THE STUDY
ON
THE REHABILITATION AND RECONSTRUCTION
OF AGRICULTURAL PRODUCTION SYSTEM
IN
THE SLAKOU RIVER BASIN,
THE KINGDOM OF CAMBODIA

VOLUME-I

MAIN REPORT

PART I GENERAL INFORMATION AND BACKGROUND

CHAPTER I-1 INTRODUCTION

I-1.1 Authority

This Final Report was prepared by the JICA Study Team in accordance with the Scope of Work (S/W) for the Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin, the Kingdom of Cambodia agreed upon between the Ministry of Water Resources and Meteorology (MOWRAM), the Royal Government of Cambodia (RGC), and the Japan International Cooperation Agency (JICA) on October 09, 2000. The S/W for the Study and the Minutes of Meeting on S/W for the Study are shown in Attachments-1 and 2, respectively.

The Report presents all the results of Master Plan Study for the Study Area and Feasibility Study on the Priority Projects selected through the Master Plan Study, which were conducted from January 2001 to March 2002.

The Report consists of the following three separate volumes:

Volume-I : Main Report

Volume-II: Appendices

Volume-III: Drawings

In addition to the above volumes, the Study Team submitted to MOWRAM "Planning Guideline for Rehabilitation and Reconstruction of Irrigation Systems"

under separate cover in accordance with the S/W.

The Main Report consists of the following four parts:

Part I : General Information and Background

Part II : Master Plan Study for the Study Area

Part III: Alternative Study on the Irrigation Area of Upper Slakou River Irrigation Reconstruction Plan (USP)

Part IV: Feasibility Study on the Priority Projects

I-1.2 Study Area

The Study Area of about 650 km^2 is shown in the Location Map. (See the opening page of this report). The Study area is located at about 70 km southwest from Phnom Penh and extends mainly on the right bank of the Slakou River originating from Kampong Spueu Province and Kampot Province. Administratively it is mostly in Takeo Province and partly in Kampong Spueu Province, bordering on the Slakou River in the north, Kampot Province in the south and the west, and on the national road No.2 and the railway in the east.

The priority projects for irrigation development selected through the master plan, on which the feasibility study were conducted, are the following three, and their locations are shown in the Location Map:

(1) Upper Slakou River Irrigation Reconstruction Plan (USP)
(2) Small Reservoir Rehabilitation Plan (SRP) consisting of Ang 160 area and Kim Sei area
(3) Small Pond Development Plan (PDP) at Trapeang Snao village in Nhaeng Nhang commune

I-1.3 Objectives of the Study

The objectives of the Study are ;

(1) To prepare a master plan for agricultural reconstruction / development in the upper to middle basin of the Slakou river as a model for the reconstruction / development of shallow bunded reservoir irrigation systems in the Kingdom of Cambodia,
(2) To carry out a feasibility study on priority project(s), and
(3) To transfer technology to the counterpart personnel through on-the-job training in the course of the Study.

I-1.4 Scope of the Study

The overall scope of the Study is defined in Clause IV of the S/W as follows :

Phase-I : Master Plan Study

(1) Review of plans and projects relevant to the Study
(2) Collection and analysis of data and information through field survey
(3) Analysis of collected data and information, and identification of constraints and development potential
(4) Formulation of the master plan including selection of priority project(s)
(5) Evaluation of the master plan through 20 workshops to obtain opinions from the beneficiaries, local government offices and NGOs.

Phase-II : Feasibility Study

(1) Collection and analysis of supplementary data and information
(2) Formulation of feasibility study plans
(3) Estimate of cost and benefits
(4) Environmental impact assessment assistance, if necessary
(5) Preparation of the implementation schedule
(6) Evaluation of the feasibility study plan from technical, economical, financial and environmental viewpoints, in consideration of opinions obtained from the beneficiaries, local government offices and NGOs through 10 workshops.

I-1.5 Joint Coordinating Committee

In accordance with the S/W, MOWRAM, which is the coordinating body for the Study, has established a Joint Coordinating Committee (JCC) to discuss and set forth the study outcomes. Eight (8) meetings with the JCC were held during the whole Study period. The meeting with the JCC about the Inception Report, was held on February 9, 2001. The meeting about the Interim Report including the Master Plan (Draft), was held on August 13, 2001. The meeting about the Progress Report (3) including the Feasibility Study Plan (Draft), was held on December 20, 2001. The meeting about the Draft Final Report was held on February 6, 2002. The minutes of these meetings are shown in Attachments - 4, 5, 6 and 7, respectively. The related organizations of the committee are as follows :

- MOWRAM as coordinating body,
- Council for the Development of Cambodia (CDC),
- Ministry of Agriculture, Forestry and Fisheries (MAFF),
- Ministry of Rural Development (MRD),
- Ministry of Environment (MOE), and

- Cambodian National Mekong Committee (CNMC).

The meeting with MOWRAM about the Inception Report was held on February 05, 2001, prior to that with the JCC, and the minutes of meeting are shown in Attachment-3.

I-1.6 Progress of the Study

The Study was smoothly conducted as scheduled in accordance with the S/W and the overall time schedule. The major Study items were as follows:

(1) Preparatory Work in Japan: preparation of the Inception Report.

(2) Phase I First Field Work: i) review of plans and projects relevant to the Study, ii) data and information collection, and iii) preparation of the Progress Report (1).

(3) Phase I Second Field Work: i) analysis of collected data and information, ii) identification of constraints and development potential, iii) formulation of the master plan including selection of priority project(s), iv) evaluation of the master plan involving the results of workshops, and vi) preparation of the Progress Report (2).

(4) Phase I First Home Work: preparation of the Interim Report

(5) Phase II Third Field Work: i) collection and analysis of supplementary data and information, ii) formulation of optimum plans for priority areas, iii) estimate of cost and benefits, iv) evaluation from technical, economical, financial and environmental viewpoints, v) preparation of the implementation schedule, vi) preparation of the Progress Report (3), and Planning Guideline for Rehabilitation and Reconstruction of Irrigation Systems in the Kingdom of Cambodia (draft).

(6) Phase II Second Home Work: preparation of the Draft Final Report

(7) Phase II Fourth Field Work: explanation of the Draft Final Report

(8) Phase II Third Home Work: preparation of the Final Report

In order to smoothly carry out the Study, the following survey works were conducted by local contractors on a sub-contract basis under the technical supervision of the Study Team :

<u>For Phase I First Field Work</u>:

1) Laboratory Analysis of Soil,
2) Water Quality Analysis (Dry Season),
3) Installation of Water Level Gauges and Staff Gauges,

4) Water Level Observation and Discharge Measurement (Dry Season),
5) Inventory Survey of Dikes/Roads, Canals, etc.,
6) Profile and Cross Section Survey in Reservoir Areas, and
7) Social Environmental Baseline Survey.

For Phase I Second Field Work:

1) Supplementary Topographic Survey , and
2) Participatory Rural Appraisal Workshops on the Master Plan (Draft).

For Phase II Third Field Work:

1) Water Quality Analysis (Rainy Season),
2) Water Level Observation and Discharge Measurement (Rainy Season),
3) Soil Mechanical Investigation,
4) Geotechnical Boring,
5) Supplementary Topographic Survey, and
6) Participatory Rural Appraisal Workshops

I-1.7 Technology Transfer

The Study Team always worked in collaboration with the Working Group (counterpart personnel) in Phnom Penh and Takeo throughout the Study period. The members of the Study Team and the Working Group are shown in Table I-1.1. An office for the Study Team was opened at DWRAM, Takeo. For mutual understanding of the Study and technology transfer, a biweekly meeting with the Working Group was held at Takeo. Sixteen biweekly meetings were held. At the end of all the meetings, the Study Team gave a lecture on technical subjects as technology transfer in accordance with the Plan of Technology Transfer submitted to the MOWRAM on February 19, 2001.

I-1.8 Acknowledgement

During the Field Works in Cambodia, the Study Team received a lot of kind assistance and cooperation from MOWRAM, MAFF, MRD, MOE, CDC, CNMC, Takeo Provincial Government, Tram Kak District Office, many commune and village offices, and all the counterpart personnel. Without such assistance and cooperation, the Study could not have been smoothly and successfully completed. The Study Team would like to express sincere thanks to all the organizations and personnel concerned.

CHAPTER I-2 BACKGROUND

I-2.1 Natural and Socio-Economic Condition

Cambodia borders on Thailand in the northwest and the west, Laos in the northeast, Vietnam in the southeast and the east, and the Gulf of Thailand in the southwest. Its total area is 181,035 km^2, of which about 20 % is used for agriculture. Geographically, the country is divided into four regions, i.e. the plain region, the Tonle Sap lake region, the plateau and mountain region, and the coastal region. Administratively, the country is divided into 24 provinces; and further into 183 districts, 1,603 communes and 13,364 villages.

The climate in Cambodia is divided into rainy and dry seasons under the influence of monsoon. It is hot and wet in the rainy season from May to November, while in the dry season, it is relatively cool during period from December to January, becomes hotter from February and hottest in April. The annual rainfall is 1,200 mm to 1,400 mm in the flood plain along the Mekong river and the Tonle Sap lake, and 90 % of the rain concentrates in the rainy season.

Population of Cambodia is 11,437,656 (1998), out of which 52 % is female. The average population density of Cambodia is 64 persons per km^2 and the highest density is 3,448 persons per km^2 of Phnom Penh. The average family size is 5.2 persons per household. About 90 % of the population is Khmer and most of them are Buddhist. The average life expectancy is low and 54.5 years. A large part of the population concentrates in the Mekong River basin and the Tonle Sap lake basin including their tributaries.

GDP per capita of Cambodia is very low, US$ 265 in 1999 which ranks as the least among less developed countries. The poverty issue always lies at the base of the social and economical matters in Cambodia. One of the causes of this poverty status has been Cambodian's unfortunate history including a large decrease of the number of educated people (public servants, engineers, doctors, teachers, etc.) and the destruction of social infrastructures. Though the growth rate of GDP was only 1 % in 1997 and 1998 due to the Asian currency crisis, it attained about 4 % in 1999.

Agriculture is the mainstay of Cambodia's economy, covering about 43 % of GDP and about 80 % of the labor force. Services (37 %) and industry (20 %) follow after agriculture. The Cambodian's staple food is rice which is the principal crop of agriculture. Rice production reached a peak of about 3,800,000 tons in 1969 and the surplus was exported. However, the production decreased drastically and came to less than the demand during the unhappy period from the middle of 1970s to the

beginning of 1980s. After that, the paddy production started to recover from the latter half of the1980s and it attained 4,047,900 tons in 1999/2000. Since 1995, Cambodia has attained self-sufficiency in paddy. The paddy field is about 2 million ha and the double cropping paddy field with irrigation is still limited. Though it is blessed with the abundant natural resources, the average yield of paddy is low, about 1.69 ton/ha. One of the causes is drought and flood. There is much room to be improved in development of irrigation facilities and farming manner/skill. Under such circumstances, 84 % of the population is living in the rural area, out of which 42 % of the rural people's financial status is below the poverty line. The socio-economic indicators are shown in Table I-2.1.

I-2.2 National Development Plan

Cambodia's Second Five-year Development Plan (2001 - 2005) is being formulated following its First Five-year Development Plan (1996 - 2000) as of February 2002. The major development targets in the First Five-year Development Plan are i) alleviation of poverty, ii) administrative and judicial reform, iii) reform and development of national economy, iv) substantial investment in the upgrading and development of physical infrastructures, particularly rural roads, v) human resources development, vi) extension of health, education and social services, vii) sustainable utilization of the natural resource base by strengthening the enforcement of environmental legislation. Out of those, the alleviation of poverty is the most important. In order to fulfil the targets, it is essential to improve rural people's income and living standard. For this, agriculture / irrigation, and rural developments have been highly expected.

I-2.3 Agriculture and Irrigation Development Strategy

A change of economic policy from a centrally controlled economy to a free market economy, has already been made, and all governmental organizations are making efforts to establish strategies / policies for the inclusion in the national development plan, and to reform their institutional structure and legal system to comply with the free market economy.

The Ministry of Water Resources and Meteorology (MOWRAM) is a new organization of RGC, which was created by Law on June 23, 1999 in recognition of the fundamental role that water resources play in the socio-economic development of the country. The MOWRAM set up a task force to prepare comprehensive strategy document and is now finalizing it. One of the MOWRAM's major targets is to

provide irrigation facilities to agricultural land in Cambodia as efficient utilization of water resources, in order to i) increase farm income, ii) improve living standards of farmers and iii) secure stable food supply system of the country based on the Five-Year Development Plan.

According to Action Program for Development of Agricultural Sector in Cambodia (2001-2010) prepared by the Ministry of Agriculture, Forestry and Fisheries (MAFF), the following basic goals are stressed :

1) Improve food security through expansion in the production of rice and other crops,
2) Contribute to economic growth and to foreign earning through export,
3) Improve opportunities income for farm households particularly those headed by women, by diversifying crop production, and
4) Add value to crop and livestock production by developing agro-processing industries.

The operational framework for long-term planning, 2000-2010 under the Action Program is as follows :

1) Increase rice cultivated areas to 2.5 million ha, equal to the areas before the civil war, and also increase the rice yield up to 2.45 ton/ha for food security of the whole population, poverty alleviation and job creation,
2) Improve yield and quality of all production through research, extension and application of advanced technology,
3) Provide livestock development opportunities to small holders through supporting services in animal husbandry, disease prevention, credit and marketing, and
4) Maintain per capita consumption of fish and increase incomes through greater value added activities.

The organization of the MAFF is shown in Fig. I-2.3.

I-2.4 Rural Development Strategy

In addition to the above agriculture and irrigation development strategy, rural development is one of the important national targets for improvement of living standard and alleviating the poverty of rural people. The Ministry of Rural Development (MRD) directs and administers rural development activities in the country. It has a mandate for the local potentialities and promoting participation of the population in the development of rural area, by setting up decentralized people's institutions. In order to create a very favorable climate for the emergence and strengthening of Village Development Committees (VDCs) and Commune Rural

Development Committees (CRDCs), the MRD issued a circular of guidance in January 1999 on the establishment of the Provincial Rural Development Committees (PRDCs). The organization of the MRD is shown in Fig. I-2.4.

I-2.5 MOWRAM

MOWRAM which is a coordinating body for the Study, is responsible for water resources management and development in irrigation, river and water supply in Cambodia, such as i) formulation of water resources management policies and strategies, ii) collection and analysis of data, iii) planning and regulating the use of water resources, and iv) activities to reduce the negative impacts on water and natural disasters, and v) construction of irrigation facilities. For this, MOWRAM has six (6) technical departments, namely i) water resources management, ii) hydrology and river works, iii) meteorology, iv) irrigation and drainage, v) water supply and sanitation, and vi) engineering. The organization of MOWRAM is shown in Fig.I-2.1. The MOWRAM has an office in the town of Takeo which was established in 1986 under MAFF. This office is now Department of Water Resources and Meteorology (DWRAM), Takeo, the organization of which is shown in Fig.I-2.2. DWRAM consists of five (5) sections, namely i) irrigation, ii) water supply, iii) hydrology and meteorology, iv) water resources management, and v) administration.

MOWRAM's annual budgets and the number of personnel are shown below :

Annual Budget and Number of Personnel of MOWRAM

Year	1995	1996	1997	1998	1999	2000
Annual Budget in 10^6 Riels	2,849	3,058	10,407	4,889	4,209	6,200
Number of Personnel	824	814	830	824	800	799

Annual Budget and Number of Personnel of DWRAM, Takeo

Year	2000
Annual Budget in 10^6 Riels	181
Number of Personnel	103

PART II MASTER PLAN STUDY FOR THE STUDY AREA

CHAPTER II-1 THE STUDY AREA

II-1.1 Location and Administration

(1) Location and Administration

Local administration and rural community in Cambodia are structured by Province (Khet), District (Srok), Commune (Khum), Village (Phum) and Group (Khrom). Commune is the lowest unit of public administration. Each unit of local government has an appointed chief of public administration.

