runoff from the drainage area of each river, causing periodical inundation in considerably wide areas. Though it may be possible to shut out the back water from Mekong river by closing the regulator gates, runoff from the drainage area during the period has to be drained out by using drainage pumps.

- Establishment of information network

At the upper reach of Huai Luang river, there is the existing Huai Luang dam and at the lower reach, the Lower Huai Luang project is currently under construction. The Huai Luang dam is provided with a gates spillway and releases of water impounded by the dam into the river is undertaken by operating the said gates. It is necessary to have a network system so that the releases of flow from the dam can be promptly informed to the O/M office for the Lower Huai Luang project which will be established in future.

Flood protection plan in the lower reaches are as follows.

1) Drainage Improvement of Huai Mong Project (proposed by the Study Team)

Drainage improvement plan is drawn up, which is enclosed the land with polder dike together with the improvement of natural drainage systems, such as new bypass drains, combined drains and short cut of outside runoff.

- To drain out by drainage canal to Mekong River directly
- To drain out excess water to reservoir through gravity, by connecting rivers and heightening up of levee elevations.

If flood of ten years return period is acceptable, this plan will be recommendable because other plans such as improvement of drainage pumps are too much costly.

2) Huai Vieng Khok and Huai Bang Phuan Area (proposed by the Study Team)

This area, extended from Huai Mong project area of DEDP to Muang Nong Khai, is protected by RID flood protection dikes. The purpose of regulating gates (no regulating pumps) is to cut off the high water from the Mekong at flood times and keep irrigation water for dry season. Farmers are irrigating the land of about 4,000 ha by their own small pumps from reservoir/swamps. This area is situated for good access to Nong Khai marketing, extensive agriculture and fishery area. This project has been selected as a project for detailed Master Plan Study , and is described in item No. 35 (Page 24).

3) Nam Suai Basin Project

As for the Nam Suai river basin, a feasibility study was conducted by Mekong Secretariat in 1981, and the project will be implemented in the near future by the DEDP. The proposed irrigation area is 12,550 ha (78,440 rai) for Stage 1 development and 5,200 ha (32,500 rai) for Stage 2 development.

In the latest 14 years after conduction of the feasibility study, agricultural policy was changed. And the purpose of this project for irrigation has been inquired to be amended. Introduction of up land crops, water requirement, and irrigation facilities including the reservoir, necessity of 67 MCM water pumping-in from the Mekong River during the dry season are required to be reviewed before the implementation of the project. As for the flood protection plan, the magnitude of flood of Mekong river adapted for the design of this project facilities having probability of being equaled or exceeded of 1:25 years is rare more than 10-year flood adapted for Huai Mong project.

4) Lower Huai Luang Project

This DEDP project started construction works in 1995 September. Flood conditions in this Area would be improved. But supplemental drainage facilities are proposed to prevent inundation originated in runoff from out-side.

31. Strengthening of Agricultural Supporting Services

1) Agricultural Researches

For the development of agriculture in the Area, many kinds of agricultural research such as adaptability and suitability of new crops in the area, rising the yields and productivity of crops, techniques for processing the agro-products, selection of beef cattle and dairy cows in the area and transplanting techniques of fertilized ova and so on, should be carried out/

2) Extension Services

Many kinds of extension services are expected for the development of agriculture in the area, these are as follows; Introduction of new promising crops for crop diversification, Making the farm pond for integrated agriculture, Classification of agro-product by quality for market, Establishment of cooperative cargo system, Cooperative use of farming machines, Improvement of information system and Supporting services for shipping and so on.

3) Agricultural Credit

In considering the poor farming capital of farmers, strong and continuous supporting services for the agricultural credit are required to realize proposed agricultural plans. For example, as about 15 % of farmer's debt in the Study Area is from non-institutional source, supporting on farm credit in lower interest rate and easy access to the credit, enlightenment of farmers about agricultural credit including farm management should be strengthened.

32. Strengthening Program of Water Users' Organization

To ensure the long life and sustain ability of irrigation projects, it is important that the provision of maintenance and operation systems be in place

prior to completion of the project facilities. Since the farmers are the end users of the irrigation facilities, they shall be made aware that the maintenance and operation of the facilities are their responsibility. It is therefore necessary to establish Water Users' Group even before the completion of the project facilities. Considering the present condition on Water Users' Organization, the followings are the major strengthening program.

- To promote training and development of administration and management capability for members and leaders of the Water Users' Group.

- To evaluate the Water Users' Group (after construction of project facilities), that will become the focal point in the decision to form Water Users Association or Cooperative. The decision will have to come from the farmers themselves.

- To undergo activities like training in the successful Water User Group, outside the Study Area, in order to learn from practical experience, about the basic knowledge of an organization and how to manage a cooperative.

SELECTION OF PROJECTS FOR DETAILED M/P STUDY

33. Selection of Projects for Detailed M/P Study

For the selection of projects for detailed M/P study, first, priority project area from each river basin has been selected. And then the suitable project from each priority project area was selected to carry out the detailed Master Plan Study on water resources development for irrigation or flood protection.

The river basin has been divided into two or three sub-basins for the purpose of selection of the priority project area as shown below.

Division of River Basin for Selection of Priority Project Area

River Basin	Sub-Basin	Area(sq.km)
1) Huai Mong River Basin	1-1. Upper Reach	1,307
	1-2. Middle Reach	747
	1-3. Lower Reach	657
2) Nam Suai River Basin	2-1. Upper Reach &Other River Basin	885
	2-2. Lower Reach	911
3) Huai Luang River Basin	3-1. Upper Reach	1,730
	3-2. Middle Reach	1,355
	3-3. Lower Reach	1,015

The criteria of priority project area selection was set up based on the followings:

① The priority project area is defined as the area with good potential for agricultural water resouces development which is capable of supporting irrigated agriculture during the dry season. Accordingly, high prioriy should be given to the area with availability of water resources, especially for dry season irrigation.

② Limited water resouces should be distributed widely in the sub-basin , therefore, the number of projects proposed in the sub-basin will be considered in selecting the priority project area.

③ The project proposed in environmentally sensitive areas such as Conserved Forest land should be given low priority.

④ The main objective of the integrated agriculture and water resources development is to improve the living condition of farm families. The high priority will be given to the sub-basin where the quality of life is comparatively low.

From the result of screening according to the criteria set up, the priority project area for each river basin is selected as follows:

Priority Project Area

1. Huai Mong River Basin — Upper Reach
(include environmental sensitive areas but has good potential for agricultural water resources development.)

2.	Nam Suai River Basin	Upper Reach & Other River Basin (In the lower reach, development project (Nam Suai Basin project: DEDP) is proposed.)
3.	Huai Luang River Basin	Upper Reach (In the middle and lower reaches, a development project (Lower Huai Luang project: DEDP) is under construction.)

For the detailed master plan study, one project from each priority project area has been selected while giving importance to the various types/nature of the projects which is more beneficial to RID as shown below.

1. Huai Mong River Basin	:	Huai Mong Project (Medium Scale Project: Dam/Irrigation)
2. Nam Suai Basin	:	Huai Vieng Kook and Huai Bang Phuan Areas Flood Protection Project
3. Huai Luang River Basin	:	Huai Luang Development Project composed of - Improvement of existing project, - Huai Luang River Training, - River Water Impounding and - Small Scale Irrigation Project.

DETAILED MASTER PLAN STUDY

34. Huai Mong Project

The Huai Mong project area is the rural area developed between the mountains/hills, which is situated in the most upper reach of the Huai Mong. The irrigation area, where water will be supplied through dam and canal system, is 1,000 ha extended over the Tambon Ban Than and Ban Khok, Amphoe Suwanna Khuha, Nong Bua Lamphu province.

The annual average family income is estimated at about 25,000 Baht which is lower than the poverty line of about 33,800 Baht, resulting in depending on off-farm incomes. Some 40 % of farmers go outside their village. Quality of life on the basis of BMN in this area is generally low and poverty is the main issue in the area.

The Huai Mong project is a medium scale project with a dam, canals, etc., and its feature is as shown below.

Features of the Project

Irrigation Area:			
Wet Season	major rice	1,000 ha	(6,250 rai)
Dry Season	Soybean	400 ha	(2,500rai)
Reservoir:			
Effective storage		12.2 MCM	
Project Facilities:			
Dam	26 m high, 150 m long, earthfill dam		
Canal	main & lateral canals of 32 km long in total, drainage canal of 6 km in total		
River Improvement		17.8 km	

Tangible benefits in this area will be generated from crop and inland fishery sectors with construction of dam and irrigation facilities, etc. As the result of economic evaluation, EIRR was calculated at 6.0 %.

35. Huai Vieng Kook and Huai Bang Phuan Areas Flood Protection Project

The Project area is located in the west of Nong Khai Province, extending to Amphoe Muang and Tha Bo on the right bank of Mekong river. The Project area consists of two river basins, namely, Huai Vieng Kook and Huai Bang Phuan, the tributaries of Mekong river. The drainage areas are 151 sq.km and 233 sq.km respectively.

The objectives of the Project are to stabilize the production of agricultural crops, income of the farmers aiming at higher living standard by protecting the farm areas from flood damages.

The Project consists of the following development plans.

1) Flood protection plan

The plan consists of the following main items.

- Establishment of drainage facilities such as regulators and
- Rehabilitation of existing regulator gates
- River improvement and/or establishment of bypass river

2) Swamp area development plan

This plan aims to improve swamp areas which is lacking of drainage facilities and to utilize existing ponds more effectively as a source of water in dry season by increasing its capacity.

The features of the project are shown below.

Features of the Project

	Bang Phuan	Vieng Kook
1. Flood Protection		
1) River		
New Bypass River	7 km	-
Improvement	9 km	18 km
2) Regulator		
New	1 set	
Rehabilitation	1 set	1 set
3) Drainage Pump	ø 1,000 mm×3	ø 1,350 mm×3
2. Swamp Development		
Nos. of Swamp	3	4
Project Area	1,340 ha	820 ha
Dredging	1.2 MCM	0.7MCM
Dike	18 km	16 km
Two Way Pump	3 sets	4 sets

In the economic evaluation, flood protection benefit was considered once in ten years. Project benefit will mainly be generated from agriculture, livestock and fishry sectors by the development of swampy areas. EIRR for this project was estimated at 1.1 %, which is lower than opportunity cost of capital of Thailand.

36. Huai Luang Development Project

The project area is located in Muang Udon Thani and Amphoe Kut Chap of Udon Thani province and extends to the directions of west and north having a total area of 7,200 ha. Irrigation area to be developed by the project is 1,190 ha.

The main two components of this project are

- Improvement and Rehabilitation of Existing Project and
- River Training and Water Impounding Project.

The feature of the project is as shown below.

Features of the Project

1. Improvement and Rehabilitation	
Nong samrong Reservoir	dike improve., drainage canal const.
On-farm Facilities	470 ha
2. River training and Water Impounding	
Huai Luang River Training	20 km
Water Impounding	4 Reservoirs
Huain Luang #1 Weir	1
Small Scale Irrigation Project	720 ha

Since the objective of this project is to improve the existing irrigation facilities, project benefit will be generated from increase of cropping intensity, increase of crop yield and prevention of innundation. As the result of the economic evaluation, EIRR was culculated at 11.4 %.

RECOMMENDATION

1) Since there are very few damsites and on the other hand the agricultural water demand is very high, water resources should be developed as much as possible in the Study Area. It is recommended that the agricultural water resources development (1) within the Study Area should be given first priority and (2) to the use of Mekong water. The target year of the agricultural water resources development within the Study Area is set to be the year of 2006 or the end of the 9th Plan period(2001-2006).

   When RID formulates a plan regarding the utilization of Mekong river water for irrigation in the Study Area, the facilities and O/M plan included in the plan should be well-coordinated with the existing facilities and concept of on-going project of DEDP. In addition, negotiation for an agreement with Mekong River Commission is necessary.