The Study Area is located in Basedth district of Kampong Spueu Province and Doun Kaev, Samraong, Tram Kak and Treang districts of Takeo Province. There is a total of 276 villages in the Study Area, 23 in Kampong Spueu Province and 253 in Takeo Province. The whole Tram Kak district (consisting of 15 communes) and Phong commune of Basedth district are in the Study Area, and several villages in other communes are also partially included in the Study Area as shown in Fig. II-1.1.1.

(2) Demography

Total population and households in the Study Area are about 165,600 and 33,000, respectively, according to "population census in 1998". Sex ratio (% of male/ female) is 89.1 %. Average family size is 5.0 person/ household. As the Study Area is 650 km^2 in total, population density of the Study Area is 255 persons/ km^2.

As the fertility rate was seriously damaged under "Pol Pot Regime"(1975-79), 20-24 year-old generation is less than two thirds of the estimated natural growth rate during 1975-1979. The present 0-4 year-old generation has also been affected by, since these would mostly be children of the 20-24 year-old generation.

The population and households are summarized below:

Population and Households in the Study Area (Summary)

Province	District	Nos of Households	Population	Sex Ratio M/F (%)	Average Family Size
Kampong Spueu	Basedth	2,674	13,836	86.8	5.2
Takeo	Doun Kaev	83	399	90.9	4.8
	Samraong	464	2,466	88.4	5.3
	Tram Kak	28,826	144,032	90.5	5.0
	Treang	978	4,847	88.4	5.0
Total		33,025	165,580	89.1	5.0

Source: 1998 Population Census of Cambodia

II-1.2 Topography and Geology / Soil Mechanics

(1) Topography

The Study Area is located mainly on the right bank of the Slakou River between 104°25' to 104°45' east longitude, and 10°50' to 11°08' north latitude. The Slakou River originates from Kampomg Spueu Province and Kampot Province, and flows eastward into flood plain located out of the Study Area. The River joins the Bassac river in Cambodia and the Mekong river in Vietnam. The elevation of the Study Area ranges from EL 6 m to EL 60 m with a slope of 1/100 to 1/1000 from west to east, but the elevation in most of the Study Area ranges from EL 6 m to EL 34 m. Takeo town is located to the east and outside the Study Area at about EL 8 m. There are some small rivers running from west to east, originating from a small mountain located in the west of the Study Area. These rivers almost dry up in dry season. The small mountain has a north to south ridge of about EL 430 m.

(2) Geology

The geological layer in and around the Study Area is alluvium consisting of sand, silty sand and sandy silt. Since clayey sand is cropping out in the riverbed of Tumnup Lok reservoir, it is assumed to exist below the sand, silty sand and sandy silt. There are two (2) laterite layers of 1.5 to 3.0 m thickness around the Study Area, and fine-grained soil underlies the laterite layer. The mountain located in the west of the Study Area is mainly composed of metamorphic rock, and talus deposits which are observed at the foot of the mountain.

(3) Soil Mechanics

The materials of the existing dike/road and canal in the Study Area, are generally silty sand, silty clay, low liquid limited silt and low liquid clay based on the results of a preliminary soil mechanical test (6 samples). If embankments are constructed from such materials with high-compaction, the density of the embankment will be high and it will be impervious to semi-pervious. However, the embankment made from those materials will also be easily eroded and probably deformed under saturated condition. To make matters worse, those soils include dispersible material. The use of only the soil available near the dikes/roads /canals should be avoided. For construction materials, such as, laterite, fine sand, riprap and gravel, the following borrow-pits and quarry sites are available (The locations are shown in Fig. II-1.2.1.):

Borrow-pits for Embankment Material (Laterite and Fine Sand)

B-1: Located adjacent to Mt. Kraol about 27 km southeast of Takeo Town.

B-2: Located adjacent to Prey Kduoch village about 6 km east of O Saray

reservoir.

Quarry Sites for Riprap and Gravel

Q-1: Mt. Chi Sou located about 22 km north of Takeo Town.

Q-2: Mt. Sanlang located about 21 km south of Takeo Town.

Q-3: Mt. Chruoh Kaev located about 25 km west of Takeo Town.

II-1.3 Meteo-hydrology and Water Utilization

(1) Climate and Rainfall

The alternating monsoon system controls the climate of Cambodia. The rainy season is brought by the southwest monsoon during the period from May to November. The remaining period from December to April, due to the northeast monsoon, is dry and less humid. March and April are the hottest months and have high potential evapo-transpiration.

The following table shows typical climate of the lowland region that includes the Study Area.

Summary of Meteorological Data

Item	Unit	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total or average
Rainfall	mm/mon	5.8	3.8	16.6	78.8	109.2	112.1	132.9	155.8	187.9	208.5	123.6	35.4	1170.5
Temperature	C degree													
mean		26.3	27.6	29.3	30.1	29.9	28.9	28.2	28.2	27.9	27.2	26.5	25.9	28.0
maximum		31.1	32.7	34.5	34.9	34.3	33.0	31.9	31.9	31.7	30.8	30.6	30.4	32.3
minimum		21.4	22.5	24.1	25.3	25.4	24.8	24.6	24.6	24.0	23.7	22.4	21.4	23.7
Humidity	%	72.9	70.5	70.6	71.4	76.4	78.8	82.3	82.9	85.5	86.0	79.6	75.2	77.7
Wind	m/sec	3.1	3.9	4.1	3.8	4.1	4.6	3.9	5.0	4.3	2.7	3.6	3.7	3.9
ETo	mm/mon	162	174	216	206	191	167	153	159	140	133	146	156	2,000
Sunshine	hr/day	8.7	8.6	8.6	8.3	7.3	6.1	5.8	5.9	5.6	5.8	7.4	8.4	7.1

Note: Averages of monthly data from Department of Meteorology, Pochentong (1991 - 2000) except potencial evapotranspiration (ETo), which was calculated by the modified Penman method and rainfall data of Takeo, which were obtained from Takeo Station (1982 - 2000)

Annual average of rainfall is about 1,200 mm in the lowland and is about 1,400 mm to 1,500 mm in the upstream mountainous area of the Slakou River. About 90 % of rain occurs during the rainy season and the peak is in October. Rainfall is very erratic and usually of limited spatial extent. There is little pattern in its occurrence, and spatial correlation in the short term is very poor.

(2) River Runoff

There are no available runoff data in the Slakou River system. This river system is shown in Fig. II-1.3.1. Only the Prek Thnot River, a neighboring basin of the Slakou River basin, has discharge measurement records for a few years.

Both basins are totally located in the eastern slope of the Elephant Mountains and rainfall patterns are almost the same for both basins. The topographic conditions and land use patterns are also similar. Thus the Slakou river runoff was estimated by analyzing the relationship between runoff of the Prek Thnot River and rainfall, taking into account differences in rainfall caused by differences in area occupied by mountains, and flow characteristics of the Slakou river, especially in the dry season. Characteristics of the Slakou river basin taken into account include:

1) The Don Phe Stream, on which Kpob Trobek Reservoir exists, is a perennial stream, but dries up two to three months every dry season at the reservoir site, because water is diverted for irrigation use at about eight (8) km upstream point of the Kpob Trobek Reservoir.
2) The Krouch Stream, on which O Saray Reservoir exists, dries up for two to three months every year in the dry season.
3) The Tras Stream (Slakou), on which the Tumnup Lok Reservoir exists, is perennial, although the flow is negligibly small in mid dry season.

The runoff estimation was made on a monthly basis for 20 years made up of two periods from 1966 to 1969 and 1985 to 2000. Rainfall data available for the Prek Thnot River basin area of 3,650 km^2 are only Kampong Spueu, Phnom Srouch, and Kirirom for four years from 1966 to 1969 and only Kampong Spueu and Phnom Srouch for 16 years from 1985 to 2000. With such poor data availability, it may be difficult to obtain reliable results. Fig. II-1.3.2 shows the simulated runoff compared with the actual one. The correlation coefficient (r^2) is 0.79.

The following table shows the estimated runoff of three tributaries at the existing reservoir sites.

Estimated Monthly Discharge at Three Reservoirs' Sites at Recurrence Period of Five Years and Two Years

Unit: m^3/sec

Name of Reservoir	Return period	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
Kpob Trobek	5 years	0.08	0.04	0.02	0.01	0.01	0.01	0.32	0.47	2.25	1.84	1.19	0.30	0.55
	2 years	0.13	0.06	0.03	0.01	0.01	0.47	0.56	1.15	3.24	4.60	1.88	0.53	1.06
O Saray	5 years	0.01	0.00	0.00	0.00	0.00	0.00	0.08	0.12	0.75	0.62	0.39	0.09	0.17
	2 years	0.02	0.00	0.00	0.00	0.00	0.13	0.17	0.35	1.13	1.62	0.66	0.17	0.36
Tumnup Lok	5 years	0.16	0.10	0.06	0.01	0.01	0.01	0.75	1.21	5.52	4.51	2.87	0.68	1.33
	2 years	0.28	0.19	0.09	0.02	0.01	1.16	1.42	2.83	7.87	11.17	4.55	1.28	2.57

(3) Water Utilization

The water resources of the Slakou River were utilized for paddy cultivation in the Study Area through a reservoir irrigation system constructed in the 1970s. Nowadays, however, the water resources are not used except in an area of about 3,000 ha in the lowland below the Study Area and in a limited area of 100 ha in the Don Phe stream

basin above the Study Area.

The lowland areas below the Study Area are mostly inundated in the rainy season with flooding water caused by backwater effect of the Bassac River. When inundation water depth gradually decreases as the Bassac River water level lowers, and reaches 10 cm to 20 cm in depth that occurs in December, farmers prepare the paddy fields by puddling and draining the excess water and directly sow paddy seeds. These puddling and sowing works need little irrigation water, since residual water is abundant in the fields. For two months from early January to early March the fields need irrigation water, which is estimated at about 600 mm or 18 MCM in total. Such irrigation water is ensured by reservoirs such as the Thnot Te Reservoir and the Krachab – Chrouy Samraong Reservoir constructed by low dikes in the lower reach of the Slakou River.

Runoff from the Slakou River is stored in the Thnot Te Reservoir in the rainy season. In addition, backed-up inundation water can enter the Thnot Te Reservoir via the spillway in the mid-rainy season. This water is also stored. In case of the Krachab – Chrouy Samraong Reservoir, a water gate is opened to allow inundation water to enter the reservoir in mid rainy season when the inundation water level is higher than the reservoir water level. In the dry season, the stored water is released for irrigation. Effective storage capacity is estimated at 18.4 MCM consisting of 13.4 MCM in Thnot Te Reservoir (refer to Thnot Te Feasibility Report, ADB, March 1994) and about 5 MCM in the Krachab – Chrouy Samraong Reservoir. The Slakou River runoff in the rainy season is enough to fill the reservoirs with water.

II-1.4 Soils and Land Suitability for Agriculture

(1) Soils in the Study Area

According to the 1:50,000 Soil Map prepared by Land Use Mapping Office of MAFF and the Study Team's survey results, the soils in the Study Area are classified into five soil groups: A) recent alluvium soils, B) alluvium soils, C) gray soils D) gray lessive soils, and E) red yellow soils. The gray lessive soils are divided into three soil sub-groups by soil depth and drainage conditions. Among the soil groups, the lessive soils are dominant occupying 54,000 ha or 83 % of the Study area. The lessive soils D1 and D2 are major soils where paddy rice is cultivated. Fig. II-1.4.1 shows soil distribution in the Study Area.

The surface of lessive soils have a coarse texture, from loamy sand to sandy loam, due to a soil formation action of "Lessivage"; eluviation of clay colloids from the surface to deeper soil layers under tropical climatic conditions. The eluviated clay is

accumulated in the lower soil at depths of 0.5 m - 1.0 m. Due to lessivage, fertility of the soils is low. Lessive soils are classified into "Prey Khmer" and "Preteah Lang" soil groups by another soil classification system in Cambodia, or would be classified as Alfisol or Ultisol orders by soil taxonomy of USDA.

(2) Land Suitability Assessment for Agriculture

The recent alluvial soils (A), old alluvial soils (B), gray soils (C) and gray lessive soils (D1 and D2) are suitable for paddy and secondary crops including vegetables during the rainy season, and during the dry season under irrigation. These areas are estimated at 57,300 ha in total or about 88 % of the total area. The above soils and gray lessive soils (D3), which account for 63,000 ha, or 97 %, of the total area, are also suitable for tree crops such as banana, mango, coconut, papaya, etc. Fertility of the above soils is low due to the sandy texture, poor nutrient content and low nutrient-holding capacity. The land suitability for agricultural use and for irrigation farming is summarized in Table II-1.4.1.

II-1.5 Agriculture

II-1.5.1 Land Use

Out of the 65, 000 ha of the Study Area, the net cultivated area is estimated at 44,240 ha, or 68 % of the Study Area, and consists of 42,540 ha of paddy field and 1,700 ha of secondary crop field. Paddy fields are dominant, occupying 96 % of the cultivated land or 65 % of the Study Area. They are used for food production, and as a source of income for rural people. Secondary crop fields are scattered in the paddy field, and in forest/shrub land on the old alluvial plain, mountain foot and older terrace land units. Crops are planted on such cultivated land during the rainy season, and paddy rice, vegetables, beans, cassava, etc. are rarely planted during the dry season. Tree crops are scattered along canals, farm ridges, and around the home yard. The present land use map is shown in Fig. II-1.5.1. The areas by land use are shown in Table II-1.5.1 and summarized below:

Land Use of the Study Area

(Unit: ha)

Land Use	Area	Ratio (%)
Cultivated land (net area)	44,240	68
Paddy field	(42,540)	(65)
Secondary crop field	(1,700)	(3)
Bush, shrub, forest land	13,500	21
Land for settlement, road, canal, reservoir, stream, etc.	7,260	11
Total	65,000	100

Source: Tram Kak District Government and JICA Study Team

II-1.5.2 Land Tenure and Landholding

According to the Land Law promulgated in 1992, land basically belongs to RGC, and farmers have land use right. The farmers are able to continuously use their lands, and are able to inherit and deal the land use right. The RGC adopted a policy of land allotment to individual farm households for private use in 1989 after dissolution of the solidarity group system *(Krom Samakki*: collective agricultural production system by farmers group from 1979 to 1989). The farm land which had been cultivated by the solidarity groups in the village, was evenly distributed to farm households according to the number of family members and land productivity.

The land registration program, which is supported by Finland government, has registered less than 10 % of farm land in the country. Farm land dealings in the Study Area are few and the dealings have been done only among villagers. Such dealings, however, have increased in recent years. The current dealing prices range between Riel 1.0 million and 3.0 million per ha. Farm land tax system does not exist in Cambodia. According to the social environmental baseline survey conducted by the Study Team, farm size per household ranges between 0.09 ha and 4.15 ha, the average and median farm sizes are 0.92 ha and 0.80 ha, respectively. The median size farmer (typical farmer:0.80 ha) has 0.74 ha of paddy field, 0.04 ha of secondary crop field and 0.02 ha of tree crop land. Tenant farmer and landless farm-labor are estimated at less than 1% and 3% of the whole households, respectively. The farm size distribution is shown below:

Structure of Farm Size in the Study Area

Range of farm sizes	Ratio (%)	Average farm size (ha/household)			
		Paddy	Secd. crop	Tree crop	Total
0.09 - 0.25 ha	5.5	0.13	0.02	0.01	0.16
0.25 - 0.5 ha	14.4	0.35	0.03	0.02	0.40
0.5 - 0.75 ha	27.4	0.58	0.04	0.02	0.64
0.75 - 1.0 ha	17.4	0.80	0.05	0.02	0.87
1.0 - 1.5 ha	19.4	1.09	0.05	0.02	1.16
1.5 - 2.0 ha	10.9	1.50	0.09	0.05	1.64
2.0 - 4.15 ha	5.0	2.50	0.06	0.02	2.58
Average	(100.0)	0.85	0.05	0.02	0.92
Median		0.74	0.04	0.02	0.80

Source: Social environmental baseline survey by interview with 201 households

II-1.5.3 Agricultural Labor Force

According to the Population Census in 1998, the total population, number of households and average family size of the Study Area are 165,600, 33,000 and 5.0, respectively. Almost all of the households are engaged in agricultural activity except households of school teachers, policemen, and residents in Angk Ta Saon market.