2) As per the result of the Study, Huai Mong project and Huai Luang Development project have been judged to be not very feasible in terms of its economic evaluation. Taking into account the social implication involved in the significance to develop this rural area, however,it is recommended that the feasibiity study for the two projects should be implemented in near future.

In order to estimate more accurate river runoff of the Huai Mong, observation of river discharge should be immediately commenced at suitable location near the damsite. Promotion of positive participation of the farmers in early stage of the project implementation will be necessary for successful implementation of the project.

3) In Thailand, small scale water resources development projects are implemented with an emphasis on areas which are less well developed. The Study Area is one such less developed area, and therefore the small scale projects should be implemented continuously in consideration of the following matters.

- To increase soundness of project planning.
- Promotion of farmer's participation at all stages of project implementation.
- Major factors impeding canal construction are difficulty in getting right-of-way, absence of proper cooperation among the benefiting farmers and lack of budget. Among these factors, the proper cooperation among the beneficiary farmers is of most importance. Therefore, technical staffs, who are well acquainted with the local conditions and can provide technical advice in the course of the project implementation for the benefiting farmers, should be assigned in the RID Changwat offices.

4) For the improvement and upgrading of distribution canals, a pipeline distribution system should be introduced, taking into account effective utilization of the water resources, lessening of right-of-way problems and introduction of upland crop irrigation. The followings will be required for construction of the pipeline distribution system.

- The pipeline distribution system should be formulated according to sound planning.
- The pipeline distribution system constructed should be used permanently by the beneficiary farmers.

5) In order to increase water storage in small scale reservoirs during the dry season, the feeder canal system, which feed water from rivers or other reservoirs by pumping or gravity into the small scale reservoir, should be introduced for the agricultural water resources development within the Study Area.

6) In general, a flood protection scheme may not always carries high economic return, however, measures for flood protection are of vital importance in securing peoples' life and properties among various types of social infrastructure facilities. In other words, it may be noted that a safe and active society could be realized only after the flood protection measures be implemented and people there could live well at ease and feel easy circumstances. From view of the above, it is recommended that the flood protection plan should be implemented one after another depending on the priority orders based on humanitarian grounds as per the available budget.

As regards the flood protection project in the Huai Vieng Kook and Huai Bang Phuan Areas, improvement of existing canals and regulator gates and swamp area development should be implemented. However, the construction of drainage pump stations should be studied more carefully.

7) Rehabilitation plan of existing Huai Luang project is being studied by RID. It is expected that an effective plan will be established and implemented for the benefiting farmers.

8) Nam Suai basin project and Lower Huai Luang project planned by DEDP should be implemented soon with the cooperation of RID and other government agencies concerned.

9) In the process of agricultural development which aims to introduce diversified cropping and integrated farming, the supporting services

for agricultural research and experimentation, agricultural extention, agricultural credit, etc. should be strengthened.

PART-1 OVERALL RIVER BASIN DEVELOPMENT PLAN

CHAPTER 1. INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The Study Area consists of three river basins of the Huai Mong, the Nam Suai and the Huai Luang covering a total area of approximately 8,600 sq.km and with a surface water resources potential of approximately 2,600 MCM. It is located in the Northern part of the Northeastern Region of Thailand. The Area is one of the frontier in Thailand, and distributed among three provinces of Nong Khai, Udon Thani and Nong Bua Lamphu. All three rivers are on the right bank of the Mekong, and the Study Area is facing Laos across the Mekong.

The Area is in the Asian monsoon zone which is characterized by a clear classification of climate with a rainy season from May to October and a dry season. Annual rainfall amounts to approximately 1,350 mm, of which 97 percent falls in the rainy season, and the remainder falls in the dry season without any effect on crop growth. Even in the rainy season, dry days are frequent. In addition, existing water resources facilities and on-farm irrigation facilities are not sufficient for the Area. Accordingly, effective utilization of water resources does not prevail so that the farmers always suffer from a shortage of water. In the Area, there are some salt-affected land and flood problems in the lower reaches, which are caused by river floods and the water level rises in the Mekong during the rainy season.

Paddy rice is a major crop in the Area, and its production per unit acreage in the rainy season is only 83 percent of the national average and in the dry season it is less than 60 percent. Annual income per farm household is 34,000 baht corresponding to 40 percent of the average household income in Thailand and only 18 percent of that of households in Bangkok and its environs. As mentioned above, agricultural productivity of the Area is low, and the living standards of the farmers are low.

In the Study Area, the Royal Irrigation Department (RID) has implemented a few large and medium as well as many small scale projects, and Huai Mong project, with a regulator composed of sluice gates, a two-way pump station, etc., has been completed by the Department of Energy Development and Promotion (DEDP) for the purposes of flood protection and irrigation water

storage. Those projects have made it possible to produce cash crops such as tobacco, baby corn, soybean, etc. in the dry season, and the farmers enjoy a higher agricultural income. However, those areas are limited to only small parts of the whole agricultural land of approximately 460,000 ha, and the rest of the area is cultivated without irrigation. And there is a still flood problem in the lower reaches of the Nam Suai and the Huai Luang. Consequently, it is strongly requested to establish a proper water resources development plan for the Study Area and flood protection plans for the lower reaches of the rivers.

Under the circumstances mentioned above, the Government of Thailand requested the Japanese Government to prepare a master plan for the Study Area and to conduct a feasibility study on the priority area(s) on July 8, 1993.

However, acknowledging the capability of RID in conducting feasibility studies, the Japanese Government recognized that the master plan study on agricultural water resources development and flood protection is of great importance because the Study Area is a quite fairly large of approximately 8,600 sq.km, and dispatched the Preparatory Study Team to discuss and confirm the Scope of Work for the master plan study with RID on December 1994. As a result of the discussions, RID and the Team agreed and signed the Scope of Work for the Study.

1.2 Objectives of the Study

(a) To conduct the Master Plan Study on the Integrated Agriculture and Water Resources Development Project of Huai Mong, Nam Suai and Huai Luang River Basins, and

(b) To carry out technology transfer to the Thai counterpart personnel during the course of the Study.

1.3 Necessity of the Study

Nong Khai and Udon Thani(including Nong Bua Lamphu) are known as the poorest provinces, placing 61th and 62th, respectively, among 74

Changwat in Thailand. As compared with 84,744 baht which is an average of the annual household income of Thailand, it would be pointed out that farm household incomes in the Study Area are lower. In addition, disparity of income between farm household and other occupation and disparity between the people in rural area and urban area, are widening mainly because of low price of farm products.

Meanwhile, TV sets and motorcycles have been extending with the sharp growth of Thai economy even in the Study Area, because of the tendency to a consuming society. Two wheels power tillers are also sharply extending instead of buffaloes which was the main power source for cultivation. Thus, it is prevailing tendency caused by the internal and outer influence on the rural areas that some farmers go outside to get off-farm incomes and some of their children get a permanent job outside the original villages, and these will be resulted in lack of young farm labours or successors, increase of farmers with a side job, overpopulation in urban areas, appreciate of farm wages.

Farming conditions in the Study Area can be roughly divided into two(2) types, that is, integrated farming in Nong Khai province which is facing to the Mekong river, combined with upland crops, fishery and mono-culture of wet season paddy in Udon Thani. Water availability through the year affects both farming condition and farm economy. The result of the farm economic survey conducted in November 1995, in which 63 % of farmers interviewed gave the highest priority to implementation of irrigation project, reflects farmer's intention that secure of irrigation water has to be given the highest priority for attaining stable agricultural production which is not affected with climatic conditions. Poverty and secure of safe drinking water are the common constraints in every Changwat and Amphoe in the Study Area according to the Basic Minimum Needs (BMN) which is studied by the Ministry of Interior.

It is forecasted that the number of farmers having a side job would be increased in the future, however, existing agricultural conditions must be improved from rainfed agriculture with lower input and cassava planted with less input to the stable production of wet season paddy and upland crops in dry season by the implementation of the study on irrigation water resources development in the Study Area.

1.4 Contents of the Study

The Study will be conducted in two years, and the implementation program is divided into five stages such as 1) preparatory home office work, 2) field work, 3) home office work, 4) draft final report explanation, and 5) preparation of the final report.

1) Preparatory Home Office Work

The objective of this preparatory home office work is to prepare the inception report.

2) Field Work

The field work consists of the following two steps.

a) First Step (Sept.1995-Dec.1995)

After the objectives of the development are clarified, and the needs, potential and constraints against the development are identified, the overall agriculture and water resources development plan, which is composed of agricultural water resources development plans and flood protection plans, will be established. And the selection of a priority project area and project for the detailed master plan study will be made in each river basin. The draft progress report will be prepared in order to put together and explain the findings of the study conducted during this period.

b) Second Step (Jan.1996-Mar.1996)

The progress report will be prepared after discussion with JICA on the contents of the report and its submission to RID. The field work will be continued for the projects for the master plan study, and the necessary information and data will be collected and analyzed. Subsequently, an outline of the detailed master plan will be established. In the Interim report, findings of the studies conducted during the period of the first and second steps will be explained.

3) Home Office Work (May 1996)

a) The detailed master plan will be formulated for the selected projects.

b) The draft final report will be prepared in order to put together and explain the study findings.

4) Draft Final Report Explanation (June 1996)

a) The JICA Study Team will submit and explain the draft final report to the RID, and the discussion on the report will be made between RID and the JICA Study Team.

b) In addition, a seminar will be held in cooperation with the RID as a part of the technology transfer.

5) Preparation of Final Report (Aug. 1996)

After the receipt of the comments from RID on the draft final report, the final report will be prepared by modifying the draft final report, if any.

1.5 National Policy on Agriculture and Water Resources Development

1.5.1 Agricultural Development Policy

Thailand's economy is currently undergoing rapid growth and restructuring of its society and economy. Development in the past has resulted in a more diversified production structure from primary agriculture products to higher value added products, such as highly priced field crops, modern forms of fisheries and livestocks. However, the share of the agricultural sector in GDP has gradually declined from 39.2% in 1961 to about 12.8% in 1992. Notwithstanding such a situation, agricultural employment is still important for the social and economic development of the country because more than half of the kingdom's population are still living on the agriculture.

The Government of Thailand has set forth the Seventh National Economic and Social Development Plan (1992-1996) with the target of average

overall economic growth rate of 8.2% per year. A growth rate in agricultural output of 3.4% per annum has been targeted and 7% per annum has been set as the target growth rate for aggregate real per capita farm income over the five-year period of the Seventh Plan.

During the 7th Plan, the main objectives can be summarized as follows:

1) Maintain economic growth rates at appropriate levels to ensure sustainability and stability.
2) Redistribution of income and decentralization development to the regions and rural areas more widely.
3) Upgrading quality of life, the environment and natural resources management, and
4) Accelerate human resources development.

Guidelines for agricultural development aimed at efficient use of national resources, development production in line with the local conditions and market demand, together with support for development of agro-processing industry. The summary of the Plan Guidelines for Agriculture Development are presented in Table 1.5-1.

Table 1. 5-1 Key Points of the Plan Guidelines for Agricultural Development (7th Plan 1992-1996)

	Items
1	Efficient Use of Natural Resources
	a. Protection of fertile agricultural areas. b. Formulate land use plan and support systematic land use. c. Encourage more efficient use of water, farmer participation in O&M at the farm level, including charging water fees.
2	Support Research, Development and Transfer of Technology
	a. Support private sector through research and development by government b. Encourage correct use of chemical fertilizer and chemical products. c. Enhance productivity and efficient use of agricultural machinery. d. Expand scope of agricultural credit and encourage contract farming.
3	Restructure Agricultural Production to Suit Local Conditions and Market Demand
	a. Create multi-disciplinary extension services so that farmers can prepare production plans by themselves. b. Support private sector and farmers in commercial forests.
4	Support Development of Agro-processing Industry
	a. Enhance productivity in agro-processing through public and private cooperation. b. Support for new products with export potential.
5	Improve Agricultural and Cooperative Development System
	a. Formulate agricultural production restructuring plan. b. Improve and develop capability of the information system for agriculture and markets. c. Providing training in management and administration.