Consequently, it is estimated that the agricultural households in the Study Area occupy about 97 % of the total households or approximately 32,000 families. The population census on Takeo Province reports that the labor force of rural area in Takeo Province is about 45 % of the total population. Assuming the labor force ratio in the province, labor force in the Study Area is approximately estimated at 74,500. Average labor force per household is estimated at 2.3 persons in total.

Labor force exchange system is traditionally usual for on-farm works in the village community during transplanting and harvesting seasons. Landless and small farmers are hired for these works at rate of Riel 2,500 and 3,500 for a day work. Labor requirement for paddy cultivation is estimated at 70 - 85 men-days per ha including 15 - 20 men-days for transplanting, and 30 - 35 men-days for harvesting. Even in the busiest season, labor force is not short in the Study Area.

II-1.5.4 Cropping Pattern and Production

(1) Crops and Cropping Pattern

Paddy is the main crop for the staple food as well as the main income source of farmers for daily life in the area. The planted area of paddy occupies 97% of total cropped area. Paddy cultivation in the Study Area is classified into four (4) categories by growing period and planting season as shown below:

Paddy Planting Type

Type of paddy	Growing period (days)	Planting - Harvesting
1. Early maturing paddy in rainy season	Less than 120	May/Jun - Aug/Sep
2. Medium maturing paddy in rainy season	120 - 150	Jul/Aug - Nov/Dec
3. Late maturing paddy in rainy season	More than 150	Jul/Aug - Dec/Jan
4. Dry season paddy (early maturing paddy)	Less than 120	Jan/Feb - Apr/May

Other crops are planted in limited area of less than 3% of total cropped area. Sweet potato, cassava and sugarcane are cultivated in the rainy season. Other diversified crops for self-consumption or cash crops are planted before or after season of the rainy season paddy. Various crops are planted, mung-bean, groundnut, maize and vegetables (pumpkin, cucumber, eggplant, string-bean, leaf onion, watermelon, etc.) in the Study Area. Planted areas by crops in the Study Area were estimated as follows by statistics of Tram Kak District shown in Table II-1.5.2 and commune interview survey:

Planted Areas in the Study Area

(Unit: ha)

	Estimated planted area (ha)	Ratio (%)
Paddy (Total)	39,600	97.2
Medium paddy	33,700	82.7
Other paddy (Early, late, dry season)	5,900	14.5
Secondary crops (Total)	1,160	2.8
Maize	40	0.1
Tuber crops (cassava, sweet-potato)	270	0.7
Beans (mung-bean/soybean, groundnut)	240	0.6
Sugarcane	40	0.1
Vegetables	570	1.4
Tree crops	(scattered)	-
Total	40,760	100.0

Note: Refer to Table II-1.5.2.

The cropping pattern is illustrated in Fig. II-1.5.2. Double cropping area of two-time paddy cultivation or paddy plus secondary crops is less than 10 % of the cultivated area. The cropping intensity is estimated at 92%.

(2) Unit Yield and Production of Crops

The unit yield of paddy in Cambodia has been gradually increasing recently, although, it is still low. The national average during the recent 5 years is reported to be 1.69 ton/ha to planted area. In the same period, the average yields in the wet and dry seasons were 1.53 and 2.93 ton/ha, respectively. Dry season paddy is produced mainly in flood area of Mekong River as receding rice. The flood area is covered with fertile soils, and HYVs are planted when it receives much sunshine radiation. The average yields of Takeo Province are 1.8 ton/ha in the rainy season, 2.8 ton/ha in the dry season and 2.2 ton/ha on annual average.

The average yield of paddy in the Study Area is estimated at 1.3 ton/ha based on the following survey results:

i) Yield of paddy varies between 0.75 and 1.5 ton/ha according to interview with commune chiefs. The mean of average yield reported by the commune chiefs is approximate 1.3 ton/ha, which is considerably lower than the average value reported by the District Office. By commune chiefs, maximum yield of good farmers in good year ranges between 1.2 and 3.0 ton/ha.
ii) The results of the social environmental baseline survey show that the yield of paddy ranges between 0.4 and 2.7 ton/ha and is averaged at 1.34 ton/ha.

Paddy production in the Study Area amounts to about 51,500 ton in total. The yield of other crops are also still low. Production of beans including groundnut and vegetables are estimated at 100 ton and 2,300 ton, respectively. The estimated yields

and production of major crops are shown in Table II-1.5.3.

II-1.5.5 Farming Practices

Farming is carried out rather traditionally by manual labor and draft animals without agricultural machinery. About 70 % of farmers raise draft animals for plowing and carting, mainly in pairs of cattle and rarely by pairs of water-buffalo. Farmers without draft animals undertake the land preparation on a contract basis. The cost of plowing and harrowing is Riel 42,000 per ha, and it needs 5 to 7 animal-days per ha.

Local varieties of medium maturing paddy such as *Neang Sar*, and *Somaly*, are dominant and HYVs are used for early maturing paddy. Farmers repeatedly use paddy seed produced by themselves without renewal of seed. This results in a mixture of different varieties, recession of variety, decrease of productivity, and low quality product. Nursery is prepared one month before transplanting under submerged conditions in an area of about 1/10 of the main field. The seeding rate is generally 65 kg/ha of main field.

Land preparation starts with plowings generally twice after sufficient rainfall to allow easy plowing. Two weeks after the plowing, harrowing is performed twice for transplanting. Transplanting spacing is about 20 cm x 20 cm, and the number of stems is 6 to 10. Some farmers apply chemical fertilizer. They use 1 to 2 sacks (50kg/sack) of urea (46:0:0) or DAP (18:46:0) or AP (16:20:0) by twice of split application. Potassium is not used usually. An average application rate of chemical fertilizer is roughly estimated at N: 20 kg/ha, P: 10 kg/ha, and K: 0 kg/ha. Around 30 % of farmers can not use chemical fertilizer due to the lack of finance, according to the social environmental baseline survey, and interview survey with farmers and commune chiefs. Weeding is usually carried out by manual labor. Chemical spraying for pest and disease control is rarely done.

The farmers harvest by hand with sickle and tie up the panicles into bundles. The bundles are dried in the field, carried to a farmer's house and threshed. Hand threshing is ordinary method used in the Study Area. The farmers strike the paddy bundles about 15 to 20 times onto a wooden board to separate paddy grains from the panicles. The straws left in the field are used as pasture for cattle, and rice straws are carried to home yard for forage of cattle. The threshed paddy is dried for one or two days on a plastic net on a backyard or road. The dried paddy is stored before milling.

Secondary crops are usually planted before or after rainy season paddy under supplemental irrigation or rain-fed conditions. Dry season crops including early rainy season crops are irrigated by using water of reservoirs, ponds or residual water in

canals. Some farmers use portable pumps for the irrigation.

II-1.5.6 Livestock

Livestock raising is an important activity for farmers in the Study Area as a cash income source and as draft power for land preparation work. Most of the farmers are raising cattle, pig and poultry. Cattle are raised for draft power for land preparation and transportation by ox-cart. The social environmental baseline survey reveals that 94% of the households raise cattle, and the average number of cattle per household is 2.9 heads. The total number of cattle is estimated at about 87,000 in the Study Area. About 45 % of the total number of raised cattle, except young cattle, can be used for draft power. It is roughly estimated at about 39,000 heads, 19,500 pairs, or 1.2 heads per household on average. Cattle husbandry is still primitive. They are mostly grazing residual rice straw in the paddy field after harvesting, but the feed is short in the late dry season. Major problem in cattle grazing is disease control to hemorrhagic septicaemia, anthrax, black leg, and foot and mouse disease. The district agricultural office is providing vaccination services, but the achievement is less than 20 % of the total number of cattle.

As shown in the following table, 96% of farm households in the Study Area are raising 1.6 heads of pigs on average. Pigs are the major income source for farmers. They are marketed at 70-80 kg weight at about 12 months of age. Major problems in pig husbandry are shortage of feed and high death rate by diseases and accidents.

Livestock Husbandry in the Study Area

	Cattle	Pig	Chicken	Duck
Raising household of the total (%)	94%	96%	97%	81%
Average of animal head/household	2.9	1.6	12	7

Source: Social environmental baseline survey conducted by JICA Study Team

II-1.5.7 Farm-Gate Prices of Agricultural Outputs and Inputs

Average farm-gate prices of the major agricultural outputs and inputs in the Study Area during a period from July 2000 to June, 2001 are shown below :

Farm-gate Prices of Outputs and Inputs

Outputs	Riel/kg	Input	Riel/kg
Paddy Local	370	Urea	800
Paddy HYV	340	Ammonium sulfate	600
Vegetables	300 - 1,000	TAP (Tri-ammonium phosphate)	1,000
Mung-bean	1,500	KCl	800
Pig (live)	2,800	Paddy seed (HYV)	420

Source: JICA Study Team

II-1.5.8 Farm Household's Economy

Table II-1.5.4 shows farm household economy by farm sizes prepared based on the social environmental baseline survey. A typical farm household (median farm size farmer) has a land of 0.80 ha (0.74 ha of paddy and 0.06 ha of other crop field), 2.6 heads of cattle, 1.7 heads of pig, and 18 heads of poultry. The characteristics of farm household's economy in the Study Area are summarized below:

- Annual household income is very low: US$118 (actual), or US$215 (including self-consumed products as income).
- The cash income source depends mainly on livestock (about 66 % of cash income, mainly pig) and off-farm (about 28 % of cash income). The crop products are mostly consumed by farmers themselves.
- Food expenses amount to 26 % of the total living.

The typical farm household's economy is as follows:

Household Economy of Typical Farmer

(Unit: Riel/year)

Item	Actual cash income/ outgo	Income/ outgo considering self-consumed products	Ratio (%)
1) Gross Income	451,530	824,170	100%
Farm Income	324,870	697,510	85%
Crop (paddy, vegetable, etc)	28,500	386,330 *(1)	47%
Livestock	296,370	311,180 *(2)	38%
Off-farm Income	126,660	126,660	15%
2) Gross Outgoing	456,990	829,630	100%
Production Cost	250,890	250,890	30%
Living Expenses	206,100	578,740	70%
Food	54,730	427,370 *(3)	52%
Health	22,190	22,190	3%
Education	26,640	26,640	3%
Others *(4)	102,540	102,540	12%
3) Balance	-5,460	-5,460	

Note *(1):Production value of paddy = 0.74 ha x 1,300 kg/ha x 370 Riel/kg = 355,940 Riel
Other crops: It is assumed that 50% of products for self-consumption and 50% for sale
*(2):It is assumed that 5% of products is consumed by farmers themselves.
*(3):=Actual expenditure + self-consumption of the products
*(4):Clothes, fuel, transportation, housing, investment of business, tax, etc.
Source: Social environmental baseline survey. Refer to Table II-1.5.4

II-1.5.9 Food Balance

The RGC gives a high priority to food security, mainly at paddy. The self-sufficiency of paddy at a national level has been attained through the increase of rice production though not quite satisfactory. Paddy balance in the Study Area was examined based on the MAFF indicators as shown below:

Present Paddy Balance of the Study Area

1.	Paddy production (ton)	51,480	Average yield 1,300kg/ha
2	Seed reserve and post-harvest loss (ton)	8,752	17 % (loss: 10%, seed: 7%)
3.	Available paddy for consumption (ton)	42,728	
4.	Recovery rate of rice milling	62%	Including broken rice
5.	Available rice for food (ton)	25,637	
6.	Population (person)	165,600	Population census 1998
7.	Rice consumption per capita (kg/year)	151.2	
8.	Rice requirement (ton)	25,039	
9.	Surplus of rice (ton)	598	
10.	Surplus of paddy (ton)	965	Equal to 2% of paddy production

As shown in above table, only 2 % of paddy produced in the Study Area is surplus. Since farmers use rice or broken rice for feed mixed with rice bran of pig raising, it can be said that paddy in the Study Area is often in short in year of low production, and that farm households of smaller than the average are usually deficit in paddy. According to commune chiefs, 40 to 80 % of households are short in paddy.

II-1.6 Agricultural Production Infrastructures

II-1.6.1 Irrigation and Drainage System

Agricultural production infrastructures in the Study Area are reservoirs / ponds / wells, irrigation and drainage canals, and the related canal structures. The present irrigation and drainage systems are as follows:

(1) Water Source

Water sources in the Study Area are summarized below:

Water Source	Command Area	Related Canal System
Tras Stream (Upper Slakou River)	Upper reach of the Study Area	Canal-33, Koh Kaek, etc
Slakou River (downstream)	Lower reach of the Study Area	Canal 66, 68
Surface water from Noreay Mountain Range	Foot of the Mountain Range	Koh Kaek, existing small reservoir systems
Standing water in the canals, small ponds, open wells	Agricultural land around the water source	-

(2) Irrigation System

The irrigation system of the Study Area consists of three main reservoirs and two main canals as shown in Fig. II-1.6.1. This system was constructed during the period of the Pol Pot Regime in the latter half of the 1970s. After several years, most of the reservoir facilities were damaged by floods due to inadequate operation.

The Tumnup Lok Reservoir on the Slakou River is located on the up-most reach of the command area as an intake facility to the system. Water diverted from the

Tumnup Lok Reservoir was conveyed to the O Saray Reservoir through a connection canal, then to the Kpob Trobek Reservoir, from which the Main Canals start.

Main Canal No.1 or Canal-33 runs on the south side of the District Road No. 33 toward the National Road No.3. Water from Canal-33 is diverted to secondary canals mostly located to the north of Route-33 through pipe or box culverts.

Main Canal No.2 or Koh Kaek Canal starts at the Kpob Trobek Reservoir and runs southward to Angkor Chey in Kampot Province. Secondary canals convey irrigation water from Koh Kaek Canal to the southwestern part of the Study Area.

Since no authorized information is available on the design features of the irrigation system, such as design drawings and design reports, the net irrigation command area of 30,400 ha estimated on the map has been believed for a long time.

(3) General Characteristics of Irrigation and Drainage System in the Study Area

Most of the irrigation and drainage facilities were constructed under the Pol Pot Regime. Characteristics of the irrigation and drainage system in the Study Area are summarized below:

1) Most irrigation canals run from west to east,
2) Canals running north to south serve as drains and distribution canals,
3) Canals are not lined,
4) Few control, diversion or regulation structures exist on the canals,
5) Canal dimensions are generally large compared with the irrigation area, mostly because of dual purpose for irrigation and drainage,
6) Capacity of structures on the canals such as culverts and bridges is insufficient compared with that of the canals,
7) Most of the canals are heavily sedimented and remain without proper maintenance works, and
8) The irrigation system is used only during the rainy season.

II-1.6.2 Reservoirs

(1) Major Reservoirs

Tumnup Lok Reservoir has three gate structures along the dike for controlling the water level in the reservoir. A connection canal to the O Saray and Kpob Trobek Reservoirs starts on the right bank at 600 m from the main stream of the Tras Stream.

O Saray Reservoir is located at six (6) kilometers from the Tras Stream on the right bank. The reservoir receives water from the Tras Stream through the connection canal, and a natural stream the Ou Krouch Stream, a tributary of the Tras Stream.

Kpob Trobek Reservoir was designed to receive water from the Tras Stream through the connection canal and O Saray Reservoir, and also from a tributary of the Tras Stream, namely the Dom Phe Stream.