1. 5. 2 Water Resources Development Policy

Water is one of the basic human needs, and it is one of the requisites for agricultural development. Therefore, water resources development has been one of the most essential government policies in decades. Population growth and economic development in Thailand have produced a rapid growth in water demand in recent years, and it has caused strong competition and conflict among different water users. Therefore, not only the demand for water resources development has been increasing, but also the proper water resources management has drawn increased attention from the government agencies concerned.

In view of the above situation, the NESDB launched a policy target in the 7th plan to upgrade the water resources management through systematizing development of all water resources nationwide to cover all of the 25 main river basins. Based on such a policy, a study on the basin-wide water resources development potential was initiated by NESDB in early 1993. The study was carried out by various academic institutes and consulting firms, and completed at the end of September, 1994.

In the 7th plan, the main policy for water resources development may be summarized as follows:

1) Budgetary allocation to plan for water resources development according to the river basin development plan and setting priorities according to the nature problems.
2) Allocate budget for medium scale water resources development projects with consideration to sound planning.
3) Budgetary allocation to small scale projects, emphasizing areas which are less well developed.
4) Encouragement of water user's organizations to participate in operation and maintenance of projects.
5) Accelerate the setting up of a national organization for water resource management and administration.
6) Formulate plan of raw water resources for water supply together with controlling water quality.
7) Encourage detailed studies concerning groundwater and formulate a master plan for groundwater development.

8) Encourage setting up data base of water resources information.

9) Improvement of water fee collection.

Aside from the above, the policies for water supply in urban and rural areas were also set forth in the 7th plan. The key elements of this plan are summarized as follows:

1) Provide an adequate water supply to meet the needs of urban and industrial growth especially in areas with intensive development.

2) Improvement of water supplies by improving the efficiency of existing water supply systems, expansion of production capacity to meet demand and promotion of private investment in the development of water service system for consumption and industrial use.

3) Organize an integrated coordination mechanism at every stage of development and designate the scope of responsibilities of related agencies together with encouragement of a greater private sector role.

CHAPTER 2. THE STUDY AREA

CHAPTER 2. THE STUDY AREA

2.1 Location and Topography

2.1.1 Huai Mong River Basin

1) Upper Reach

The Huai Mong river basin with a drainage area of some 2,711 sq.km is located in the west of the Study Area, extending to Nong Khai, Udon Thani and Nong Bua Lamphu provinces. Based on the topography, river regime, etc., the river basin may be categorized to the upper reach with a drainage area of some 1307 sq.km, the middle reach with some 747 sq.km and lower reach with some 657 sq.km.

Topography in the Huai Mong upper sub-basin is steep and declines to the east with a slope of 1/10 to 1/20 in the mountainous area of the western part, moderate in the eastern area, declining to the east along Huai Mong and the southwest in the other parts with a slope of about 1/150-1/800. The land elevations are about 600 m above M.S.L. at the top of mountains, and about 190 m above M.S.L. at the lower land. The farm lands are distributed in strips along the rivers/streams. On the other hand, in the Huai Nam Bon sub-basin, the lands are undulated and gently sloped down to the north with a gradient of about 1/300 to 1/500 and about 250 m to 190 m above M.S.L. in the elevation of farm lands.

The Huai Mong originates in the mountains of Na Duang District, Loei Province and runs to the east, joining with the tributaries of the Huai So, Huai Yap, etc. The river again joins with 3 other major tributaries, Huai Kholo, Huai Khana and Huai Nam Bon up to the vale of the Phuphankham mountain range which is the boundary between the upper reach and middle reach of the Huai mong river basin.

2) Middle Reach

The middle reach is bounded by the Phuphankham mountain range on the west, the Huai Luang river basin on the south and east, and the lower reach of the Huai Mong on the north. The topography in the flood plain, situated in

the west of the middle reach, is gentle and sloped with a gradient of about 1/2,000 along the Huai Mong. Due to the narrow span length of bridges along the road between Amphoe Ban Phu and Ampoe Na Klang, these low lands are currently flooded in the rainy season and developed to about 23 km in the distance and about 2 to 3 km in the width. On the other hand, the topography in the hilly land area is moderate and undulated, and declines to the said flood plain with a slope of 1/40 to 1/400.

The stream of the Huai Mong turns toward the north-northeast in its direction immediately after passing through the vale of the Phupkan Kham mountain range, and traverses the flood plain branching and interconnecting each other. In the flood plain, the Huai Mong joins with several tributaries, such as the Huai Nam Ngao, Huai Kradon, Huai sit, etc, from the right river side and a few tributaries from the left river side, interconnecting with each other, and finally consolidates as one stream and runs to the lower reach of the Huai Mong.

3) Lower Reach

The lower reach of the Huai Mong lies in the northwest of the Study Area. In the topography, the lower reach of the Huai Mong consist of three areas, the hilly land area to the left of the river, the flood plain area in the middle and the terrace land area to the right river. Topography in the hilly land to the left side of the river is steep in the mountainous parts with a gradient of about 1/10 to 1/50 and moderate in the hilly parts with a slope of about 1/50 to 1/300. The land elevations are varied to 588 m above M.S.L., (the highest mountain) and 170 m above M.S.L. in the low land. Paddy fields are distributed in strips along the rivers/streams in its lower land.

The flood plain extends along the left river side in the middle part of the Huai Mong lower reach. The topography is flat. The land elevation is about 160 m to 170 m above M.S.L. While, on the terrace land, the topography is gently and undulating, and sloped towards the flood plain with a gradient of 1/100 to 1/200, and 170 m to 190 m above M.S.L.

The Huai Mong traverses the flood plain meandering to the north-northeast and the northeast before reaching the river mouth, connecting with the Huai Thon and several streams on the right of the river directly and with

several rivers/streams on the left river side through the flood plain, and finally joins the Mekong river at Tha Bo, Nong Khai Province.

2.1.2 Nam Suai River Basin

1) Upper Reach

The Nam Suai river basin is located in the middle of the Study Area to the north, extending to Nong Khai and Udon Thani Provinces, and has drainage area of some 1,314 sq.km. The upper reach of the Nam Suai has a drainage area of some 403 sq.km and are bounded by the Nong Khai swamp area and the Huai Mong river basin to the west, the Huai Luang river basin on the south and east, and the Mekong river to the north.

The topography in the upper reaches is moderate and undulated, slopes to the east-northeast in a gradient of 1/200 to 1/400. The width of drainage area for each river is 4 to 5 km and sloped in 1/50 to 1/100 to the respective river. The land elevation varies from 170 m to 220 m above M.S.L.

The Nam Suai, originates in the undulating hilly land to the south of highway No. 2021 in Amphoe Ban Phu, Udon Thani province, and flows to the northeast, changes direction to the north-northeast at a distance of about 20 km from the origin, joins with the Huai Thong before reaching the Highway No.2, and entering its lower reach.

2) Lower Reach

The lower reach of the Nam Suai is bounded by highway No.2 to the east, and has a drainage area of some 911 sq.km. The topography in the lower reach is gentle in the upstream area, and flat in the middle and downstream areas along the river. The slopes to the nearest river, vary from about 1/50 to 1/300. Land elevation ranges from about 190 m to 160 m above M.S.L. but about 20 % of the total land area is below 165 m above M.S.L.

The river runs to east-northeast direction after joining with Huai Thong, and then turns northward at Ban Suai Long, Amphoe Muang, Udon Thani province and proceeds to the lower lying flood plain in Amphoe Muang, Nong Khai province, joining with the Huai Bak Ya, the Huai Dan, the Huai

Phen, the Huai Bo and other rivers/streams. After passing the lower flood plain, the river runs to the river mouth meandering, changing the direction to the east-northeast and meets the Mekong river at Ban Pak Suai Noi, Amphoe Muang, Nong Khai province. The Nam Suai in the lower reach is currently affected by the incoming water from the Mekong river, depending on the water level of the Mekong river. While the water is scarcely available in the dry season.

2.1.3 Huai Luang River Basin

1) Upper Reach

The Huai Luang river basin widely extends over the southern and the eastern parts of the Study Area, and has a drainage area of some 4,100 sq.km in total. The basin can be divided into three (3), the upper, middle and lower reaches from a standpoint of the topography, the river regime, etc.

The upper reach with a drainage area of some 1,730 sq.km is located in the middle part of the Study Area to the south within Nong Bua Lamphu and Udon Thani provinces. The topography in the upper reaches is steep in the mountainous area of the water shed with a slope of about 1/20 to 1/50, moderate and undulated in the hilly land with slopes of about 1/50 to 1/200 and the ground elevation of about 190 m to 230 m above M.S.L. in the western parts of the upper reach, relatively flat with a gradient of about 1/1,000 to 1/2,000 and ground elevation of about 170 m to 190 m above M.S.L. in the eastern parts of the reach, near the town of Udon Thani.

The Huai Luang originates in the Wat mountain in Amphoe Nong Wua So, Udon Thani province, runs to the northward and reaches at the Huai Luang reservoir completed in 1984. After joining with the Huai Sai, the Huai Siang and the Huai Ri, the river turns to the east and gradually runs the northern part of the reach, collecting the water from the Huai Raeng, the Loeng Nong Bo, the Huai at and other tributaries. In the eastern part, the river system is poorly developed and most of streams flow into the reservoirs/ponds and/or disappear without connection to the Huai Luang river.

2) Middle Reach

The middle reach is some 1,355 sq.km in a drainage area within Udon Thani province, and involve the drainage areas of the Huai Suang Luang and other tributaries along the Huai Luang and the drainage area of the Huai Dan which lies in the southeast of the Study Area, with a drainage area of some 338 sq.km.

The topography in the Middle reach along the Huai Luang is gentle and undulating with a slope of about 1/600 to 1/1,000 and a land elevation of about 170 m to 190 m above M.S.L. While the Huai Dan drainage area is moderate and undulating in topography with about 1/100 to 1/300 in land slope, and ground elevation of 170 m to 200 m above M.S.L. There are paddy fields distributed along the rivers/streams in narrow strips.

The Huai Luang runs meandering continuously in an eastwards direction. The Huai Dan, a tributary of the Huai Luang, extended over the south and east of the middle reach, runs northward and then joins the Huai Luang towards the end of the middle reach.

3) Lower Reach

The lower reach of the Huai Luang has a drainage area of some 1,015 sq.km and extend from the confluence of the Huai Dan up to the river mouth at Ban Wat Luang, Amphoe Phon Phisai, Nong Khai province. The topography in the lower reach is flat along the Huai Luang and moderate with a gradient of about 1/200 to 1/300 toward the river. The land elevation varies from 160 m to 190 m above M.S.L. in the cultivated land, while the land elevation is below 160 m M.S.L.in the swampy area.

The Huai Luang runs northward meandering widely with an almost flat river bed, joining with Huai Rai Noi, Huai Thon, Huai Chiang and a number of other rivers and streams. In the lower land, about 20 km from the river mouth, a number of natural reservoirs and swamps occur.

2.1.4 Other River Basins

The Study Area involves other river systems with a total drainage area of some 482 sq.km directly joined to the Mekong river, in addition to these three (3) big river basins. These basins are made several groups according to geographical location, such as six (6) river basins in the northwest, Pa Sak drainage area, Kong Khai east drainage area, Huai Mak Kong & others drainage area and Nong Saen drainage area. Each drainage area has their own drainage sluice to control the incoming flood from the Mekong and impound the water in the rainy season for irrigation and domestic use, except six river basin in the northwest and Nong Saen drainage area.

Nong Khai east drainage area, has a large drainage area with a land area of some 384 sq.km, consisting of the Huai Vieng Kook and Huai Bang Phuan river basins. Both basins have a land slope of about 1/100 to 1/300 and land elevation of 180 m to 200 m above M.S.L. in the upper and middle reaches, and a land slope of 1/300 to 1/800 in the lower reach. The land along the rivers/streams are cultivated to an elevation 170 m to 190 m above M.S.L. and below 170 m M.S.L. forms swampy/natural reservoir in the lower reach.

2.2 Meteorology, Hydrology and Geology

2.2.1 Meteorology

1) Climate

The climate of the Study Area may be characterized as tropical being influenced by southwest and northeast monsoons. Therefore, climatic conditions of the Area depend on the prevailing monsoon winds dividing a year into three seasons, such as, Summer, Rainy and Winter. In general, winter and summer are called as dry season and rainy as wet season.

The summer is very short, falling between March and April with an average maximum temperature between 35-36 degree Celsius. The rainy season falls between May and October. Most of the annual rainfall occurs during these six months. The winter begins in November and ends in February. The temparuture goes down to even 5 degree Celsius.

However, for the purpose of the different analysis, climatological data of Udon Thani (1961-90) and and Nong Khai (1965-90) province were collected and reviewed. The source of data is the Meteorological Department of Thailand. Values of important climatological parameters of these two stations are presented below.

Item	Nong Khai	Udon Thani
Temperature(°C/month)	5-42	5-42
R.Humidity (percent)	13-96	12-93
Evaporation (mm/month)	127	148
Sunshine (hrs/day)	6.8	6.8
Wind Speed (km/hr)	3.8	4.1
Rainfall (mm/year)	1,543	1,413

Source: Meteorological Department, Thailand, Sunshine data is from Loei station

Monthly variation of average values of temperature, humidity and evaporation is presented in Figure 2.2-1.

As it can be seen that temperature and relative humidity of two provinces have more or less the same value. But in case of evaporation Udon Thani has a higher value of about one millimeter per day.

2) Rainfall

There are a considerable number of rainfall gauging stations in and around the Study Area. These rainfall stations are operated by RID, Meteorological Department (MD) and also by other agencies. However, for this subject Study rainfall data of 20 stations scattered all over the Study Area were collected from RID and MD. Locations of the stations are presented in Figure-2.2-2. From these stations, 13 belong to Udon Thani, five to Nong Khai and two to Nong Bua Lamphu, the three provinces in the Study Area. A list of stations with average annual rainfall is presented below. Monthly average of three representative stations i.e. amphoe Muangs of the three Study related provinces are presented in Figure-2.2-3. Deatail is presented in Appendix B.

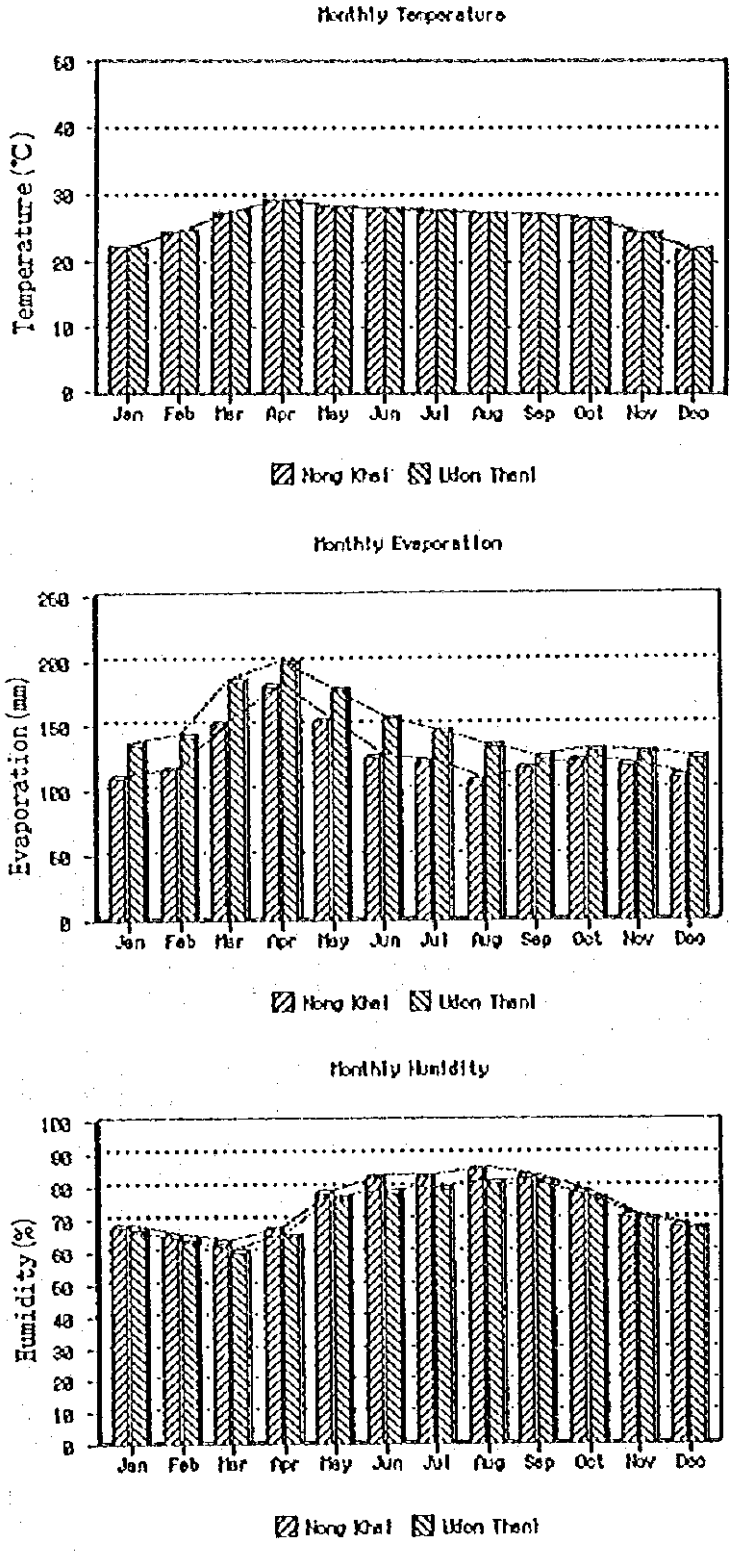


Figure 2.2-1 Monthly Average of Meteorological Parameters

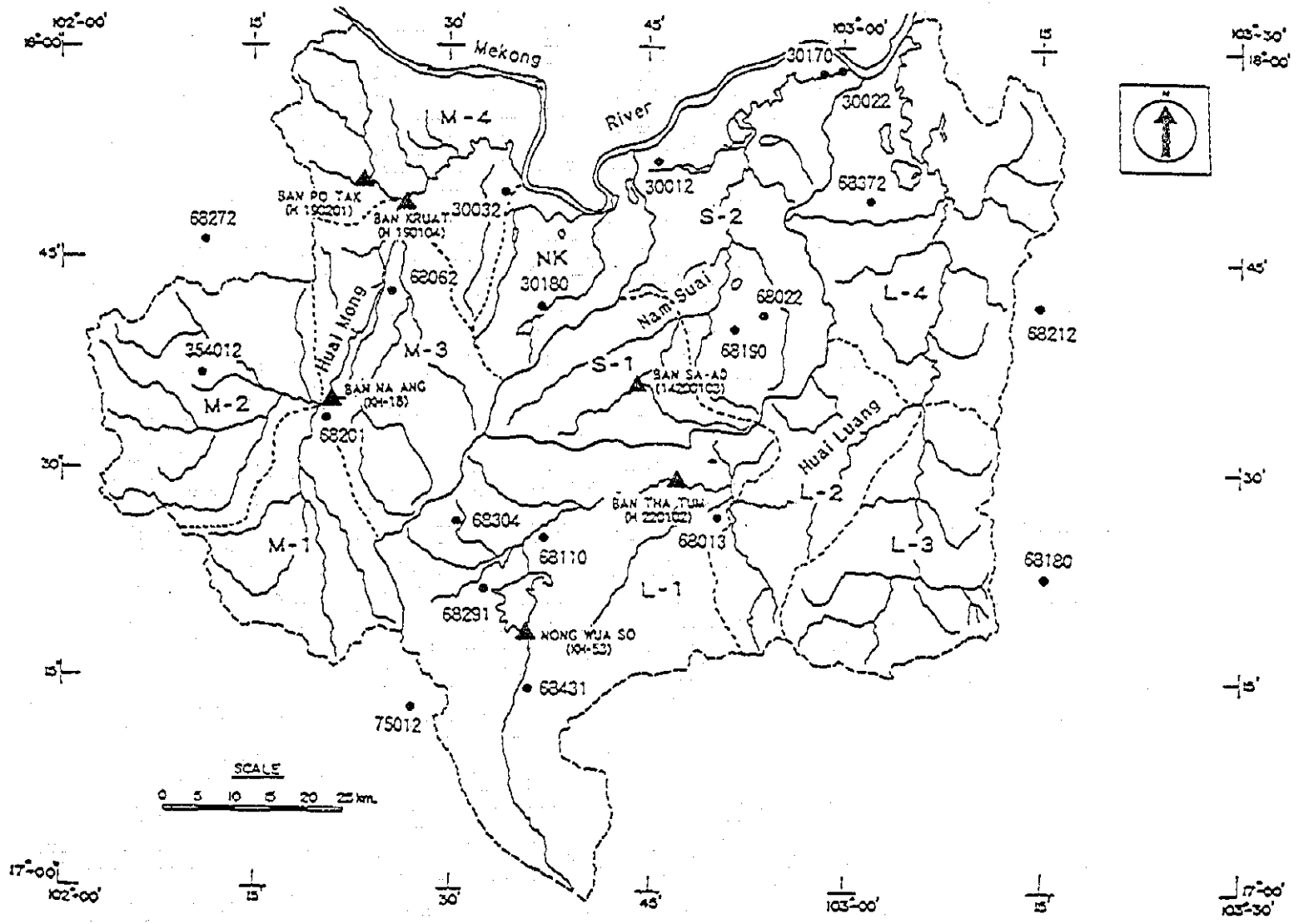


Figure 2.2-2 Location of Rainfall and Discharge Gauging Stations

Station Name	Code	Province	Annual Rainfall (mm)	Period
1. A. Muang	75012	Nong Bua Lamphu	977	1943-93
2. A. Suwanna Khuha	354012		1,298	1989-94
3. A. Muang	68013	Udon Thani	1,413	1952-93
4. H. Luang Old Dam	68110		1,494	1954-89
5. H. Luang New Dam(kh-29)	68291		1,231	1976-93
6. H. Luang S.S.settelement	68304		1,263	1977-93
7. H. Luang (Kh-53)	68431		968	1988-93
8. A. Phen	68022		1,504	1952-90
9. H. Nam Thieng Tank	68190		1,236	1971-93
10. Nong Bo Tank-80	68180		1,263	1961-93
11. A. Ban Phu	68062		1,328	1954-93
12. Huai Mong (Kh-18)	68201		1,342	1956-82
13. A. Ban Dung	68212		1,383	1974-93
14. A. Nam Som	68272		1,336	1975-93
15. A. Sang Khom	68372		1,451	1980-93
16. A. Muang	30012	Nong Khai	1,543	1943-93
17. A. Tha Bo	30032		1,452	1950-93
18. Ban Phuan Tank	30180		1,211	1956-93
19. A. Phon Pisai	30022		1,902	1952-90
20. Pleo Nguak Tank-4	30170		1,969	1954-93

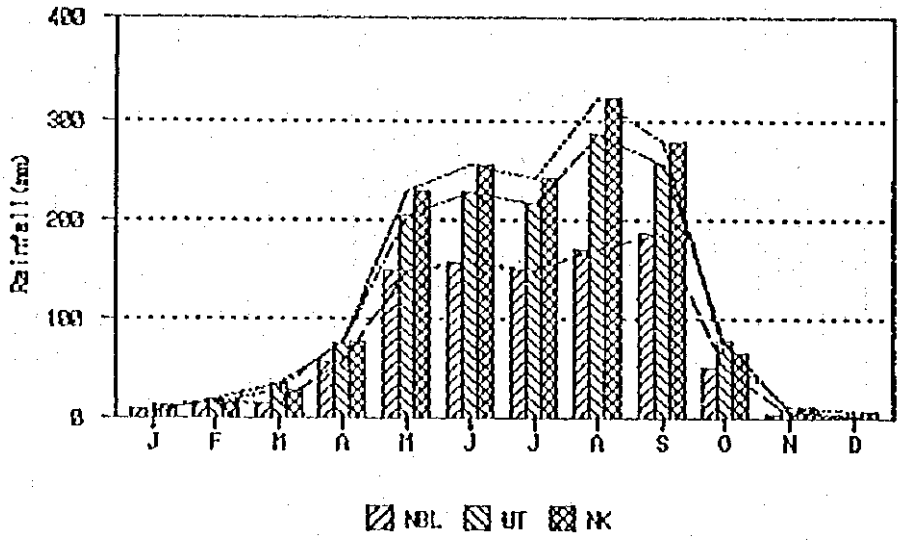


Figure 2.2-3 Monthly Average Rainfall of Representative Stations

About 90% of the total rainfall occurs from May to October. The driest months are November, December, January and February. Daily maximum was observed in August in all three stations considered. The values are 247.0mm in Udon Thani in 1974, 190.0mm in Nong Bua Lamphu in 1974 and 276.0mm in Nong Khai in 1948. Data also reveal that the lower reaches of the Study Area, more specifically, along the Mekong river have higher rainfall than the upper and middle reaches.