The main canals start at the Kpob Trobek Reservoir. Main Canal No. 1 or Canal-33 starts at north end of the sub-dike, while Main Canal No.2 or Koh Kaek Canal starts at 100 m south of Canal-33. The main features of reservoirs are summarized below:

Main Features of Three Reservoirs

Description	Kpob Trobek	O Saray	Tumnup Lok
1.River	Don Phe	Krouch Stream	Tras (Slakou)
2.Catchment area	137 km^2	51 km^2	332 km^2
3.River gradient: Average	1/110	1/120	1/190
4.River gradient: At Reservoir	1/540	1/250	1/460
5.Total Volume at Present [1)]	2.63 MCM	0.23 MCM	1.00 MCM

Source: 1); Estimated by the Study Team based on the results of level survey and the 1:50,000 map

(2) Other Small Reservoirs

Many small reservoirs were constructed along and on the upstream side of roads. These were provided with a gate structure (stop log) or culvert as an intake cum spillway. Most of the reservoirs have malfunctioned due to sedimentation and flood damage to the dikes or structures.

(3) Ponds

There are many sites for ponds, such as the backyard of farmers' houses and canals, for storing rainfall for supplemental irrigation, domestic water and aquaculture in the Study Area. There are currently few ponds used exclusively for aquaculture.

II-1.6.3 Canals

(1) Survey at Commune Level

During the field study, information on the existing canals was collected and confirmed at commune level. The information includes name, length, dimensions and location of the canals, irrigation capacity (area) at present, direction of the water flow, and present condition are shown in Fig. II-1.6.2 to Fig. II-1.6.6.

The lengths, cultivated areas and density of canals by communes are as follows :

Canals by Commune

Districts	Length of Canal (m)	Cultivated Land (ha)	Canal density (m/ha)
Tram Kak District	385,615	37,718	10.2
Angk Ta Saom	38,350	2,767	13.9
Cheang Tong	22,950	2,516	9.1
Kus	44,050	3,517	12.5
Leay Bour	56,700	4,854	11.7
Nhaeng Nhang	24,250	2,131	11.4
Otdam Souriya	15,700	2,500	6.3
O Saray	12,400	2,713	4.6
Popeel	13,750	1,786	7.7
Samraong	18,150	1,380	13.2
Srae Ronoung	26,000	2,504	10.4
Ta Phem	31,515	3,021	10.4
Tram Kak	18,250	2,574	7.1
T.T.K. Cheung	35,250	2,159	16.3
T. Kranhung	7,000	1,332	5.3
T.T.K. Tboung	21,300	1,964	10.8
Samraong District	19,200	1,440	13.3
Lumchang	19,200	1,440	13.3
Treang District	48,100	2,114	22.8
Total	452,915	41,272	11.0

Note: T.=Trapeang, T.T.K=Trapeang Thum Khan
Source: Provincial Department of MOWRAM, 2001 (collected from commune)

(2) Inventory Survey

Inventory Survey on the canals was carried out by a local sub-contractor. The condition of canals was examined at crossing or diversion points, or at every one kilometer. There were a total of 853 survey points. The canals were classified into one of four categories :

1) A: Fully functioning
2) B: Partly deteriorated but function is maintained
3) C: Deteriorated, and does not function well, and
4) D: Completely damaged, and does not function

The results are given below:

Results of Inventory Survey

Evaluation Item	A	B	C	D	Total
Number	25	158	616	54	853
Percentage	2.9%	18.5%	72.2%	6.3%	100.0%

From the above results, it can be said that more than 70 % of canal sections do not function well. One of the causes of deterioration is sediment, mostly from erosion of the canal and surrounding area.

II-1.7 Farmer Water User Community

II-1.7.1 Present Farmer Water User Community

At present legally authorized farmer water user community (FWUC) does not exist in the Study Area. Along the existing canals, very limited farmer groups are traditionally utilizing canals for supplementary irrigation. Those irrigation canals are basically maintained once a year by their groups before cultivation of the rainy season crop starts.

There are small reservoirs scattered in the Study Area, which are partially damaged but utilized for supplemental irrigation to surrounding paddy fields in the rainy season and for irrigation of dry season upland crops in very limited areas by farmers' groups

There are several FWUCs in areas neighboring the Study Area. These FWUCs were established during the period from 1994 to 1999 and supported mainly by International Organizations (IOs) like ADB. Most of the FWUCs are carrying out the following activities, although they are not always at satisfactory level:

1) Operation and maintenance of irrigation and drainage system,
2) Collection of irrigation service fee (ISF) determined by the Committee meeting,
3) Dispute resolution among the community members, and
4) Making balance sheet and explaining to all members.

The following table shows the ISF in cash or kind (paddy) so far collected in the above mentioned existing FWUCs :

Name of Scheme	Type of Irri.	Year	Wet season	Dry season	Paddy	Planned ISF/ha		ISF Collected/ha		% of ISF
			(ha)	(ha)	(t/ha)	(Riel or kg)	US$/ha	(Riel or kg)	US$/ha	Collected
Kantourt	Pumpping	1999		300	3.50	110,000Riel	28.68	60,800Riel	15.85	55.3
Plovic	Gravity	1999		2,000	3.50	140kg	10.95	82kg	6.41	58.6
		2001		807	2.50	140kg	10.95	77kg	6.02	55.1
Sain Prea Ream	Gravity	2001	380	96	2.00	*80kg	6.26	71kg	5.55	88.8
O treng	Gravity	2001	300	# 200	2.20	*40,000Riel	10.43	20,000Riel	5.21	50
Thnot Te	Gravity	2000		2,274	3.50	30kg	2.35	27kg	2.11	90
Average							**8.19**		**5.06**	**68.5**

* ISF was applied only for the dry season crops.
\# Water melon is mainly cultivated.

As shown in above table, an average actual ISF collected was US$5.06 equivalent in

case of the gravity irrigation system, and 68.5% of the amount determined in the Statute by the Committee was collected. The reason for it was mainly due to the following:

1) Unclear accounting of collected ISF,
2) Unfair and improper distribution of irrigation water,
3) Lack of accountability and trust among the members of FWUC, and
4) Price of paddy produced is low, less than 300 Riel/kg resulting in low net income of farmers.

II-1.7.2 Farmers Perception of Management Problems

Most of farmers in the Study Area do not always understand the policy for sustainability of an operation and maintenance irrigation system prepared by MOWRAM in June 2000, particularly the following provisions:

1) Irrigation development and rehabilitation programs shall be implemented only on the basis of the feasibility and demand of the majority of the farmers.
2) Full participation of organized users during the planning and implementation of irrigation projects shall take place at all levels from the very beginning.
3) Formation of FWUC shall be the primary task leading towards the implementation of an irrigation project.
4) Upon the completion of construction, the responsibility for operation and maintenance and the emergency repair shall rest with FWUC in gradual process.

Most of the farmers in the Study Area do not clearly understand that the FWUC shall comprise the farmer representatives from various levels of the irrigation system or water user groups (WUGs), and that FWUCs have the following duties:

1) Implementing the work program of the Community,
2) Coordinating between members of FWUC and Community, and
3) Collecting ISFs from the members according to the terms set by the Community.

II-1.7.3 Institutional Framework of FWUC

(1) Regulation (Prakas 306) including Circular No. 1 issued by the RGC

For the successful implementation of the irrigation development and for the sustainable operation and management of irrigation systems, RGC has entrusted MOWRAM to review and evaluate all the irrigation systems to standardize the statutes of FWUC. This will facilitate farmers to become organized to prepare feasibility studies and construct irrigation systems to supply water to the fields in an

efficient and sustainable manner. This will also be able to cooperate with the concerned ministries in the process of creating FWUC.

The RGC issued Circular No. 1 SR on the Implementation Policy for Sustainable Irrigation System on 11, January 1999, containing model statutes of FWUCs and provisions for the assessment and collection of ISFs.

(2) Draft Law on Water Resources Management

Enacting the Water Management Law will support this policy. Under Article 20 in the Draft Law on Water Resources Management of the Kingdom of Cambodia, all farmers using water from the same irrigation system or part thereof may form a FWUC. This law also enables FWUC to be established upon the initiative of MOWRAM in the interests of the efficient and sustainable management of the irrigation system, or part thereof. The statutes of a FWUC shall be registered with MOWRAM. As of the date of registration, the Community shall acquire juridical status. The procedures for the establishment, functioning and dissolution of FWUCs shall be determined by way of sub-decree.

(3) Transfer of the Management Responsibility and Water Allocation to FWUC

Based on the capacity of the farmer organizations, the irrigation schemes shall be transferred to FWUCs for their sustainable operation and maintenance and for the promotion of irrigated agriculture. The right to operate the transferred irrigation scheme and related infrastructures and the responsibility of its protection shall be with FWUC recognized by the government.

(4) Formation of FWUC

In addition to providing technical and managerial support in the formation of a FWUC, MOWRAM shall be responsible for getting the FWUCs registered with the government in order to make it legal. An FWUC will be managed by its Committee, which is elected by the members of the FWUC.

(5) Irrigation Service Fee (ISF)

The responsibility to collect ISF from the water user farmers shall rest on the Committee of a registered FWUC. The FWUC Committee shall be obliged to keep records of the farmers receiving the irrigation facilities (area, crop type). The income and expenditure of a FWUC shall be annually audited by an independent auditor hired by FWUC and the reports shall be presented in general meeting of FWUC for approval.

II-1.8 Agriculture Support Services

II-1.8.1 Agricultural Research and Extension Services

(1) Research

The Cambodian Agricultural Research and Development Institute (CARDI) was established in 1997 in collaboration with UN agencies, IRRI, and Australian government. CARDI aims to increase agricultural productivity through human and institutional development. Other than CARDI, there are six national research stations, five agricultural development centers and three rural development centers in the country for agricultural research, dissemination of improved farming technology, training of farmers and agricultural technicians, and seed production. Tonle Bati and Kobal Po Agricultural Development Centers are located in Takeo Province. The former was established in 1989 supported by NGO; the World Council of Churches is providing technical services for the dissemination of paddy farming technology and paddy seed production. Kobal Po aims at rice and vegetable production.

(2) Agricultural Extension

Agricultural extension service is managed under the Department of Agricultural Extension, MAFF. Improvement of the extension service in Cambodia is being implemented under the support of the Australian Government as the Cambodia Australia Agricultural Extension Project (CAAEP). Provincial Department of Agriculture, Forestry and Fisheries (DAFF) under MAFF is providing field-level agricultural extension services. The Agricultural Extension Section of Takeo PAFF has 32 staff including the section chief. The extension workers from this office cover 10 districts in the province. Three (3) extension workers have been newly transferred from the provincial office in the Tram Kak District office of DAFF in 2001.

The DAFF Takeo is providing Farmers Field School (FFS) from 1996 aiming at extension activity by farmers at village level. The FFS provides technical guidance of improved farming technology including IPM (Integrated Pest Management) through seminar and workshop to leader farmers. The farmers trained in FFS are expected to work as trainers of farming technology in their villages. The extension system has still not well functioned in the Study Area. Because the extension system covers only a part of the Study Area due to the shortage of manpower and budget of DAFF. In addition, the village activities by trained farmers are insufficient due to non-availability of the facilities (such as demonstration plots) and support to the activities.

There is no technology extension program by the governmental agencies concerning

the processing and marketing of agricultural products in Takeo Province except for Vocational Training Center in Takeo Province, and Rural Development and Resettlement Project (RD&RP).

II-1.8.2 Credit Service

Institutional micro-credit by NGOs is expanding in the rural area, because there is no governmental institutional credit system in Cambodia. NGOs, such as CRS, MCC, and OXFAM (in Kampong Spueu Province) have worked in the Study Area for the rural micro-credit. The RD&RP supported by JICA and ASEAN countries is also providing micro-credit through group farmers. Repaid capital from this scheme can be used as a revolving fund in the farmers group. The interest rate of micro-credit varies between 2 % and 6 % per month, depending on the purpose and conditions. The credit for purchase of fertilizer by RD&RP is the lowest interest rate of 2 % per month. Farmers who can't access micro-credit usually use money lenders (traders) at high interest rates of about 10 % per month.

II-1.8.3 Agro- Processing of Paddy and Other Agricultural Products

There are no factories that can be called "industry", other than the rice processing, in the Study Area. Only traditional small processing operated on family base, such as noodle making and cake making, exist in the Study Area. The agro- processing of paddy/rice in the Study Area is as follows:

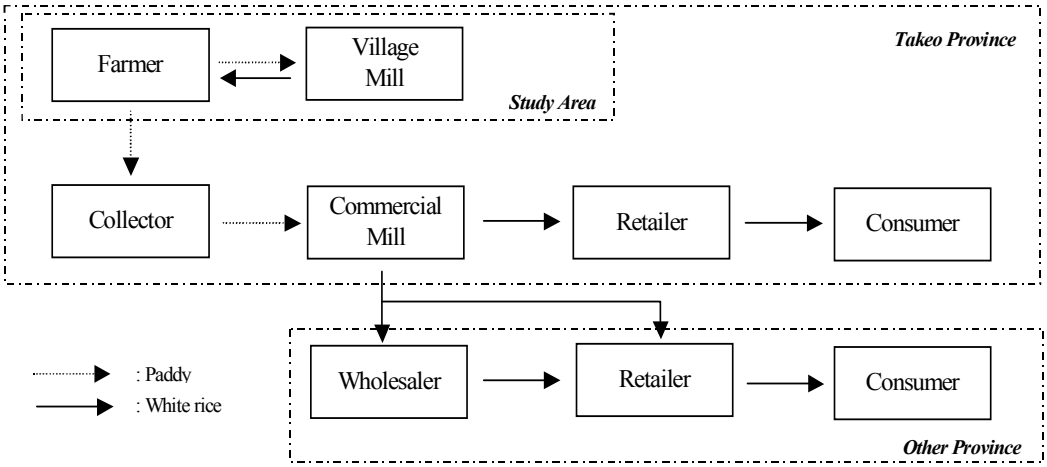
Storage : There are two ways for storage of paddy after drying. One is bulk storage in bamboo baskets placed on the floor of the house. The other is that the paddy is put in plastic bags of 50 - 70 kg capacity and stored in a house or in a wooden shed. It is said that no serious losses / damages by rats and mold during storage are observed.

Rice Mill :Based on data of the Department of Industry and Mining in Takeo Province, it is estimated that there are about 1,000 rice mills in the Study Area. The processing capacity of those rice mills is very small, say 200 - 300 kg/hr. The most popular machinery is the Chinese made Engerberg Type. Another is the smaller Vietnamese made "Stamar" that combines a rubber roll type husker and friction type whitener. The processing fee is normally paid in bran and husk as by-products. When millers return the by-products, the fee is Riel 250 - 300 per basket (12 kg) of paddy.

II-1.8.4 Marketing of Agricultural Products

The marketing practices by farmers in the Study Area are as follows:

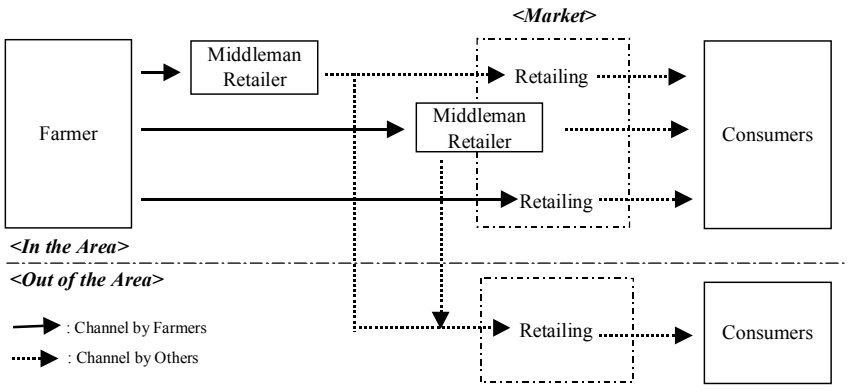
(1) Rice : Since they need money for their daily life, most farmers sell their paddy to collectors soon after harvest and store a small amount for home-consumption. Some farmers store their paddy and sell it when they need cash and/or when the market price rises. Some farmers sell the white rice after milling it themselves. Some farmers sell the paddy directly to a middleman, a big rice mill and retailers in the market. Farmers receive market information mainly from i) collectors coming to their houses, ii) markets they go to, and iii) neighboring farmers.