2. 2. 2. Hydrology

Hydrology of the Study Area is influenced by three tributaries of the Mekong i.e. Huai Mong, Nam Suai and Huai Luang, and never the less by the Mekong river itself, which flows along the northern boundary of the Study Area.

1) River Network

a) Huai Mong river

Among the three rivers, Huai Mong is the furthest upstream. It originates from the high mountains of Nong Bua Lamphu from an elevation of about 600m MSL and traverses Udon Thani and then meets the Mekong river at Amphoe Tha Bo 30km west of Nong Khai. The drainage area of Huai Mong river is 2,711 sq.km. There are quite a few tributaries that contribute to the Huai Mong but only active in wet season. The important tributaries in the upstream are Huai Khanan, Yap, Ko Lo etc. and Huai Thong in the downstream. The length may be estimated as 100km and has a rather steep slope of about 1:800.

There is a large scale project called the Huai Mong Project (DEDP) in the downstream. The purpose of this project is irrigation and mitigation of floods. The river mouth is equipped with pumps and a regulator. The project area is 3,170 ha (19,820 rai). Pump irrigation is also noticeable along the river and some weirs have been constructed in the upper reach of this river.

There are only three gauging stations in the basin. One in the upstream, the Ban Na Ang covers a drainage area of 1,307 sq.km. In the downstream there are two. One is at Ban Po Tak and the other is at Ban Kruat. The drainage areas are 255 and 2,370sq.km respectively.

b) Nam Suai river

Nam Suai is another tributary of the Mekong. It has a basin area of 1,314 sq.km in Nong Khai and Udon Thani. The small tributaries of Nam Suai originate from Amphoe Ban Phu in Udon Thani and flow northeast. In the middle of the basin these streams join with Nam Phen at Amphoe Phen of Udon Thani. The river then flows northwards and joins the Mekong at Ban Pak Suai

in Nong Khai. The total length is about 80km with an average slope of about 1:8,000.

There are many weirs constructed across the river for irrigation or domestic purposes. In the rainy season, due to the open river mouth and high water level in Mekong, water enters into the basin area up to the middle reach and causes inundation for a duration up to two to four weeks.

RID does not have a single gauging station in this river basin. According to the information DEDP has established few stations recently. However, no data regarding this river has been collected. Data from only one station presented in a report prepared by Asian Institute of Technology (AIT) for NESDB, Thailand, will be used as reference. The name of the station is Ban Som Sa-ad (14200103) which covers a drainage area of 170 sq.km.

c) Huai Luang river

Huai Luang river is the longest among the three Study related rivers and has a basin area of 4,100 sq.km. It traverse a length of about 150 km before it joins Mekong at Amphoe Phon Phisai of Nong Khai. The slope is estimated as 1:3,000.

There is a large scale dam project constructed by RID in the upstream of this river. The reservoir capacity is 113.3 MCM with a water surface area 31.1 sq.km. There are also weirs across the river for retaining water for dry season irrigation or for domestic purpose same as in Nam Suai. DEDP has pump irrigation projects along this river. The river mouth is open and the lower reach of the basin is inundated every rainy season due to intrusion of Mekong water.

There are two gauging stations on this river. Both of them are in Udon Thani, a little upstream. One is at Nong Wua So covering a drainage area of 436 sq.km and another is at Ban Tha Tum with a drainage area of 1,210 sq.km.

All three rivers are very active during the rainy season but in the dry season they have a very slow or even no flow. However, the river network and locations of the gauging stations are presented in Figure 2.2-2.

2) River Discharge

Of the three rivers in the Study Area, the discharge data of two rivers could be collected. For Nam Suai, data of Ban Som Sa-ad mentioned in NESDB report will be used for reference. Annual average discharge of these stations are presented below. Monthly total are presented in the Appendix B.

Code	River Name	Drainage area (sq.km)	Annual discharge (MCM)	Specific yield (ℓ/s/sq.km)	Runoff percent*
H190101(Kh-18)	H. Mong	1,307	271.30	6.58	16
H190104	H. Mong	2,370	614.21	8.22	19
H190201**	H. Mong	255	126.48	15.73	35
H220102(Kh-53)	H. Luang	436	97.76	7.11	17
H220102	H. Luang	1,210	219.57	5.75	14
14200103	Nam Suai	170	53.77	10.00	24

* Estimated, assuming annual rainfalls 1,300mm for H. Luang, Nam Suai and Kh-18, for other stations 1,400mm

** This station is on a tributary of Huai Mong

River runoff concentrates between the months June and October. Peak falls in August or September. Monthly average discharge of representative stations are presented in the Figure 2.2-4

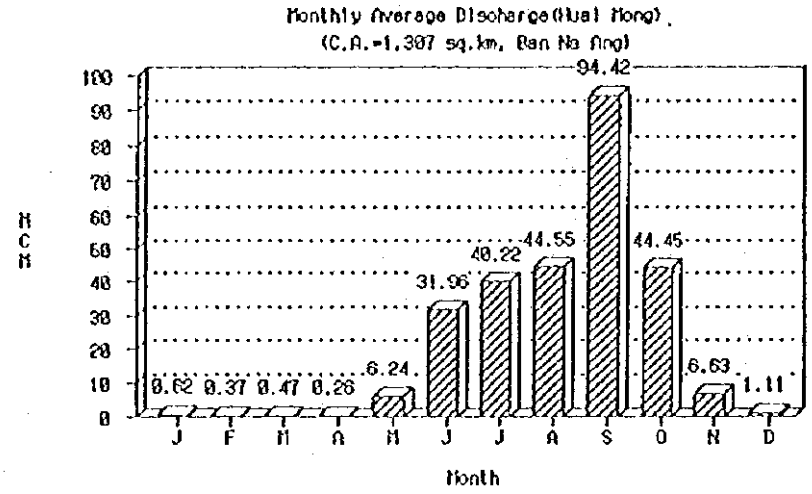
Apart from this river network there are a considerable number of swamps in the Study Area, especially in the middle to lower reaches of the Area. These swamps are also playing an important role in the Study Area hydrology.

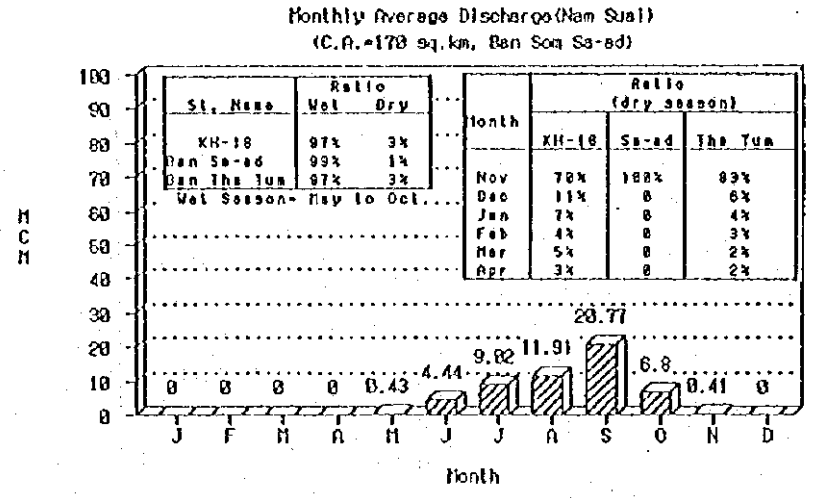
3) Water Level of the Mekong River

The high and low water levels fluctuate between 8 and 10m. High water levels are usually observed in August or September. A normal high water level is about 160-163m MSL and low goes down to a level of 154-56m MSL(at Kh-1(RID), Nong Khai). However, the water levels of past floods in 1966, 1971 and 1995 were recorded at Kh-1 as 167.59m MSL, 166.42m MSL and 166.23m MSL respectively.

2.2.3 Geology

The Study Area is formed by the folding made the Sang Mountain range on the west of the Study Area as a antisyncline axis and inclined to the





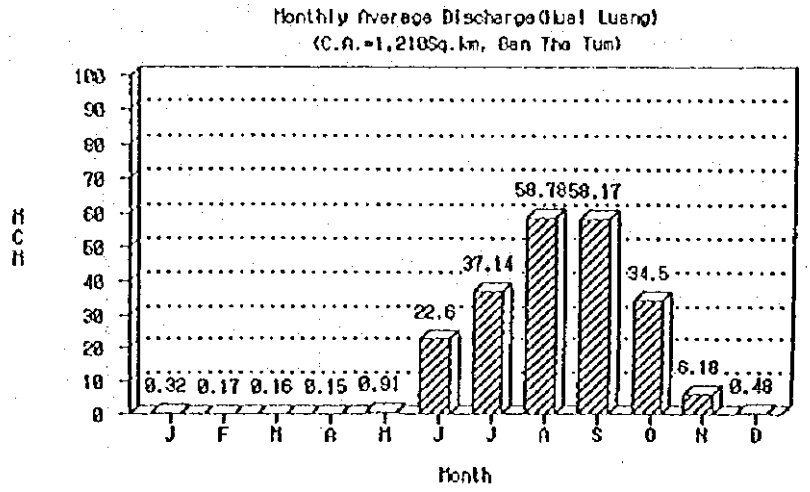


Figure 2.2-4 Monthly Average Discharge

east in the geological structure. Most of the Study Area lies in the concave of this gentle fold. The fault lies in the downstream area of the Nam Suai basin in Nong Khai province. The geology in the Study Area is classified into the Korat group formed between the Triassic of the Palaeozoic era and the Tertiary of the Cenozoic era and extended over most of the Study Area, and the quarternary sediments in the low land, and the Paleozonic rocks in the mountain side.

The Korat group is composed of Maha Sarakham, Khok Kruat, Phu Phan, Sao Khua, Phra Wihan, Phu Kradung and Nam Phong formations in order of formation age. Among them, the Maha Sarakham formation in the Cretaceous of the Palaeozic era through the Tertiary of Cenozoic era, consisting of the mudstone, siltstone, and fine-grained sandstone with salt rock at the lower part, accounts for over 60 % of the Study Area. The Sao Khua and Phu Kradung formations with some lime-noduled conglomerate inserted the Phra Wihan formation, composed of shale in the middle to lower Jurassic in between lies along the Phuphanham mountain range in strip.