Paddy /White Rice Market Channel

(2) Other Products (Vegetable, Fruits, Pig, Duck and Chicken) : Pigs are usually sold to collectors who transport them from the farmer's house to a slaughterhouse. For other products, farmers have the following ways for selling:

i) Selling to a retailer in a market or a trader coming to their houses.
ii) Going to a market and selling to a trader or a retailer.
iii) Going to a market and selling to consumers as a retailer in a market.



Market Channel of Products except Rice

II-1.8.5 Markets

There are 26 public markets authorized by Department of Commerce in Takeo Province of which five (5) are in the Study Area. The five markets are shown in Fig. II-1.8.1. In the market, many kinds of agricultural products are sold, such as rice, vegetables, fruit, fish, and meat. Other than these public markets, there are many places, such as entrances to villages and cross roads where several small shops are located, and where small quantities of agricultural products are traded. Each public market is managed by its own Market Management Committee authorized by the District Government. The Market Management Committee collects a fee from all the sellers. There are 2,022 sellers in the markets registered in Takeo Province, of which 543 are in five markets in the Study Area.

In the early morning, from about 5 to 8 a.m., retailers, traders and producers in the surrounding area gather in the market and carry out wholesale trading. Afterwards, the retailing activities are carried out. Most of the sellers of agricultural products in the market are the women of farm households. They collect the products from the neighboring farmers and sell them as well as their own products. Some of them go to other markets, even to Phnom Penh, to collect products to sell in the local market. Thus, their activities often combine various functions such as producer/retailer, retailer/middleman and producer/middleman.

Each public market has one or two slaughterhouses where pigs, mainly, are slaughtered from midnight. Their carcasses are transferred to the market in the early morning. The facilities are very poor in view of sanitary control. An authorized butcher does the slaughtering and a veterinarian must inspect the carcasses and stamp those that are passed.

II-1. 9 Rural and Social Infrastructures

II-1.9.1 Rural Roads

(1) Access in the Study Area

The main roads in the Study Area are National Roads No.2 and No.3 shown in the location map. Other road network and accessibility have been confirmed by interview survey at each commune and also in the field. Total length of the roads in the Study Area is about 585 km and the road density is 8.8 m/ha. These roads are classified into the following and are illustrated in Fig. II-1.9.1:

- Road width : less than 3 m / 3 to 5 m / over 5 m
- Condition : good / poor

- Accessibility : All season accessible by car (ASC) or by motorcycle (ASM)
  Dry season accessible by car (DSC) or by motorcycle (DSM)
  All season not accessible (ASX)

It should be noted that there are no road bridges over the Slakou River upstream of the National Road No.3.

(2) Inventory Survey

In the course of the Inventory Survey, the present conditions of roads/dikes in the Study Area were checked at 661 points at crossings or junctions. All roads on the 1:50,000 scale map were inspected. They were evaluated according to the same classification as used for the irrigation canals. The results are given below:

Results of Inventory Survey of Roads /Dikes

Evaluation Item	A	B	C	D	Total
Number	272	194	164	31	661
Percentage	41.1%	29.3%	24.8%	4.7%	100.0%

II-1.9.2 Other Infrastructures

(1) Domestic Water Supply

People in the Study Area, obtain water for domestic use from wells (open well, tubewell with pump), rivers and natural streams, reservoirs and ponds. On average about 30 families depend on one well. O Saray and Kus Communes have the poorest condition in terms of access to wells or safe drinking water. Most people drink this water after sterilizing by boiling, but some poor villagers drink without any treatment. Provincial Direction of Rural Development (DRD) has a section for water supply, which coordinates development of wells and treatment of surface water for drinking purpose in rural areas. The distribution of wells in the communes related to the Study Area (Takeo Province) is illustrated in Fig. II-1.9.2.

(2) Sanitation

Sanitation facilities in the Study Area are mostly prepared by individual household. However, in rural or remote areas, people are not accustomed to use latrine. On average, the density of latrine is about 17 households per one toilet. The distribution of latrines in the communes related to the Study Area (Takeo Province) is illustrated in Fig. II-1.9.2. Parts and materials for the latrine are made and provided by various programs and projects funded by government, NGOs and IOs. Provincial Rural Development Committee and District Office jointly coordinate the improvement of sanitation facilities in the rural area.

(3) Electric Supply

There exist only two power stations in/around the Study Area. They are the power station of Electricite de Cambodia (EDC) in Takeo town and a private power station in Angk Ta Saom. Out of Takeo town and Angk Ta Saom, there are no facilities for electricity supply. Features of the stations are given below:

Features of Power Stations in Takeo

Features / Power Station	EDC Takeo	Angk Ta Saom
Type of power generation	Diesel	Diesel
Power	500 KW+200KW	150 KW+90KW
Service household	2,000 HH	300 HH
Unit charge (average)	900 Real/KWH	2,000 Real/KWH
Average household consumption	50KWH/month	3~15KWH/month

Source: EDC Takeo, Seng's Power Station, Angk Ta Saom

(4) Community Center and Communication

There are several community centers in the Study Area. In some communes, "multipurpose community centers" are built beside the commune offices on the project basis. The commune office itself is quite small without even minimum facilities such as water supply, toilet, etc.

No ground lines for telephone are available in the Study Area. Only mobile phones are used east of National Road No.3. Chiefs of the communes or police stations have hand transceivers (walky-talky) for communicating with the District office.

(5) School

According to the Provincial Direction of Education, Takeo, there are 59 primary schools, four (4) secondary schools, and two (2) high schools in Tram Kak District. In general, a main primary school is established at the commune center, and four or five branch schools are distributed around the commune. The numbers of teachers and students for the primary school in Tram Kak District are 912 and 34,638 (38.0 students per teacher), while those for the secondary schools are 105 and 6,395 (60.9 students per teacher). The primary school is built by DRD in coordination with other departments, NGOs and IOs. The distribution of schools in the related communes is illustrated in Fig. II-1.9.2. When compared with other types of infrastructure, schools are evenly distributed in the Study Area.

(6) Health Center and Hospital

Infrastructure for health care is handled by the Ministry of Health, Provincial

Direction of Health (DOH), and District Office. There are five provincial hospitals (DOH calls "referral hospital") in Bati, Kiri Vong, Doun Kaev, Prey Kabas and Tram Kak. Under each hospital, health centers are distributed. Doctors and/or other medical staff at the hospital make rounds of the health centers periodically. Some medical staff are trained at the health center for daily medical consultation and primary health care. In Tram Kak District, there is a provincial hospital at Angk Roka in Ta Phem Commune, and nine health centers exist under the hospital.

II-1.10 Rural Society

II-1.10.1 Living Condition of Farmers in the Study Area

Most poor farmers live in thatched or plywood-walled high-floored houses. About 79 % of households have only one room and about 19 % have two rooms. About 68 % of households have a radio, and about 58 % have a television set in spite of no-electricity supply. Bicycle and motorcycle are the most popular means of transportation in villages. About 78 % of households have a bicycle and about 31 % have a motorcycle. Ox cart is still common in rural areas. In case of long distance transfer or heavy/ large load, pickup motorbike and pickup truck are used as public transportation. Most of the households in the Study Area use kerosene for lights, and firewood for cooking, while some use batteries that are rechargeable at a small shop.

II-1.10.2 Rural Community and Community Groups

The fundamental community unit in the rural area is the village (Phum), which is a group of around 100 - 150 families. The commune (Khum), which is a terminal administrative unit in the country, generally consists of around 10 to 20 villages. It seems that most of the residents in the rural area have a greater sense of belonging to their village than to their commune. Some studies report that a family consisting of parents and children, is a basic unit for living. Consequently, families are generally not large, and the relationship to their relatives is not so strong traditionally.

Activities by farmers groups in the rural community are traditionally unusual except those by religious groups. This is because it makes farmers remember i) the Pol Pot regime, and ii) the collective farming system by the solidarity group, *Krom Sammaki Bangkor Bangkaeun Phall (Krom Sammaki)* organized by the government in 1980's, which is disliked by them.

Under these circumstances, NGOs and MRD have recently tried to organize rural community associations. These community groups are established at village level

under the community development programs by "participatory and grass root approach". The following community groups are observed:

- Exchange of labor force for on-farm work
- Pagoda activity for construction of temples, village infrastructure, such as schools, and roads
- Farmers or community groups in village for drinking water use and credit
- Rice Bank Group supported by NGO or Village Development Committee (VDC)

II-1.10.3 Poverty and Vulnerable Groups

The Socio-Economic Survey of 1993/94 indicated that 38 % of Cambodia's households were below the poverty line; 24 % of Phonon Penh's households, 35% of households in other urban area, and 40 % of rural households. The poverty line was defined only by the per capita calorie requirement of 2,100 calories per day.

"A Poverty Profile of Cambodia, 1997" by the World Bank based on the above survey presented the following description of poverty:

- Poverty rate of rural households is 43 %, 4 times that of Phnom Penh city, which has an 11 % of poverty rate.
- Poverty rate of farmer-headed households is 46 %, and more than 75 % of the poor households are headed by a family member with an agricultural occupation.
- The poverty rate of households with uneducated heads of the household is 47 %.

Based on the interview survey with each commune chief, the rate of these vulnerable groups in the Study Area are estimated as follows:

Preliminary Estimation of Vulnerable Groups in the Study Area

(Unit: % of households)

1. Repatriates of refugees from Thailand's border during Khmer Rouge Regime	2 %
2. Displaced households by calamities/insecurity in the country	Less than 1 %
3. Tenant farmers	Less than 1 %
4. Landless farmers (farm labor)	4 %
5. Female-headed households	24 %

Source: Interview survey with each commune chief by the Study Team

II-1.10.4 Institution and Program for Rural Development

The Ministry of Rural Development (MRD) is responsible for rural development in Cambodia aiming at contribution to alleviation of poverty. For this, MRD started SEILA program in 1996 and it is now at Stage II (2001-2005) . The program aims at i) strengthening of local government's ownership and governance, and ii) alleviation of poverty in rural area by decentralization and deconcentration. The program is conducted by i) beneficiaries participation to rural development, and ii) local

government's management for finance, planning and implementation of rural development plans. Stage I of the program covered 220 communes in 6 provinces and the Stage II is scheduled to cover 1,216 communes in 17 provinces. One hundred communes in Takeo province are included in the program. A development plan on rural infrastructure prepared by a commune is evaluated/assessed and financed if approved by the MRD. However, CRDCs and VDCs having not been functioning well under establishment stage, no plans have yet been submitted by any of the communes in the Study Area. The budget of the program is about US$ 95.2 million which is expected from donor countries and international aid organizations.

In line with the program, the MRD is also promoting establishment of a Village Development Committee (VDC) and Commune Rural Development Committee (CRDC) in each village and commune to facilitate a bottom-up approach and participation in each project by villagers. In the Study Area, five (5) out of 18 communes surveyed by interview with a commune chief have established VDC and CRDC. Other three communes have established only VDC but no CRDC. The VDC generally have five members including two females. Some VDCs consist of three members including one female. The members of CRDC consist of representatives from VDCs. The major activities of VDC and CRDC are rice bank, credit for fertilizer and micro-credit (of RD&RP), agricultural extension, health education, education for women and children, repairing of roads, etc. supported by MRD and in collaboration with NGOs.

II-1.10.5 Rural and Community Development by Foreign AIDs and NGOs

In and around the Study Area, the following rural and community development program / projects are underway with the support or collaboration of international organizations, and NGOs.

- RD&RP by JICA and ASEAN countries of Indonesia, Malaysia, the Philippines and Thailand for agriculture, income generation, education and public health (17 villages of 4 communes in the Study Area are included in the RD&RP.)
- PRASAC II (Support Program for the Agricultural Sector in Cambodia) by EU for domestic water supply, sustainable agricultural productivity, credit and micro enterprises, and project management / institutional support
- Community Development by OXFAM for establishment of FWUC, community organization, credit / village bank, etc.
- SEILA Program II by RGC and UNDP for rural development and capacity building of local administration (Commune) by using grant and loan funds by bilateral and/or multilateral organizations (By the year 2004, all 100 communes

in Takeo will be covered by the Program.)

- Rural Infrastructure Improvement Project by ADB for improvement of road and infrastructures, irrigation development, and well development for domestic use in six (6) provinces (Takeo, Kampot, Kandal, Svay Rieng, Preyeleng, Kampong Cham) with a cost of USD 24 million
- In addition, there are several rural infrastructure projects by international organizations and NGOs in and around the Study Area. For example, NGOs such as MCC and AMDA are working for forestry, fishery and health sectors.

II-1.10.6 Farmers' Needs and Awareness

A social environmental baseline survey conducted on a local sub-contract basis examined problems and constraints in farming, and expectations from and needs to the project or government support. The results are summarized as follows:

(1) Problems and Constraints in Farming

1)	Shortage of irrigation water	85.1 %
2)	Low yield of paddy rice	73.6 %
3)	Low knowledge of farming technology	51.7 %
4)	Damage by insect and/ or disease	34.8 %
5)	Shortage or lack of cash income product	21.9 %
6)	Shortage or lack of fertilizers	14.9 %
7)	Low quality of productive paddy rice	10.0 %
8)	Low price of paddy rice	8.0 %

(2) Expectations from and Needs to the Project or Government Support

1)	Improvement of irrigation facilities	72.2 %
2)	Improvement/ repair of farm roads	65.2 %
3)	Guidance of pest/ disease/ rat control	56.2 %
4)	Credit for purchase of fertilizer and improved seed	32.8 %
5)	Guidance of paddy farming techniques	17.4 %
6)	Distribution of fertilizers	12.4 %
7)	Distribution of improved seed	9.0 %
8)	Supply of drinking water	7.0 %

(3) Participatory Awareness Level for the Project

Participation of beneficiaries in the project at every step, such as planning of project, construction and/or reconstruction/rehabilitation, and operation and maintenance is necessary to make the project effective and sustainable. Most farmers (almost 100 %) agree to participate in construction works for on-farm irrigation facilities; construction, hauling, assistance, sharing construction cost, donation of local materials, and equipment and draft animals for construction works.

Most farmers clearly show their intention to be a member of FWUC and pay ISF and

member fee on condition that such fee is reasonable. They also agree to participate in O & M for irrigation services.

(4) Negative Benefit

At present, farmers are planting on reservoir areas in the rainy season. If the existing dikes of reservoirs are rehabilitated, inundation depth in the reservoir area will increase. Most of the farmers who use such area for rain-fed paddy cultivation understand that reservoirs and dikes/roads/canals are RGC's property, and that planting on such areas is illegal. About 35 % of farmers agree to lose their present cultivation area without any compensation, but about 60 % of farmers require compensation such as substitute land or money. If the application of fertilizers and agricultural chemicals cause serious negative impact on the present drinking water sources, such as rivers, ponds and wells, most of the farmers (almost 100 %) will need other drinking water source.

CHAPTER II-2 DEVELOPMENT CONSTRAINTS

II-2.1 Analytical Methods

The objectives of the master plan aiming at sustainable development in the Study Area are to increase farm income and improve the present low living standard. The development constrains for the master plan objectives shall be identified and assessed in due consideration of their causes and effects under the present socio-economic and natural conditions. On the basis of data and information obtained, identification and verification of the development constraints were made by undertaking the following studies:

1) Review of the available reports, literature and documents,
2) Review of engineering data and information collected on local sub-contract basis, such as soil, water quality, runoff of rivers, profile and cross section of reservoirs, supplementary topographic survey, inventory survey of existing facilities, etc.,
3) Social environmental baseline survey on local sub-contract basis,
4) Field observation and survey with counterpart personnel,
5) Meeting with RGC's officials, such as MOWRAM , MAFF, MRD, etc.,
6) Meeting with provincial governmental officials,
7) Interviews with beneficiaries,
8) Interview survey with traders, middlemen and collectors in local markets,
9) Workshops at several villages with counterpart personnel, and
10) Interviews with NGOs.

II-2.2 Constraints Resulting in Farmers' Low Living Standard

The majority of households in the Study Area depend on income from farming activity that is the mono culture of paddy under rain-fed conditions. A small amount of harvested paddy is stored for home-consumption and most of it is immediately sold for cash to meet production and living costs. After the stored paddy has been consumed, some farmers need to buy rice at local markets or from neighboring farmers. Around 70 % of farm households in the Study Area have a very limited surplus of rice after balancing sales and home consumption. In order to get more cash income, livestock raising and cash crop cultivation are practiced in the area, but the levels of productivity and income are still low. A problem tree for the low living standard of farmers was prepared on the basis of causes and effects assessment as shown in Fig. II-2.2.1. It is concluded that this low living standard of farmers is caused mainly by i) insufficient food (rice) and ii) low farm income arising from the

following causes:

- Non-availability of irrigation water,
- Poor knowledge on improved farming technologies,
- Little availability of rice bank, i.e. village level rice security and marketing system through depositing storage and lending consumption,
- Little availability of agricultural credit,
- Unawareness of marketing,
- Non-availability of market information,
- Poor agro-processing facilities, and
- Poor road condition.

II-2.3 Development Constraints

The development constraints are summarized by the following critical subjects :

1) Irrigation
   - Economically and environmentally suitable sites for shallow bunded reservoir are topographically limited, and their storage capacity of irrigation water is also limited.
   - The existing irrigation facilities have been considerably damaged.
2) Agriculture
   - About 90 % of the rainfall is concentrated in the rainy season.
   - The soil in the area is of poor fertility.
   - The farmers have difficulty in buying agricultural inputs such as quality seed and fertilizers due to a shortage of funds.
   - The farmers have hardly received any agricultural extension services for cultivation of paddy and cash crops, and animal husbandry including vaccination services.
3) Agriculture Support Services (Farmers Group, Extension, Credit, Agro-processing and Marketing)
   - The farmers hardly have any experience of farmers group.
   - The number of extension workers for agriculture and animal husbandry is limited.
   - Agro-processing facilities for product of animal husbandry and cash crops is limited.
   - No farmers groups have been organized for purchase of agricultural inputs and marketing.
   - The farmers have not yet become familiar with the free-market policy of

RGC.

- Agricultural credit services are very limited.
- The roads to markets is very poor.

4) Institution of FWUC and Governmental Project Office

- The farmers hardly have any experience of FWUC.
- The farmer's income is very low for payment of irrigation fee.
- The farmers have hardly any experience in communication with the central and local government offices.
- The organization of Takeo Office of MOWRAM (DWRAM) is not appropriate for the implementation.
- The engineering capability of MOWRAM (DWRAM) for planning, design, construction or its supervision and operation and maintenance, is not appropriate for the implementation of the master plan.

5) Environment

- Cultivation is illegally undertaken inside the reservoir areas.

The Master Plan shall be formulated taking the above constraints into consideration. The required countermeasures for solution of the development constraints are shown in Table II-2.3.1.

CHAPTER II-3 WATER RESOURCES POTENTIAL

II-3.1 General

Surface water resources available for irrigation in the Study Area are i) rainfall, ii) water of the Slakou River system, and iii) water in small reservoirs and small ponds.

Average rainfall in the rainy season of six (6) months from May to October ranges from 150 mm to 250 mm on a monthly basis. With this average, the amount seems to be nearly sufficient to the water demands of paddy cultivation except for the period of land preparation and puddling. However, the rainfall is very erratic and unreliable for the efficient use for paddy cultivation. This is one of the major constraints leading to unstable agricultural production. Thus, a reliable irrigation water supply is required to attain stable agricultural production, even in the rainy season.

The water resources of the Slakou River system will be utilized in a practical manner through the rehabilitation and reconstruction of the dikes of the three reservoirs, canals and related structures.

Even in achievement of these water resources developments, the areas to benefit will be limited to the upper part of the Study Area because of absolute shortage of water resources in comparison with available vast cultivation area. The irrigation water in the most of the middle and lower parts of the Study Area will have to largely rely on return flow and surplus runoff coming through the upper irrigated areas in the rainy season.

It is, however, very risky to rely on only the return flow and surplus runoff, because in the drought year such water is drastically reduced. In order to cope with drought occurring even in the rainy season, as well as to practice normal irrigation, it may be proposed that existing small reservoirs and ponds should be rehabilitated and that small reservoirs and ponds should be provided in places where runoff can be easily utilized, and/or groundwater table lies near the ground surface.

II-3.2 Irrigation Development Potential by Water Resources of the Slakou River

(1) Development Alternatives

The development alternatives were studied on condition that the existing reservoirs be rehabilitated or reconstructed to a present level or similar level. The development alternatives under high dam and reservoirs in the upstream of the three existing reservoir sites were not studied.

In order to estimate the area that can be irrigated by the water resources of the Slakou River, a water balance between available water resources and irrigation water demands was prepared for various development alternatives.

Figure II-3.2.1 shows the relationship between water level and storage volume in the three reservoirs: Kpob Trobek Reservoir, O Saray Reservoir, and Tumnup Lok Reservoir. The following reservoir alternatives were conceived on condition that the dike top elevations of the reservoirs should not be changed largely from the present ones.

Features of Reservoir Alternatives

Reservoir	Elevation of Dike Top	H.W.L	Gross Capacity	20 years life			50 years life		
				Dead Storage	L.W.L	Effect.Storage	Dead Storage	L.W.L	Effect.Storage
Tumnup Lok	43.0 m	41.3 m	1.66 MCM	0.66 MCM	40.4 m	1.00 MCM	1.66 MCM	41.3 m	0.00 MCM
	44.0 m	42.3 m	3.30 MCM	0.66 MCM	40.4 m	2.64 MCM	1.66 MCM	41.3 m	1.64 MCM
O Saray	40.5 m	38.9 m	0.33 MCM	0.10 MCM	38.3 m	0.23 MCM	0.26 MCM	38.8 m	0.07 MCM
Kpob Trobek	39.0 m	37.3 m	2.77 MCM	0.13 MCM	34.2 m	2.63 MCM	0.34 MCM	34.8 m	2.43 MCM
	40.0 m	38.3 m	5.13 MCM	0.13 MCM	34.2 m	5.00 MCM	0.34 MCM	34.8 m	4.80 MCM

Further, the combination of the three reservoirs presents further development alternatives. A reservoir located nearest to the benefited area generally has advantage. Based on this principle, the development will be carried out in the order of (1) Kpob Trobek, (2) O Saray, and (3) Tumnup Lok, if other constraints do not override the proximity principal. O Saray Reservoir does, however, have a disadvantage in terms of its storage effectiveness.

Considering these matters, water balance calculation between available water resources and irrigation water demands were examined for the following 12 alternatives to find out irrigation acreage:

Alt. 1: Development of Kpob Trobek Reservoir only
- Alt. 1-1: Dike top elevation is 39 m.
- Alt. 1-2: Dike top elevation is 40 m.

Alt. 2: Development of Kpob Trobek Reservoir and O Saray Reservoir with a diversion canal from the O Saray to the Kpob Trobek.
- Alt. 2-1: Dike top elevation of the Kpob Trobek is 39 m.
- Alt. 2-2: Dike top elevation of the Kpob Trobek is 40 m.

Alt. 3: Development of Kpob Trobek Reservoir and Tumnup Lok Reservoir with a diversion canal from the Tumnup Lok to the Kpob Trobek.

	Dike Top Elevations	
	Kpob Trobek	Tumnup Lok
Alt. 3-1:	39 m	43 m
Alt. 3-2:	39 m	44 m
Alt. 3-3:	40 m	43 m
Alt. 3-4:	40 m	44 m

Alt. 4: Development of Kpob Trobek Reservoir, O Saray Reservoir and Tumnup Lok Reservoir with a diversion canal from the Tumnup Lok via O Saray to the Kpob Trobek.

	Dike Top Elevations	
	Kpob Trobek	Tumnup Lok
Alt. 4-1:	39 m	43 m
Alt. 4-2:	39 m	44 m
Alt. 4-3:	40 m	43 m
Alt. 4-4:	40 m	44 m

With reference to the Kpob Trobek Reservoir, the JICA Study Team was informed that RGC had a development plan to rehabilitate an existing reservoir (hereinafter called the Don Phe Reservoir) under the financial and technical assistance from the International Fund for Agricultural Development (IFAD). It is located on the Don Phe Stream about 13km upstream of the Kpob Trobek Reservoir in Kampot Province. This will seriously affect to the rehabilitation of Kpob Trobek Reservoir in terms of water resources availability and the development scale of the irrigation area. Thus the water balance calculation between irrigation water demands and available water resources was carried out for with-development of the Don Phe Reservoir. The catchment area of the Don Phe Reservoir is 70 km^2 corresponding to about 51 % of the Kpob Trobek Reservoir's catchment area (137 km^2).

(2) Water Balance Calculation

Farmers suffer from water shortage for paddy cultivation in the rainy season. They plant paddy seeking a period with an appropriate level of water availability during the long period from June to September every year and are often obliged to plant paddy in spite of water shortage due to erratic rainfall.

The land resources are large and many areas depend primarily on rainfall plus some residual water. This situation would not be drastically improved even after water resources development of the Slakou River, since the water resources are insufficient compared to the land resources. Under these circumstances, the farmers desire small amount of irrigation water to wider area than sufficient irrigation water to a limited area. They say that they need maximum use of the reservoir's water resources to extend irrigated fields to include as many of rain-fed fields as possible, even in high-water years. In response to their request, it is proposed to apply water saving irrigation method in the paddy fields to extend irrigated paddy fields.

The water balance calculation was therefore made between irrigation water requirements estimated based on the water saving irrigation method and available water resources.

Major conditions and assumptions used for the water balance calculations were as follows:

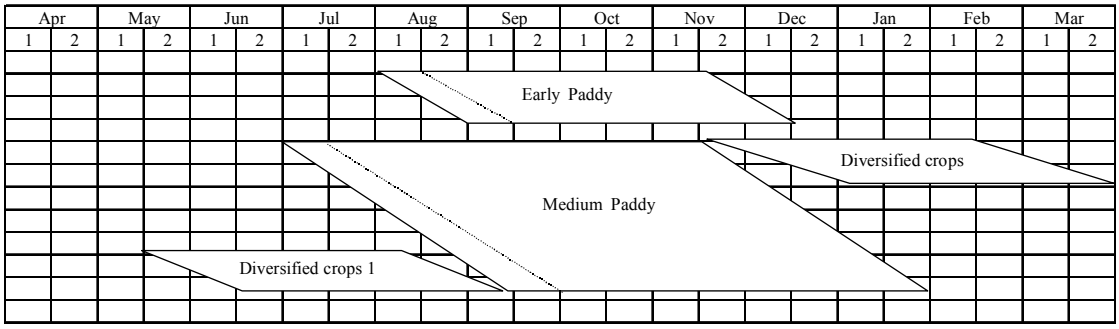
The water balance calculation was made for 20 years made up of four years from 1966 to 1969 and 16 years from 1985 and 2000 for estimating an irrigable area at 80 % dependability.

Estimated monthly runoff presented in Section II-1.3 was utilized for O Saray Reservoir and Tumnup Lok Reservoir.

For the Kpob Trobek Reservoir, assuming development of the Don Phe Reservoir, runoff flowing into Kpob Trobek Reservoir was taken to consist of (i) overflow discharge from the Don Phe Reservoir, and (ii) runoff from the basin between the Don Phe Reservoir and Kpob Trobek Reservoir. The overflow discharge from the Don Phe Reservoir was estimated by water balance calculation at the Don Phe Reservoir assuming that the cropping pattern the Study Team has proposed is adopted in the Don Phe Reservoir's benefit area, and that the Don Phe Reservoirs' effective storage is 2.5 MCM.

Net irrigation water requirements were estimated on the basis of the proposed cropping pattern (see the following figure), which basically follows the currently prevailing cropping pattern in which medium paddy is gradually transplanted through a long period from July to September.

Proposed Cropping Pattern



Under the water saving method, the paddy field after puddling and transplanting is supplied with water corresponding to the amount deducted effective rainfall from evapotranspiration throughout the total growing period except a period of 30 days starting at head initiation till the end of flowering. During the 30 days, moderate submergence is practiced with additional water supply including water corresponding to percolation loss. In this irrigation practice, percolation losses can be remarkably reduced and this irrigation method is expected to save water by 20 % to 25 % of

irrigation water requirements in comparison with conventional ponding irrigation method. Gross irrigation water requirements were estimated by simply dividing the irrigation water requirements by irrigation efficiency that is assumed to be 60 % for paddy cultivation or 55 % for diversified crop cultivation. The water saving irrigation method is illustrated in Fig. II-3.2.2.

The irrigation water requirements under the water saving irrigation method are shown below.

Irrigation Water Requirements at Five Year Recurrence Period

Unit: m^3/sec/1,000ha

Crop	Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Jan		Feb		Mar	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Medium Paddy							0.03	0.47	0.63	0.73	0.76	0.81	0.55	0.54	0.91	0.77	0.50	0.18						
Early Paddy										0.07	1.12	1.22	0.61	0.88	1.11	0.42								
Diversified Crop 1				0.22	0.44	0.62	0.53	0.57	0.42	0.11														
Diversified Crop 2																0.11	0.28	0.46	0.70	0.81	0.98	0.75	0.55	0.22

The water balance calculation results are shown in Table II-3.2.1. The following table shows irrigable areas and total irrigated cultivation areas for all the alternatives.

Irrigable Area and Total Irrigated Cultivation Area

Alternative	Irrigable Area (ha)	Total Irrigated Cultivation Area (ha)
Alt. 1-1	800	1,100
Alt. 1-2	950	1,500
Alt. 2-1	1,100	1,550
Alt. 2-2	1,350	1,800
Alt. 3-1	3,500	4,550
Alt. 3-2	4,000	5,400
Alt. 3-3	4,000	5,500
Alt. 3-4	4,500	6,100
Alt. 4-1	3,700	4,800
Alt. 4-2	4,100	5,600
Alt. 4-3	4,100	5,800
Alt. 4-4	4,600	6,300

(3) Influence to the Downstream Area by the Slakou River Water Resources Development

As explained in Section II-1.3, there are about 3,000 ha of paddy field below the Study Area that are habitually inundated. These paddy fields depend on the Slakou River together with inundation water. According to the water balance calculation, runoff spilling out from the three reservoirs would be more than the irrigation water demands of 18 MCM in the downstream area for 19 years out of 20 year, even for the

biggest development alternative (Alt. 4-4) as shown in Table II-3.2.2. Thus, it is judged that the water resources development of the three reservoirs would not affect the downstream paddy cultivation.

II-3.3 Other Water Resources

As for small ponds and small reservoirs, no hydrological data are available. The following specific runoff, which is simply derived from the estimated runoff for the O Saray Reservoir, is expected to be used for estimating the acreage to be irrigated by ponds or conversely for estimating the storage required to irrigate a certain area on condition that proposed ponds and reservoirs have a certain catchment area. In case of small ponds and reservoirs surrounded by paddy fields, runoff-starting is often one or two months late from June to July or August even in the normal year.

Estimated Specific Runoff from Small Catchment Area

m^3/month/ha

Dependability	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	13	0	0	0	0	69	89	186	595	852	345	89
80%	6	0	0	0	0	0	42	64	394	327	206	48

CHAPTER II-4 THE MASTER PLAN

II-4.1 Master Plan Concept and Development Framework

II-4.1.1 Master Plan Concept

(1) Objectives of the Master Plan

The objectives of the master plan are to i) increase farm income, and ii) improve the present low living standard of farmers in the Study Area to contribute to poverty alleviation and to stabilize regional food supply in the Study Area. In addition, development plan proposed in the master plan shall be a model for irrigation-based rehabilitation and reconstruction of agricultural production system in Cambodia.

(2) Preconditions for the Master Plan Formulation

The developments presented in the master plan need to satisfy the following conditions for sustainable development of the Study Area:

- They must have engineering adequacy in planning, design and construction in due consideration of i) conventional irrigation methodology in the Study Area, and ii) technical capability of central / local governments, and farmers.
- They shall not cause negative natural and social environmental impact.
- They shall not have a negative influence on the neighboring on-going projects.
- They shall not place an excessive financial burden on the central/local government and farmers in due consideration of their present financial status.
- They shall be economically viable.
- They shall satisfy the beneficiaries' needs and expectation.
- They shall create a framework of beneficiary participation and promote self-efforts of farmers.