In the upstream reach of Huai Mong to the west of this mountain range, the geology comprises the late Mesozoic to palaeozonic rocks. Among others, limestone and shale layer, are distributed in the middle and east part of Suwan Khuha ,Suwanakhuha district, Nong Bua Lamphu Province. In the surface exploration during the survey period, the limestones were not found in the proposed dam sites but are required to survey further before the implementation of the projects. In the mountainous area on the west of the Huai Mong basin, tuft, andesite site and rhyorite outcrop.

The alluvial deposit, consisting of gravels, sand, silt and clay, are spread along the Huai Mong in the downstream area. The land along the Mekong river in Nong Khai is comprised terrace deposits.

2.3 Water Resources

2.3.1 Surface Water

In order to understand the water resources potential in the Study Area, the three basins have been divided into sub-basins on the basis of their topographic conditions, following a map of 1:50,000. For example, the Huai

Mong has been divided into four, the Nam Suai into two, and the Huai Luang into four. Few areas that discharge directly to the Mekong have also been identified. The sub-basins are shown in Figure 2.2-2.

The runoff analysis for each sub-basin has been performed using a Tank Model which was calibrated by trial calculations. As it is mentioned earlier that discharge records are very scarce, therefore, calibration was done for KH-18, a discharge measurement station in the upstream of the Huai Mong river with a catchment area of 1,307 sq.km. The calculated runoff in each sub-basin is presented in Table 2.3-1 (referring to the Table-C-2 of Appendix C). Basin-wise graphical presentation of water resources potential is presented in Figure 2.3-1. Tank coefficients and best suited calibrated graph (1976) is presented in the Appendix-C.

For river water quality, RID officials have reported that in general, quality is good for irrigation and any other uses.

2.3.2 Groundwater

The Study Area consists of Metasediment aquifer, Lower Korat aquifer, Middle Korat aquifer, Upper Korat aquifer, and alluvial aquifer in Hydrogeology.

Metasediment aquifer, distributed in the Huai Mong upper reach, consists of conglomerate, shale, sandstone, limestone, phyllite, quartzite and schism in the Devonian to Permian. The groundwater is mainly in joints and fractures. The yields of wells are generally less than 5 cu.m/hr, with good quality.

The upper Korat aquifer, lies along the Phuphankham mountain range in the Huai Mong upper reach, consists of shale, siltstone and sandstone of Khok Kruat formation. The groundwater of good quality can be generally obtained from the depth of 30 m to 60 m at the pumping rate of 5 to 25 cu.m/hr. The water yield is very poor at deeper zones. The middle Korat aquifer, extends to the eastern side area along the Phuphankham mountain range. The yield of well is generally 3 to 5 cu.m/hr.

Table 2.3-1 Water Resources Potential

Basin Name	Sub Basin	Area (sq. km)	Season	Average Rainfall (mm)	Runoff (MCM) Average Year (1989)	Runoff (MCM) 1/5 Year Probability (1976)
			D	131.7	27.74	9.17
			W	1200.9	118.66	102.61
	M1	522	T	1333	146.39	111.78
Huai Mong			D	128.1	39.78	12.74
			W	1203.6	166.45	158.68
	M2	785	T	1332	206.23	171.42
			D	122.5	37.18	14.43
			W	1194.7	162.78	129.85
	M3	747	T	1317	199.96	144.28
			D	113.6	32.35	14.71
			W	1208.1	138.97	101.99
	M4	657	T	1322	171.32	116.70
	Total	2711			723.90	544.18
			D	134.9	23.85	8.54
			W	1216.5	101.64	76.35
	S1	403	T	1351	125.49	84.89
Nam Suai			D	139.9	65.85	18.94
			W	1322.4	259.69	199.48
	S2	911	T	1462	325.54	218.42
	Total	1314			451.03	303.31
			D	134.2	86.62	36.82
			W	1163.0	339.29	373.84
	L1	1730	T	1297	425.91	410.66
			D	145.3	28.66	11.47
			W	1191.8	172.96	116.87
Huai Luang	L2	541	T	1337	201.62	128.34
			D	145.3	43.35	17.27
			W	1191.8	260.25	175.84
	L3	814	T	1337	303.60	193.11
			D	139.9	73.36	21.10
			W	1322.4	289.34	222.25
	L4	1015	T	1462	362.70	243.35
	Total	4100			1293.83	975.47
			D	123.6	23.92	8.07
			W	1267.0	89.56	63.78
Others	NK	384	T	1391	113.48	71.85
			D	123.9	6.13	2.05
			W	1268.6	22.93	16.37
	OT	98	T	1393	29.06	18.42
	Total	482			142.54	90.27
G. Total		8607			2611.30	1913.23

Note: D= Dry Season
W= Wet Season
T= Total

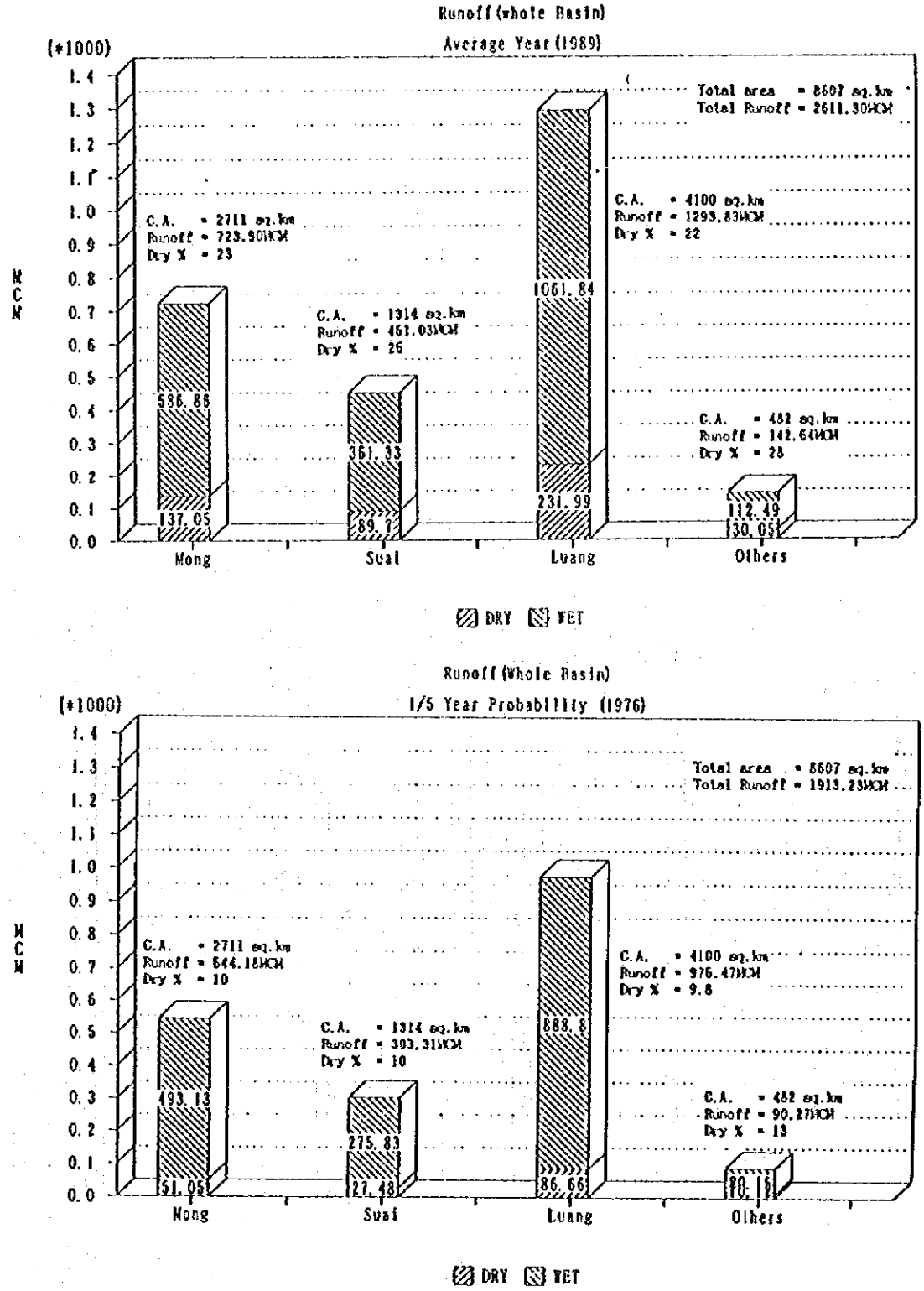


Figure 2.3-1 Graphical Presentation of Water Resources Potential

The lower Korat aquifer, distributed in most of the Study Area, consists of shale, mudstone, siltstone sandstone of the Maha Sarakham and Khok Kruat formations. The salt rock is interbedded at the depth of 60 m to more than 290 m. The groundwater of this aquifer varies both in quality and quantity all over the place. A yield of well is from 3 to 10 cu.m/hr. Many wells produces brackish water.

The alluvial aquifer, is lying along the Huai Mong up to the middle reach as a narrow strip, consists of alluvial gravel, sand, silt and clay. A yield of well give 10 to 30 cu.m/hr in the unconsolidated layer.

A great number of deep wells with 30m to 100m in depth are constructed within the Study Area and used for only domestic use, while the drinking water are taken through the mineral water on the market and/or rain water. The ground water utilized for agricultural water are taken by a portable pump in the area along the Mekong river but very small in its number of well. In the deep well the ground water tables are varied from 5m to 10m and depth of aquifer are 20m to 40m on an average. The shallow wells are available in the area along the antisyncline axis lying parallel to the highways, route No.2 and 21, and used for domestic water but mostly dry up in the dry season.

The groundwater potential in the Huai Mong river basin is less from the Metasediment aquifer and expected from the lower Korat aquifer with a yield of 3-10 cu.m/hr in the upper reaches but reported that the groundwater table came down in the dry season, and low in the middle reach. In the lower reach of Huai Mong as well as the Nam Suai, Huai Luang and other river basins, the groundwater are available from the upper Korat aquifer with a yield of well 3-20 cu.m/hr. The groundwater potential is high only in the area along the Mekong river.

The groundwater development, however, faces the problem of water quality. The water is generally brackish and high in the chloride ion content. The salt rock interbedded in the lower Korat aquifer dissolves and makes the water salty. The depth of salt rock is about 80 m below the ground in Amphoe Muang, Udon Thani province and Amphoe Si Chiang Mai, Nong Khai province, according to the groundwater map published by the Department of Mineral Resources. Groundwater with a chloride content of over 1,000 ppm widely

spread over the vicinity of this area. The overuse of groundwater may result in the spread of salt water throughout the area.

From the above viewpoints, the variety of crops to be irrigated by the groundwater will be selected due to salt contents. Since the a volume of water are required for irrigation, it is concerned that the groundwater table will be badly drawn down and affected to the wells for domestic use, and the groundwater table with high salt contents may be come up. The use of groundwater, therefore, is available for domestic water but remain problems for irrigation water.

2.4 Socio-Economic Conditions

2.4.1 Administrative Division

At the central government level, there are ministries, each of which is divided into departments. Each ministry is headed by a minister and the permanent secretary is the top civil servant in each ministry, whereas each department is headed by director a general.

Local administration is directly under the control of the Ministry of Interior. The administration of each province is divided into district (Amphoe) and further subdivided into subdistrict (Tambon) and Village (Mu ban). Each province has a Governor, one or two Deputy Governors and each Amphoe has Nai Amphoe and one or two assistants (Paled Amphoe). Subdistricts are headed by a Kamnan and every village by a Phuyaiban.

The Study Area is administratively composed of 22 Amphoes in 3 provinces as shown below (refer to Table D. 1-1 of Appendix D):

Administrative Division of Study Area

Province	Amphoe	Tambon	Village	Municipalities	Sanitary Dis.
	(No.)	(No.)	(No.)	(No.)	(No.)
Udon Thani	12	118	1,298	1	25
Nong Khai	6	58	564	1	6
Nong Bua Lamphu	4	31	334	-	7
Total	22	207	2,196	2	38

2.4.2 Population

The majority of people in the Northeastern Region of Thailand have been working in agricultural sector since ancient times. Over the last decade, the population in the Northeastern Region increased from 16 million to about 20 million or about one-third of the total population of the country.