(3) Development Concept for the Master Plan

The development concept used to formulate the master plan is as follows :

1) To efficiently utilize water and land resources for sustainable development,
2) To rehabilitate the existing reservoirs and irrigation facilities, as far as technically feasible, by minimizing new construction,
3) To construct ponds near farmhouses and use the existing Pol Pot canals as ponds for supplemental irrigation, domestic use and fishery,
4) To improve the present paddy-oriented agriculture for stabilization of the regional rice supply by applying irrigation, improved varieties and improved farming,
5) To introduce cash crops such as beans, vegetables, and oil crops, and livestock raising, such as pig and cow for increased farm income and improvement of

farmers nutrition

6) To improve the following agriculture support programs for realization and enlargement of irrigation and agriculture development effects, and to assure sustainable agricultural system by farmers themselves :
   - Organization of farmers groups at village level and training of leaders of farmers groups
   - Agricultural extension service including animal husbandry
   - Micro-credit service
   - Improvement of marketing of agro-product
   - Extension of agro-processing technology and information
7) To improve rural and farm roads for enhancement of farming, marketing and organization activities of farmers groups and FWUCs,
8) To organize sustainable FWUCs through beneficiary participation and undertake capacity building of the project office staff of MOWRAM for the implementation of the projects, and
9) To conserve the environment not to give negative impacts in and around the Study Area.

II-4.1.2 Master Plan Framework

(1) Framework for the Master Plan

The fundamental constraint for rehabilitation and reconstruction of agricultural production systems in the Slakou river basin is the limited water resources to increase productivity and promote product diversification. In order to fulfill the above objectives of the master plan, irrigation-based rehabilitation and reconstruction shall be applied for the formulation of the Mater Plan.

However, the amount of irrigation water that can be stored in reservoirs is very much limited as described in Chapter II-3. The Slakou River irrigation system constructed during the Pol Pot Regime was supposed to irrigate over 30,000 ha, but hydrological study shows that it would cover only about 3,500 ha under water-saving irrigation. On the other hand, there are about 15 small reservoirs in the Study Area, but the total irrigation area covered by them is only 280 ha with an average area of about 20 ha per reservoir. Without construction of a high dam and/or new diversion dam(s) in the Slakou River, the only way to increase irrigation water is to store as much rainfall and drainage water coming from upstream areas as possible by constructing ponds and utilizing the existing Pol Pot canals.

Based on the present availability of water resources, the following three (3)

development plans shall be applied for irrigation-based development in the area :

1) Upper Slakou River Irrigation Reconstruction Plan (USP)
2) Small Reservoir Rehabilitation Plan (SRP)
3) Small Pond Development Plan (PDP)

In addition, in order to assure and enlarge the above irrigation-based development benefits, the following support programs will be crucial ;

1) Rural/farm road improvement
2) Agriculture production
3) Agriculture support
4) Institutional development
5) Environmental conservation

Linkage between irrigation-based rehabilitation and reconstruction plans and support programs was formulated as follows:

Linkage between the Plan and Support Programs

Support Program	Irrigation-Based Development Plans		
	USP	SRP	PDP
Rural/farm road improvement	○	○	○
Agriculture production	○	○	○
Agriculture support	○	○	○
Institutional development	○	○	○
Environmental conservation	○	○	□

○ : Required □ : Limitedly required

Taking the period of Second Five-Year Development Plan (2001-2005) and the composition of the master plan components into consideration, the master plan period is set at from 2001 to 2010 for 10 years. The development concept and the framework for the master plan is illustrated in Fig. II-4.1.1.

(2) Development Frame on Rice Demand and Supply Situation

Based on the master plan concept, the future rice demand and supply situation in the Study Area needs to be assessed to clarify potential production volume and supply to the local and domestic demand. The Ministry of Planning[1] of RGC estimated that annual population growth rate will remain at a high level of 2.4 % for 2000 to 2010. Based on this growth rate and the population census in 1998, the population in the Study Area will increase from 165,600 in 1998 to 220,000 in 2010, that is 1.33 times the 1998 population. In order to secure the presently balanced demand and supply of

[1] : Statistical Year Book 2000 by National Institute of Statistics, Ministry of Planning

rice in the Study Area, paddy production needs to be increased by 2.4 % per year. Paddy demand in the Study Area in 2010 is estimated at 64,640 tons as shown below :

Paddy / Rice Balance in the Study Area in 2010

1	Population in 2010	220,000	At growth rate of 2.4 %/year
2	Per capita rice requirement	151.2 kg/year	MAFF standard
3.	Rice demand in 2010 in the Study Area	33,264 ton	
4.	Recovery rate of rice milling	62 %	MAFF standard
5.	Conversion to paddy	53,650 ton	
6.	Ratio of seed use and post-harvest loss	17 %	MAFF standard
7.	Paddy demand in 2010	64,640 ton	
8.	Paddy production of with-project	68,000 ton	Agri. production program
9.	Forecast paddy surplus at 2010 = (8)-(1)	3,360 ton	5 % of production

(3) Land Use Framework

Land use in the master plan was determined from the present land use and the following considerations:

1) Forest/wood/tree crop area: There are forest areas in the west of the Study Area where deforestation is in progress by logging, and there are elevated areas in the east of the Study Area where land lies in fallow. For such areas, tropical fruit trees are suitable. Reforestation including fruit trees needs to be undertaken at 240 ha per year. The target area is about 7,000 ha corresponding to about 160 % of the present forest area.
2) Bush/shrub area: The bush/shrub area will decrease from 9,130 ha to 5,000 ha by reforestation and new development to cultivation area.
3) Residential / facility area : Residential area and facility area including roads and canals will increase in the future from 7,260 ha to 10,000 ha through economic development and increase in residential area.
4) Cultivation area : As a balance of new cultivation area converted from bush/shrub area, and residential and facility area converted from present cultivation area, cultivation area in 2010 will be at the same level as the present cultivation area.

Land Use Plan

(Unit: ha)

	Cultivation area	Forest /tree crop	Bush / shrub	Residential area	Total
Present	44,240	4,370	9,130	7,260	65,000
Proposed	43,000*	7,000	5,000	10,000	65,000
Balance	-1,240	2,630	-4,130	2,740	0

* : Paddy filed 40,000 ha□Dry crop field 3,000 ha

II-4.2 Upper Slakou River Irrigation Reconstruction Plan

II-4.2.1 Development Alternatives

(1) Assumed Alternatives

Development alternatives were primarily examined on combination of reservoirs, route of diversion canal, and height of dikes.

Four series of alternatives are set by combination of reservoirs as follows:

Alternative 1: Kpob Trobek Reservoir only
Alternative 2: Kpob Trobek Reservoir and O Saray Reservoir
Alternative 3: Kpob Trobek Reservoir and Tumnup Lok Resrvoir
Alternative 4: Kpob Trobek Reservoir, O Saray Reservoir and Tumnup Lok Reservoir

Two alternative dike top elevations were set for both Kpob Trobek and Tumnum Lok Reservoirs, respectively. The alternatives are summarized in the following table along with dike top elevation and irrigation area.

Development Alternatives

Alternative	Combination of Reservoirs and Dike Top Elevation					Irrigation Area (ha)
	Kpob Trobek		O Saray Dike top EL=40.5m	Tumnup Lok		
		Dike top Elevation			Dike top Elevation	
Alt 1-1	○	39m	-	-	-	800
Alt 1-2	○	40m	-	-	-	950
Alt 2-1	○	39m	○	-	-	1,100
Alt 2-2	○	40m	○	-	-	1,350
Alt 3-1	○	39m	-	○	43m	3,500
Alt 3-2	○	39m	-	○	44m	4,000
Alt 3-3	○	40m	-	○	43m	4,000
Alt 3-4	○	40m	-	○	44m	4,500
Alt 4-1	○	39m	○	○	43m	3,700
Alt 4-2	○	39m	○	○	44m	4,100
Alt 4-3	○	40m	○	○	43m	4,100
Alt 4-4	○	40m	○	○	44m	4,600

Note: Irrigation area is the total irrigable area of rainy season with the estimated reservoir capacity of after 20 years of operation.

Alternative routes of a connection canal between Tumnup Lok and Kpob Trobek Reservoirs were examined as illustrated in Fig.II-4.2.1 and summarized as follows:

Route of Diversion Canal

Route	Dscription
Route-1	Existing canals (Kpob Trobek ~ O Saray ~ Tumnup Lok) are utilized.
Route-2	A canal is constructed to bypass O Saray Reservoir. Another diversion canal from O Saray Reservoir is connected to the bypass canal.
Route-3	A canal is constructed to bypass O Saray Reservoir. Water of the Ou Krouch Stream (O Saray) is not used.

Judging from construction cost and water management required for each route, Route-1 was adopted for Alternative series 2 (2-1, 2-2), Route-2 was adopted for Alternative series 4 (4-1, 4-2, 4-3, 4-4) and Route-3 was adopted for Alternative series 3 (3-1, 3-2, 3-4, 3-4).

(2) Screening of Alternatives

Water balance analysis was conducted for the above alternatives, in order to estimate the irrigable area by alternative. The results are explained in Sub-Section II-3.2 (2) "Water Balance Study".

The results show that O Saray Reservoir contributes to an increase in irrigable area in Alternative series 2, but little in Alternative series 4. Thus, Alternative series 4 is not considered further. Taking into account the irrigable area and the combinations, the following alternatives were finally selected for further evaluation.

Alternatives to be Evaluated

Alternatives	Reservoirs		Diversion Canal
	Stage-1	Stage-2	
Alternative 1-1	Kpob Trobek Low	None	None
Alternative 1-2	Kpob Trobek High	None	None
Alternative 2-2	Kpob Trobek High	O Saray	Route-1
Alternative 3-1	Kpob Trobek Low	Tumnup Lok Low	Route-3
Alternative 3-4	Kpob Trobek High	Tumnup Lok High	Route-3

(3) Irrigation System

In this development plan, the irrigation area is determined according to the irrigable area possible from the effective reservoir storage volume existing after 20 years of operation. Then, according to the irrigation area, irrigation command area was determined as follows.

Existing irrigation system should all be benefited even though the command area is small. Three irrigation canals start from Kpob Trobek Reservoir. They are Main

Canal 33, Koh Kaek Main Canal and Canal 24. Main Canal 33 irrigates northern part of the District Road No.33 until National Road No.3 amounting to 5,840 ha. Main Canal Koh Kaek irrigates exclusively between itself and Canal 60, totaling 12,220 ha. Canal 24 irrigates 1,840 ha between the canal itself and the Slakou River. The irrigation area of each alternative will be allocated according to the proportion of the above irrigation command area, namely 61.4 % for Main Canal Koh Kaek, 29.3 % for Main Canal 33 and 9.3 % for Canal 24.

The irrigation area[2] by canal system is shown below by alternative:

Irrigation Area by Alternative

Alternatives	Irrigation Area (ha)						
	Canal 24		Canal 33		Koh Kaek		Total
	Stage-1	Stage-2	Stage-1	Stage-2	Stage-1	Stage-2	
ALT 1-1	74	-	234	-	492	-	800
ALT 1-2	88	-	279	-	583	-	950
ALT 2-2	125	-	396	-	829	-	1,350
ALT 3-1	74	251	234	791	492	1,658	3,500
ALT 3-4	88	330	279	1,040	583	2,180	4,500

According to the above irrigation area, the extent of canal system or command area is delineated.

(4) Selection of Alternatives

Alternatives were examined and evaluated according to the following factors:

1) Cost and benefit (development cost per irrigation area)
2) Technical soundness (assumed technical problems, suitability as "development model")
3) Negative impact (social and natural environmental impact)
4) Government intention
5) Beneficiaries intention

1) Cost and Benefit

Direct construction cost was estimated for each alternative. It should be noted that the cost estimate has been carried out for comparative purposes only for selection of alternatives, and the cost consists of major works only. The actual construction cost is expected to be higher and will be estimated in the feasibility study.

The direct construction cost per irrigation area, which consists of reservoir,

[2] Irrigable area after 20 years of operation for rain season paddy rice.

diversion canal, and irrigation system is summarized below.

Direct Construction Cost by Alternative

	Irrigation Area (ha)	Direct Construction Cost per Ha (US$)			Total Cost (US$)
		Reservoir & Diversion	Irrigation System	Total	
ALT 1-1	800	3,210	1,980	5,190	4,152,000
ALT 1-2	950	4,102	2,017	6,119	5,813,000
ALT 2-2	1,350	4,711	1,996	6,707	9,055,000
ALT 3-1	3,500	2,049	1,434	3,483	12,189,000
ALT 3-4	4,500	2,285	1,738	4,023	18,103,000

Thus, the Alternative 3-1 is considered as the best development alternative in terms of "cost per irrigation area".

2) Technical Soundness

As for Kpob Trobek Reservoir, the "High" alternative has a maximum water level of EL.39.1 m and requires special attention to the O Saray village center (Tuol Khlong) which is located on the depression on the downstream of the proposed diversion canal and Kpob Trobek Reservoir. It is recommended to keep the dike elevation as low as possible for minimizing the flood risk to the village on the downstream.

There is a village road on the left bank of Tumnup Lok Reservoir at 600 m from the Tras Stream of the Slakou River. The present elevation of the road is about EL.42.0 m. For the "Tumnup Lok High" alternative, namely, Alternative-V, the maximum water level in the reservoir will be 42.3 m, which exceeds the present elevation of the village road and residential area. As mentioned in "3) Negative Impact" in the following, large area of existing paddy fields would be submerged by the reservoir. As a model plan of reconstruction and rehabilitation, such development alternative is not suitable both in terms of negative impact and increase of project cost for land acquisition and relocation. Thus "High" alternatives of Kpob Trobek and Tumnup Lok are evaluated as being lower in terms of technical soundness.

3) Negative Impact

As for Alternative 3-4, reservoir or inundation area of Tumnup Lok Reservoir will increase by 90 ha by raising the dike height by one (1) meter. This increased inundation area is being used as paddy field legally on private land. Negative impact not only physical impact as "decrease of production from that area" but also social impact by relocation and/or land acquisition would be significant.

If Kpob Trobek Reservoir were raised to EL. 40.0 m, some households would have to be relocated from the reservoir area. Moreover, more farmers cultivating within the reservoir area will have to abandon the cultivation, even though the land is registered as a public asset and their cultivation is illegal.

4) Government Intention

The government of Cambodia, MOWRAM and local government of Takeo Province, Tram Kak District, etc. all intend to develop a larger area for increasing food production, activation of the local economy and poverty alleviation.

5) Beneficiaries Intention

According to the results of interview survey of people in the Study Area, the biggest development need is "irrigation". Thus, the alternatives providing the largest irrigation area meet the need of the beneficiaries.

Evaluation of Alternatives

	Alt 1-1	Alt 1-2	Alt 2-2	Alt 3-1	Alt 3-4
Cost and benefit	□	○	○	○	□
Technical soundness	○	□	□	○	□
Negative impact	○	□	□	○	×
Government intention	×	□	×	○	○
Beneficiaries intention	×	□	×	○	○

Consequently, Alternative3-1 is recommended as the best alternative. The proposed irrigation area is shown in Fig. II-4.2.2.

II-4.2.2 Consideration on Operation and Maintenance

(1) Survey on Beneficiaries' Intention

According to the extent of the above-mentioned irrigation area, a preliminary survey on beneficiaries' intention was carried out by using a questionnaire form at the village level. The purpose of the survey was to formulate an adequate operation and maintenance plan through an understanding of the beneficiaries' intentions and readiness to accept the development plan.

As a result, most of the villages agreed with the government policy on FWUC, namely, payment of the ISF, O&M works by FWUC, contribution to the project, etc.