In 1993, the population and the average family size per household in the province related to the Study Area can be summarized as follows:

Province	Population (Persons)	Average Family Size (Persons/household)	Rural Population (% of total population)
Udon Thani	766,000	4.97	70
Nong Khai	313,000	5.00	86*
Nong Bua Lam Phu	103,000	5.12	78
Total	1,182,000		

Note * information from the year 1990

At te present, the agricultural area occupies more than 50 % of the Study Area and more than 55% of the total employed population are engaged in agriculture. From this fact, it can be said that the agricultural occupation is still important for the social and economic development in the Study Area. The farming activities in Northeastern Region predominantly take place in rainy season. During the dry season, some people especially young ones migrate to towns for temporary job, but they return home for rainy season farming.

The average growth rate of population in Udon Thani and Nong Khai province are estimated at about 1.5% per annum and 1.3% per annum respectively.

2.5 Existing and On-going Water Resources Development Projects

2.5.1 RID Projects

1) General Description

The Royal Irrigation Department (RID) has dealt with planning, construction and management of the water resources development projects

regarding to the irrigation and its related works including domestic water supply, dredging, flood mitigation etc. For the implementation of those project, the RID defines the large, medium and small scale projects, depending on the construction costs, storage volume, irrigation area and construction period.

The RID is responsible for the development, construction and management of the large and medium scale irrigation projects in coordination with the EGAT and other agencies concerned on the water allocation. The construction of the large and medium scale projects are implemented under the supervision of the central office in Bangkok and regional office, respectively. While, the operation and maintenance of the completed project are undertaken under the regional office for the large scale projects and provincial irrigation office for the medium scale projects.

The small scale projects (SSIP) are initiated by the request of the beneficiaries and approved by the central government through endorsement of the Water Resources Development Council in the province. The project budget provides for the water storage/diversion facilities but principally not for water distribution works and land compensation. The SSIP implemented by the RID includes construction of earth dams, concrete weirs, and tank rehabilitation for the purposes of irrigation and domestic water supply. The RID also implement the pump irrigation projects, providing supplementary and compensation water supplies with the diesel driven pump.

2) Large Scale Project

Huai Luang project, which is only one large scale project within the Study Area, has initially constructed Huai Luang diversion dam (old dam) with about 28.5 km of irrigation canals to serve a land area of some 3,200 ha and the domestic water for Udon Thani urban area. The reservoir project started in 1970 to expand the irrigation service area and completed in 1984, which is located about 25 km on road to the west of the town of Udon Thani. The project is equipped with the reservoir, diversion dam and irrigation canal and its structures, and has served to a land area of some 13,600 ha for the rainy season crops and about 2,100 ha for the dry season crops in the average of the latest 5 years. Major elements of the project facilities as follows:

Reservoir	Type;	Earthfill dam
	Catchment Area;	666.4 sq.km
	Water Surface Area;	31.1 sq.km
	Total Storage Capacity;	118.5 MCM
	Effective Storage Capacity;	113.3 MCM
Diversion Dam	Type;	Barrage
	Width;	2.0 m×2
Irrigation Canal	Main Canals;	81.1 km
	Secondary and Lateral Canals;	131.85km

The reservoir water have been allocated to irrigation water, domestic water and industrial water, giving first priority to the domestic water. Thereby, the irrigation water was supplied by about 30 % of planned quantity in 1993, though the domestic water was given up to nearly 100 % of planned ones.The reservoir water level are recovered in September through October every year by collecting runoff water in the rainy season, except 1993, according to the operation records of the reservoir. The water surface level, however, have not been reached to the design water level every year, because of advanced discharge to the expected flood. In addition, the pumping station with a capacity of about 1.2 MCM per month for the domestic water supply to Udon Thani urban area was constructed in 1995, starting the operation in 1996. Under such situation, the reservoir operation plan may be urgently required to be reviewed in coordination with the agencies concerned.

The major facilities have been operated and maintained vitally by the Huai Luang O&M office. However, the diversion dam seems to be timeworn, which was constructed in 1952 and has a volume of leakage water through the gates and structure. The intake gates is deteriorated. The right main canal has a considerable seepage losses due to unlined canal bottom. In addition, on-farm ditches are irregular shape and have no check structures. The improvement of the canals and structures as well as the improvement and upgrading of on-farm facilities may be required.

The water control through the reservoir may be supply-oriented in cooperation with agricultural extension officers, reportedly. According to the reservoir operation records, the water is delivered from June to October for the rainy season crops and from December to April in the following year for the dry season crops. Nevertheless, the water management manual is seemed to be missing.

3) Medium Scale Project

Within the Study Area, thirteen (13) medium scale projects consisting of nine (9) existing irrigation reservoir projects, two (2) existing domestic water supply reservoir projects and two (2) on-going irrigation reservoir projects exist, of which number of the existing irrigation projects for each river basin are shown below:

Existing Medium Scale Irrigation Projects

Name of River Basin	Nos.	Storage (MCM)	Irrigated Area (ha) Wet S.	Dry S.
Nam Suai River Basin	1	0.19	70	-
Huai Luang River Basin	6	12.50	1,640	246
Nong Khai East Drainage Area	2	10.50	1,980	297
Total	9	23.19	3,690	543

Among nine (9) existing projects, Kut Ling Ngo reservoir in the Huai Luang river basin and Bang Phuan reservoir in Nong Khai east drainage area, are operated comparatively well, which are supplied the water to the land area of some 2,570 ha for the rainy season crops and 530 ha for the dry season crops or about 88 % of the service area, while the remaining seven (7) reservoirs are irrigated to be some 120 ha and 20 ha for the rainy and dry season crops or about 30 % of service area in the rainy season.

In fact, the distribution canals are improperly maintained. No check structures are provided. The on-farm ditches network are absent. Such inadequate infrastructures may result in the ineffective water delivery. Some projects are not operated due to social constraint, such as land ownership and right-of-way problems. In order to increase the irrigation rate, the upgrading of distribution canals and structures as well as on-form facilities will be required.

4) Small Scale Irrigation Projects (SSIP)

Within the Study Area, 147 small scale projects were constructed so far, of which 125 projects or about 80 % of SSIP, consisting of 85 projects for the reservoir construction and 40 projects for the weir construction, were constructed for irrigation purpose. The remains were 17 domestic water projects, 3 water tank projects and 2 drainage improvement projects.

As the SSIP are provided to serve the basic needs of rural people, the water are allocated to the various fields, such as domestic water, irrigation, livestock and fisheries. According to the post-evaluation report for the SSIP with the financial assistance of OECF, about 73 % of the reservoir are used for domestic water, more than 90 % of the project facilities are used for livestock during the dry season, and about 95 % of the facilities are used for fisheries. While, it is reported that about 40 % and 20 % of the project area are irrigated in the rainy and dry season, respectively. In fact, the water in the reservoirs and impounded by the weirs constructed close to the villages are used in many case for the domestic water and livestock water. The reservoirs without storage water and structures deteriorated are remained but enable to remedy and improve.

Existing Small Scale Irrigation Projects

Name of River Basin	Reservoir	Weir	Others	Total	Service A.(ha)	Storage V.(MCM)
Huai Mong River Basin	24	13	4	41	2,813	9.91
Nam Suai River Basin	15	10	3	28	2,565	10.50
Huai Luang River basin	42	14	12	68	4,237	24.45
Nong Khai Drainage Area	4	3	3	10	544	4.08
Total	85	40	22	147	10,159	48.94

The small scale projects proposed for the future are hardly specified, since the projects are identified based on the request of beneficiaries and implemented for the construction period within one year.

2.5.2 DEDP Projects

1) Pump Irrigation Projects

The objective of the pump irrigation project is to supply irrigation and domestic water to local people. 545 pump irrigation projects corresponding to about 48 percent of the whole pump irrigation projects are implemented in the Northeastern Region by DEDP as of 1988. In the Study Area, 32 pumping stations have been constructed since 1973, and 7 pump stations are currently under construction or proposed for future construction. Water resources in the pumping stations in the Study Area are the Mekong river, its tributaries and swamps. Most of the pumping stations of the floating type are constructed along the Mekong river. The pump station is normally equipped with one pump which

is driven by an electric motor. A canal system consisting of main and lateral canals with concrete lining are also provided. Water users' cooperatives are established, and farmers pay about 50 percent of the running cost (80 Bahts/rai/crop season). The numbers of the pumping stations and respective irrigation areas are as shown below.

River Basin	Source	Nos.of P. Station	Project Area (ha)	Cropped Area (ha)	Canal L. (m)
Huai Mong	Huai Mong	5 (540kw)	2,750	1,130	20,250
	Mekong R.	9 (990kW)	4,380	2,820	54,260
Nam Suai	Nam Suai	1 (150kw)	800	700	12,060
	Mekong R.	9 (990kw)	4,640	2,640	67,730
Huai Luang	Huai Luang	7 (740kw)	2,510	1,560	29,040
	Mekong R.	1 (110kw)	480	300	34,260
	Total	32(3520kw)	15,560	9,250	217,600

2) Huai Mong Project

The Huai Mong project has been constructed in the area of Amphoe Sri Chiangmai and Tha Bo located at the lowest reach of the Huai Mong river. The project aims is to eliminate flood and drought damage and consists of regulators, dikes,irrigation and drainage pumps, a canal system, etc..

The feasibility study was conducted by DEDP in cooperation with the Mekong Secretariat. The main project facilities were constructed with financial assistance of EEC and the Belgium Government and completed in 1987. At present, the on-farm facilities such as tertiary canals are under construction by ALRO, and the construction is scheduled to be completed in 1997.

Major features of the project are as follows.

- Project Area 9 blocks 8,830 ha (55,000 Rai)
- Cropped Area 9 blocks 3,170 ha (19,800 Rai)
- Regulator with two sluice gates (opening 5.50 m×6.00 m) and four sets of two-way pumps (capacity : each 2.36 cu.m/s), which will be used to control the water level in the reservoir.
- Reservoir with storage capacity of 26 MCM
- Dikes 39 km long
- Irrigation and drainage pumps: 9 pumping stations for irrigation and one for drainage.
- Irrigation and drainage canals
  Concrete pipelines L=8.7 km

Concrete lined canals	L=163 km
Drainage canals (improved)	L=95 km

A water users' cooperative was organized and farmers pay about 50 percent of running costs (80 Baht/rai/season).

In August 1995, the water level in the reservoir rose to approximately EL. 170 m, which is the same as the dike crest elevation, due to large-scale river floods and the high water level of the Mekong river. As a result, the dikes failed and a greater part of the farmland was inundated.

Gates of the regulator began operating in June, and are normally opened completely in July. The gates are opened during the three months from August to October, and are closed in November. Lower elevations of farmland usually are in poor drainage conditions because of insufficient capacity of the drainage pumps.

3) Lower Huai Luang Project

Lower Huai Luang project has the same objectives as the Huai Mong project and being implemented on-going by DEDP. The regulator, which is one of the main project facilities is being constructed at Amphoe Phon Phisai in Nong Khai province.

Outline of the project is follows.

-	Project Area	11 Blocks 19,200 ha (120,000 Rai)
-	Construction Period	1995 to 2000
-	Regulator	14.0 m×11.0 m×3
-	Reservoir capacity	155 MCM
-	Retention Water Level	160 m MSL
-	Dike	L=24 km (W=4.0 m)

4) Nam Suai Basin Project

As for Nam Suai river basin, a feasibility study has been conducted by the Mekong Secretariat in 1981. The major features of the project shown in the feasibility report are as follows.

- Project Area — Stage 1: 12,550 ha (78,440 rai); Stage 2: 5,200 ha (32,500 rai); Total: 17,750 ha (110,940 rai)
- Average rainfall: 1384 mm
- Regulator with five sluice gates (opening 20 sq.m)and four two-way pumps (Capacity : each 3.40 cu.m/s).
- Reservoir with 215 MCM storage capacity.
- Irrigation and drainage Pumps: 43 pump stations (pumps of 76 sets in total) for irrigation and no drainage pump.
- Irrigation and drainage canals
  - Delivery pipes: L=8.7 km
  - Irrigation canals: L=163 km
  - Drainage canals: Improvement of natural drains
- Dike/Service road: L=2 km

2.5.3 Other Agencies' Projects

Many government and local agencies other than the RID and DEDP takes part in the water resources development and implements mainly construction of farms pond and wells for purpose of domestic water supply. Among others, the construction of wells are great numbers in the project implementation and undertaken by 8 agencies included the Office of Accelerated Rural Development, the Department of Mineral Resources, the Department of Health, the Department of Public Works etc. The farm pond for the purpose of domestic water supply are implemented by the ARD and provincial government but small in the scale and not so much in the number of construction. On the other hand, the irrigation purpose projects undertaken by the agencies other than the RID and DEDP are negligible.

2.5.4 Operation and Maintenance of RID's Irrigation Facilities

Generally, irrigation facilities are operated and maintained by the provincial main office of RID by its O/M department. In the case of large scale projects, a separate O/M department is created. O/M department may also have other sections such as administrative, repair/improvement and operation etc.

In each province there is an O/M department in the main office. The Amphoes of each province are brought under O/M sections. Each section takes care of the irrigation facilities of the Amphoe designated to that section. Usually medium and small scale projects are maintained by these sections. These

sections also coordinate with other governmental agencies, and also develop small scale projects.

In the case of Huai Luang project there is a central O/M department with two O/M sections under it. One takes care of the right main canal system and the other left main canal system. The command area of each main canal is divided into four zones, which means that each section covers four zones for O/M.

For better management, Nong Bua Lamphu has put all its Amphoes into three O/M sections, in the same way Udon Thani has four O/M sections and Nong Khai has three. A typical schematic diagram of functions performed by a provincial O/M office is presented below. Organization chart of RID O/M division is presented in the Figure I-1 of Appendix I.

2.6 Soil and Land Use

2.6.1 Soil Characteristics

Distribution of soil in the Study Area is shown in Figure 2.6-1 in Appendix E. In the figure, the soil is classified by the USDA's standard.

The main soils of agricultural land in the Study Area are Clayey Tropaquepts (No. 16 in Figure, mostly acid brown-colored gray soil), Loamy Paleaquults (No. 43 in Figure, low humic gray soil, mostly paddy soil), Skeletal Plinthustults (No. 53 in Figure, mostly red-yellow podzolic soil), Loamy Paleustults (No. 54 in Figure, gray podzolic soil, mostly upland soil).

In mountainous area, Skeletal Paleustults (No. 56 in Figure) and Slope Complex (No. 89) are distributing. In Mekong river basin, Loamy Ustifluvents (No. 8 in Figure, mostly low land soil) is distributing and is using for the production of garden crops.

Main soil characteristics are shown in Appendix E, Table 2.6-1, with the area of main soil series in Udon Thani and Nong Khai provinces.

The most of soil in the two provinces is gray or red-yellow podzolic soil with loam or sandy loam in texture. Soil organic matter is generally insufficient, available phosphate and potassium also low or moderately low, surface CEC are low to moderately low and soil pH ranges from 5 to 6. These are showing the characteristics of the low fertility, and it is main cause of low productivity of crops in the Area.

In addition to the low fertility of soil, there is a problem of saline soils in the Area. Distribution of salt-affected soil in the Study Area is shown in Appendix E, Figure 2.6-2, dividing seven degrees of affection by DLD.

The very severely and mildly severely salt affected soil (degree-1 and 2) are appeared in some areas of Muang Udon Thani, and Ban Khak Chung in Muang Nong Khai. However, these areas are very small and limited, the moderately salt affected soil (degree-3) is also distributed in small area. Most of soil of agricultural land in the Study Area is slightly salt affected soil (degree-4) or non-salt affected soil.

However, with the progress of crop diversification and integrated agriculture, many kinds of crops will be introduced in the Study Area in the near future. Some of these crops may be affected even in slight degree of soil saline. Therefore, it is required to study more carefully for countermeasures against saline soils when new crops are introduced in the Area.

2. 6. 2 Land Classification

1) Land classification by soil suitability for paddy (wetland) rice.

DLD has classified the whole provincial land into 5 groups by the soil suitability for paddy (wetland) rice. The classification was made by considering the water availability from rainfall, present land use and soil survey reports etc..

The area of each group in Nong Khai and Udon Thani (including Nong Bua Lamphu) are shown in Table 2.6-1 with the classification of each area.

Table 2.6-1 Area of Soil Suitability Group for Paddy Rice (Unit : ha)

Groups		Nong Khai		Udon Thani	
		area (ha)	ratio(%)	area (ha)	ratio(%)
P-1	Very well suited for paddy land	0	0	0	0
P-2	Well suited for paddy land	15,060	2.1	39,872	2.6
P-3	Moderately suited for paddy	87,910	12.2	287,514	18.7
P-4	Poorly suited for paddy land	29,332	4.1	23,301	1.5
P-5	Generally not suited for paddy	584,408	81.0	1,165,516	75.9
	Swamp etc.	4,796	0.7	20,393	1.3
	Total	721,506	100.0	1,536,595	100.0

Source : Land capability for upland crops and soil suitability for paddy rice by DLD.

P-1 is the area which has no significant limitation for rice production, and has sufficient water availability from rainfall or irrigation and high yields in most of year.

This type of land does not exist in both provinces, and P-2 and P-3 which are well and moderately suited for paddy land are 14.3 % in Nong Khai and 21.3 % in Udon Thani.

It may be said that most of the Area is a moderately suited area for paddy cultivation.

2) Land classification by land capability for upland crops

As well as grouping the land by soil suitability for paddy field, the DLD classified the whole area in the provinces into 8 classes by land capability for upland crops. The classification was done according to soil conditions and the degrees of limitation for crop production.

The land class, area of each class and ratio of area in Nong Khai and Udon Thani (including Nong Bua Lamphu) are shown in Table 2.6-2.

Table 2.6-2 Land Classification by Land Capability for Upland Crops

(Unit : ha)

Classes		Nong Khai		Udon Thani	
		area(ha)	ratio(%)	area(ha)	ratio(%)
U-1	Very well suited for upland crops	0	0	0	0
U-2	Well suited for upland crops	15,893	2.2	43,839	2.9
U-3	Moderately suited for upland crops	135,557	18.8	754,531	49.1
U-4	Poorly suited for upland crops	20,384	16.7	85,335	5.5
U-5	Little or no erosion, having some limitation and unsuited for upland crops	53,126	7.4	32,518	2.1
U-6	Having severe limitation and unsuited for cultivation	448,546	48.3	423,238	27.5
U-7	Very severe limitation and unsuited for cultivation	21,602	3.0	176,741	11.5
U-8	Having limitation and restrict to use	21,602	3.0	0	0
	Swamp etc.	4,796	0.7	20,393	1.3
	Total	721,506	100.0	1,536,595	100.0

Source : Land capability for upland crops and soil suitability for paddy rice by DLD.

Land capability for upland crops is different among the two provinces. Udon Thani has a larger area for well suited and moderately suited land capability for upland crops than Nong Khai. In Nong Khai, the area having severe limitation and unsuited for cultivation for upland crops occupies almost one-half of the area. These facts mean that the Udon Thani is more suitable for the production of upland crops than Nong Khai.

3) Some constraints for suitable use of paddy and upland field

DLD has pointed out that there are some kinds of limitations, that either to apply to both the land capability classes and paddy suitability groups or to only classes or groups in upper tables (Table 2.6-1 and 2.6-2). They are as follows;

(1) Soil erosion, (2) Soil limitation in the root zone by shallowness, unfavorable texture and low fertility, (3) Lack of moisture for plant growth, (4) Unfavorable topography, (5) Flooding, (6) Impeded drainage, (7) Salinity or alkalinity, and (8) Soil acidity.

2.6.3 Land Use

Existing of agricultural land use in the Study Area is shown in Appendix E, Table 2.6-4 by area and Appendix E, Table 2.6-5 by percentage, and

the area of each Amphoe divided by river basin is shown in Appendix E, Table 2.6-6.

As shown in the tables, agricultural land occupies about 50 % of whole Study Area, and paddy field occupies 72.8 % of all agricultural land, upland field occupies 21.3 %, fruit and perennial crop areas occupy 3.5 % and vegetable area occupies only 1.2 %.

However, ratio of agricultural land varies by Amphoe. In Muang Nong Khai, Sra Khrai, Phen, Phibul Rak and Na Klang, the area of over 90 % is paddy field. On the contrary, the paddy field in Si Chiang Mai and Sang Khom are under 20 %. Amphoe in the Study Area will be classified some groups according to the characteristics of land use as shown in Table 2.6-3.

Table 2.6-3 Characters of Amphoes by Land Use

A.	Ratio of cultivable area in whole land area	
	a-1 Over 60 % is cultivable	Muang Nong Khai, Tha Bo, Phon Phisai, Kumphawapi, Sang Khom (UT), Nong Han, Muang Nong Bua Lamphu Na Klang
	a-2 Under 40 % is cultivable	Sang Khom (NK), Nong Wua So,
B.	Ratio of main crops in cultivable area	
	b-1 Over 80 % is paddy field	Muang Nong Khai, Tha Bo, Sra Khrai, Thung Fon, Phen, Sang Khom (UT), Nong Han, Phibul Rak, Na Klang,
	b-2 Over 50 % is upland field	Si Chiang Mai, Sang Khom (NK), Nong Wua So, Na Wang
	b-3 Over 5 % is fruits and perennial crop field ...	Si Chiang Mai, Muang Udon Thani, Ban Phu,
	b-4 Over 2 % is vegetable field	Tha Bo, Si Chiang Mai, Muang Udon Thani

Table 2.6-6 of Appendix E shows the area of Amphoe by river basin, and it is found that some characteristics on agricultural land use are different by river basin. Agricultural land in Nam Suai basin and Huai Luang river basin are almost paddy field, and in the Huai Mong basin, there are comparatively large areas of upland crops.

2.7 Agricultural Conditions

2.7.1 Land Ownership

The type of farm holding land in Nong Khai and Udon Thani provinces in 1991 is shown in Table-2.7-1.

Table 2.7-1 The Type of Farm Holding Land in Nong Khai and Udon Thani in 1991

(Unit:ha)

Province	Total Farm Holding Land	OWNER			OTHERS			
		Owner	Mortgaged out	Total	Rented	Mortgage in	Free of Charge	Total
Nong Khai	394,820	334,309	10,429	344,736	23,656	345	26,083	50,084
Ratio (%)	100.0			87.3				12.7
Udon thani	844,325	715,806	61,101	776,907	36,611	3,216	27,591	67,418
Ratio (%)	100.0			92.0				8.0

Source: Agricultural Statistics of Thailand,

The statistical data on the type of farm holding land in the Study Area has not been obtained. However, the above data which shows the farm holding land in all provinces explains that about 87 % of total farm holding land in Nong Khai and about 92 % of farm holding land in Udon Thani are owned by farmers in 1991, and 96.5 % (Nong Khai) and 92.1 % (Udon Thani) of the owned farm land are utilized by holding farmer themselves. Only 3.0 % in Nong Khai and 7.9 % in Udon Thani of owned land are mortgaged out to tenant farmers, and most of their land are not specified for any period.

These facts prove that over 90 % of farm land is owned by the farmers and utilized by themselves both in Nong Khai and Udon Thani. The data on the type of farm holding land has not been obtained for Nong Bua Lamphu. However, in the province, it is said that some farmers reclaimed their farm land from the forests, and the registration as a landowner are inadequate. So the ratio of farmland which is owned by farmers is slightly lower than in the other two provinces.