Judging from the results of the interview survey, an overview of the beneficiaries in the irrigation command area is as follows:

> They do not have experience of activities of WUG or FWUC, but they have done some O&M works of irrigation system before at village level. They are ready and willing to organize FWUC for the project. They will contribute to the project by participating in the construction works, provision of lands, etc. They did not know the policy of FWUC prepared by MOWRAM, but now agree with the policy on O&M, paying of ISF, and duties of FWUC. The first development priority for them is "irrigation".

(2) Possible Operation and Maintenance to be Conducted by Beneficiaries

Considering the above-mentioned overview of the beneficiaries, it will be possible to involve the beneficiaries in the project. However, it will not be possible to hand over the Upper Slakou Irrigation System to the beneficiaries right after completion of the construction. Moreover, the technical irrigation system proposed here is not familiar even to the staff of MOWRAM.

Therefore, intensive training on operation, maintenance and water management should be conducted as component of the project for the staff of MOWRAM and FWUC. In the course of the project implementation, MOWRAM staff in Takeo Province will be trained intensively as "training of trainers", and they will train FWUC. The hand over of the system to FWUC is considered as a "target" of the master plan even the target year of the hand over could be earlier.

II-4.2.3 Design of Irrigation Facilities

(1) Basic Concept of Design

Taking into; i) basic concept of the irrigation development plan, ii) poor experience of farmers on water management or community-level activities, and iii) poor O&M ability and budget, the irrigation system should be designed to use local materials and technologies, and maintenance-free facilities as much as possible. Moreover, the design should focus on restoration of the original function of facilities but not on increasing the capacity.

(2) Irrigation Water Requirement

Based on the agriculture production program mentioned in Section II-4.5, irrigation water requirements were examined. The water requirements were estimated for 20 years by using actual rainfall data. The peak requirement is 1.1 liter/s/ha, which

occurs at the end of land preparation period. Irrigation efficiencies are set at 60 % for paddy rice and 55 % for diversified crops.

(3) Reservoir Facilities

Reservoir facilities, such as dike, gates, spillway, etc. are designed based on the following criteria and approaches:

1) The dike will be a homogenous structure with mixture of laterite and soil material with rip rap protection on the upstream and sod facing on the downstream,
2) 1 in 100 year flood is adopted as design flood,
3) Sedimentation rate of 0.1 mm/km^2/year is adopted,
4) Spillways consist of overflow fixed concrete type and operational gate type,
5) Freeboard of the reservoir is set at 0.90 m,
6) All the gates are to be operated manually, and their dimension and numbers are determined taking maneuverability into account.

(4) Canal System

The design capacity of the canal is determined by the peak irrigation requirement, namely 1.1 liter/s/ha.

According to the results of the inventory survey on the canal and structures, the capacity of the above-mentioned three main and secondary canal is mostly sufficient to accommodate the design capacity. However, design of canal should be done also taking into account current velocity so that erosion and sedimentation in the canal be controlled. The design velocity should, in general, range from 0.4 to 0.7 m/s for earth canal, while for lined canal, it should range from 0.4 to 1.0 m/s.

Related structures of the canal system, particularly crossing structures such as road crossing culvert, bridges, etc. should be designed to have sufficient capacity or section for both water flow and maintenance works.

II-4.3 Small Reservoir Rehabilitation Plan

II-4.3.1 Development Concept

In the Study Area, there are 31 small reservoirs registered as shown in Fig.II-4.3.1, which were mostly constructed under the Pol Pot Regime. The reservoirs were generally constructed across the natural stream or depression composed of earth dike, outlet structure (gate or pipe) and gate-type spillway.

In this Study, rehabilitation of the existing small reservoirs for irrigation purpose is considered. The reservoirs which are located outside the Upper Slakou Irrigation

Reconstruction Plan (USP) and have higher benefit, will be given priority. Since little technical information is available on the small reservoirs, field inspection survey was conducted to evaluate technical and economic viability based on the availability of a water source, estimated capacity, and confirmation of beneficiaries' intention.

The irrigation area of these reservoirs is mostly less than 50 ha. Thus, the Small Reservoir Rehabilitation Plan (SRP) is considered as a model of small scale irrigation scheme with the reservoir.

II-4.3.2 Evaluation of Existing Small Reservoirs

(1) Field Survey

The existing reservoirs were examined by field inspection survey, which was conducted focusing on; i) water source, ii) reservoir capacity, iii) effective water depth for operation, iv) number, dimension and condition of structures, v) necessary rehabilitation works, vi) irrigable area and vii) beneficiaries' intention. Out of 31 reservoirs registered, two reservoirs used for the Upper Slakou Irrigation System, namely, Kpob Trobek and Tumnup Lok Reservoirs were excluded. Some reservoirs were also excluded through preliminary screening, because they have been abandoned or already converted to land for other purposes such as paddy field. A few reservoirs were newly identified according to additional information from the communes or villages. Results of the survey are given in Table II-4.3.1.

(2) Evaluation

Considering the development concept of the Small Reservoir Rehabilitation Plan, the existing small reservoirs were evaluated on six items of; i) water source availability, ii) construction volume required, iii) technical soundness (balance of design flood and reservoir capacity), iv) increase of irrigation area after rehabilitation (effectiveness of the project), v) possibility of participation of beneficiaries and vi) location (if the irrigation area is located within the USP command area).

Each small reservoir is evaluated according to the total score as follows:

Overall Evaluation

Total Score	Evaluation
Over 25	A
21 to 25	B
16 to 20	C
15 or less	D

II-4.3.3 Development Plan

The evaluation results are shown in Table II-4.3.2. Two reservoirs scored "A", namely, Kim Sei Reservoir in Nhaeng Nhang Commune and Ang 160 Reservoir in Trapeang Thum Khang Tboung Commune. The details are given in Fig. II-4.3.2 and Fig. II-4.3.3. These two reservoirs are recommended with top priority for a pilot rehabilitation plan. Seven reservoirs with the evaluation "B" and six reservoirs with "C" are recommended for the second and the third stages, respectively, while the reservoirs with the evaluation "D" or lower are not recommended for the Plan. The Small Reservoir Rehabilitation Plan is shown in Table II-4.3.3, and summarized below :

Development Plan by Stage

Stage	Nos of Reservoirs	Total Irrigation Area
Stage -1	2	42 ha
Stage-2	7	144 ha
Stage-3	6	101 ha
Total	(15)	(286 ha)

II-4.4 Small Pond Development Plan

II-4.4.1 Development Concept

(1) Type of Small Ponds

There are a number of multipurpose ponds in the Study Area. They are mostly operated by individuals and/or groups of several families. In this Study, development of three types of small ponds is proposed and examined. They are i) small pond operated by farmers groups, ii) small pond operated by an individual farmer, and iii) small ponds utilizing an existing canal.

(2) Target of the Plan

In the Study Area, there are 276 villages, out of which about 30 villages are fully covered by the Upper Slakou River Irrigation Reconstruction Plan (USP). Priority for the Small Pond Development Plan (PDP) will be given to the villages which would not be covered by USP. All such villages in the Study Area (about 250 villages) will be covered by the Plan (PDP).

(3) Stages of Development

Aiming at providing all the households located outside the USP and SRP with small ponds, the Small Pond Development Plan (PDP) is proposed to be conducted in three stages as follows:

1) Pilot Development Stage (Stage-1)

Four years will be spent on the "Pilot Development Stage". The purpose of the stage is i) to train two "village extension workers" on vegetable cultivation in each village through development of one "small pond operated by a farmers group" and five "small ponds operated by an individual farmer" in each village, and ii) to feed back outcomes for formulation of further development stages.

2) Intensive Development Stage (Stage-2)

Five years will be spent on the "Intensive Development Stage". The target of the stage is to develop small ponds intensively with trained village extension workers. Three additional "village extension workers" for vegetable cultivation will be trained in each village through development of four (4) "small ponds operated by a farmers group" and 20 "small ponds operated by an individual farmer" in each village. There are five sub-villages in a village on average, and an extension worker would be responsible for a sub-village.

3) Self-supportive Development Stage (Stage-3)

Four years until the target year will be spent as "self-supportive development stage". Trained extension workers and project staff in each village will manage the project for new applicants. The target of the stage is to develop small ponds self-supportively to provide the remaining households with seven (7) "small ponds operated by a farmers group" and 35 "small ponds operated by an individual farmer" in each village.

Number of Ponds to be Developed per Village

	Stage-1	Stage-2	Stage-3
Training of Village Extension Workers	2	3	-
Small Pond Operated by Farmers Group	1	4	7
Small Pond Operated by Individual Farmer	5	20	35

II-4.4.2 Small Ponds Operated by Farmers Group

(1) Design Concept

Taking into account the size of existing ponds and construction works which can be managed by several farm households, the maximum size of a pond is assumed at 25 m x 25 m with a depth of 3 m as shown in Fig. II-4.4.1. The depth of 3 m is set considering ground water table in the lowland of the Study Area, i.e. 2 to 2.5 m below the ground level, so that the groundwater can be utilized to some extent through the year. According to the agricultural development plan, the irrigation area to be achieved by these ponds is based on the following conditions:

- Crop-1: vegetables (90 days, August to October)
- Crop-2: vegetables (90 days, November to January)
- Net water requirement: 400 mm (for 90 days)
- Irrigation efficiency: 80 %
- Other water requirement: 50 mm
- Evaporation loss: 5 mm/day
- Percolation loss: 2 mm/day

A model plan and its irrigable area are shown in Fig. II-4.4.1. As a result, 0.34 ha of vegetables can be irrigated for the Crop-1 (August to October), while 0.15 ha of vegetables for the Crop-2 (November to January).

Water requirements for other purposes such as drinking water for livestock or aqua culture are included in the pond capacity, taking into account actual and practical usage of the ponds in rural areas.

(2) Project Formulation

This type of small pond would be constructed, operated and maintained by the farmers' group. The project will prepare an application form for the target villages, and the villages or VDCs will organize farmers groups which possess the necessary land for the small pond irrigation system. The groups will send an application form to the project office through the VDCs, and the project will assess the application confirming i) availability of land, ii) location and technical feasibility (particularly on catchment area and water sources), iii) contribution of beneficiaries to the project, etc. The target groups would be selected from the applicants or recommended groups by the village, paying special attention to poor farm households.

The project will provide i) engineering services, ii) construction materials, iii) rent of equipment for construction works if necessary, iv) rent or provision of portable engine pump, v) agricultural supporting services including training of village extension workers, etc. The construction machines of DWRAM, PRASAC and/or private contractors are available in Takeo, and they can be utilized for the construction works.

II-4.4.3 Small Ponds Operated by Individual Farmer

(1) Design Concept

According to the agricultural development plan and cultivable area of vegetables by a family, i.e. 0.05 ha~0.10 ha, the dimension of the model pond is determined as shown in Fig. II-4.4.2. The depth of the pond is set at 3 m.

Following the same design conditions, the irrigable area and necessary catchment are examined. As a result, 0.07 ha of vegetables can be irrigated for the Crop-1 (August to October), while 0.03 ha of vegetables for the Crop-2 (November to January).

(2) Project Formulation

This type of small pond would be constructed, operated and maintained by individual farmers. The application and appraisal procedure are the same as those mentioned above.

Since the constructed pond would be a private asset, a certain percentage of the project cost including salary for the extension workers should be borne by the beneficiaries.

II-4.4.4 Small Ponds Utilizing Existing Canal

(1) Design Concept

According to the size of the existing canals, two types of small ponds are examined as shown in Fig. II-4.4.3. "Small type" is for the canals with top width of 5 to 10 m, while "large type" is for the larger canals with top width of 10 m or more. The former has a depth of 2 m and the latter has 3 m.

According to the same design conditions, the irrigable area and necessary catchment are examined. The irrigable area is summarized below:

Irrigable Area by Pond Utilizing Existing Canal

Type of Pond	Irrigable Area (m^2/m)		Catchment Area Required
	Crop-1 (August to October)	Crop-2 (November to January)	
Small type (B=7 m, H=2 m)	10 m on both side	4 m on both side	0.02 ha (29 times of pond area)
Large type (B-10 m, H=3 m)	27 m on both side	11 m on both side	0.05 ha (50 times of pond area)

The size and location of existing canals and location are shown in Fig. II-4.4.4, which was prepared according to the results of the Inventory Survey of the canals. Most of the canals seem to have enough width for the large type.

(2) Project Formulation

In general, the land for the canal belongs to the public, and the small pond utilizing the existing canal should be operated by "farmers groups" that are registered and entitled to use the canal as a pond.

According to the same procedure as other ponds, the farmers who have lands along the canals would form a group and apply for participation in the project. The target groups would be selected from the applicants or recommended groups by the village, paying special attention to poor farm households.

The project will provide; i) engineering services, ii) construction materials, iii) rent of equipment for construction works if necessary, iv) rent or provision of portable engine pump, v) agricultural supporting services by village extension workers, etc. Operation for the individual ponds will be managed by the related farmers group, and FWUC will be organized for each canal system consisting of the farmers groups. Each farmers group would pay a water charge to FWUC.

II-4.5 Agriculture Production Program

II-4.5.1 Crop Selection and Cropping Pattern

Proposed crops for the three (3) irrigation development plans are selected as shown below, on the basis of the following principles necessary for attainment of the objectives of the master plan mentioned in Section II-4.1:

Selected Crops of 3 Development Plans

Plans	Paddy	Diversified Crops
1. Upper Slakou River Irri. Reconstruction (3,500 ha)	HYVs (early duration period paddy of IR-series) and Improved local varieties (medium duration period varieties)	Maize, Beans (Mung-bean, Soybean), Groundnut, Sesame, and Vegetables (Cucumber, Tomato, Eggplant, String-bean, Watermelon, Pumpkin, Mustard green, Chili, etc.)
2. Small Reservoir Rehabilitation (280 ha)		
3. Small Pond Development (2,100 ha out of 39,220 ha)	HYVs or Improved local varieties (medium duration period varieties) under rain-fed condition	Beans (Mung-bean, Soybean), Groundnut, Sesame, and Vegetables (Cucumber, Tomato, Eggplant, String-bean, Watermelon, Pumpkin, Mustard green, Chili, etc.)

1) To adopt paddy-based farming system in order to attain food sufficiency of the residents in the Study Area, and to plant paddy during the rainy season,
2) To introduce crop diversification before or after paddy cropping within the extent of available irrigation water in order to increase farmers' income, and
3) To select suitable diversified crops by examination of the suitability for natural conditions, profitability, marketability of products including processing capacity for industrial development in Cambodia, and present level of farmers farming technique. The selected crops are tabulated below :

The proposed cropping patterns for the three (3) development plans are shown in Fig. II-4.5.1, which were examined by the following considerations:

1) To plant HYV paddy in about 30% of irrigated paddy area for attainment of food sufficiency in the Study Area, and increase in double cropping of paddy and diversified crops. (HYVs are of higher yield and shorter growing period than improved local varieties, but are not liked by farmers because of the low market price and unsatisfactory taste to Cambodian people.)
2) To carry out land preparation during the heavy rainfall period from September to October, because the highest water demand is for land preparation,
3) To plant and irrigate diversified crops before or after paddy cropping within the extent of available irrigation water,
4) To plant high-profitability crops (vegetables) as some of the proposed diversified crops in the irrigation area in due consideration of available labor force, marketability, technical level of farming and available supporting system of guidance on farming technique and marketing of products. Especially, for the Small Pond Development, such vegetables and beans are proposed for the whole irrigation area because one farmhouse operates only 0.07 ha of irrigation area on average.

Irrigation area of the three development plans is 5,880 ha in total, and the plans will cover all of villages and farm households in the Study Area. Estimated beneficiaries of Upper Slakou River Irrigation Reconstruction Plan (USP), Small Reservoir Rehabilitation Plan (SRP), and Small Pond Development Plan (PDP) are roughly estimated at 4,500, 1,400 and 30,000, respectively.

Beneficiaries of 3 Development Plans

Plans	Irrigation area (ha)	Estimated beneficiaries	
		Nos. of villages	Nos. of beneficiaries
1. USP	3,500	36	4,500 (households of related villages by population census)
2. SRP	280	15	1,400 (0.2ha/household)
3. PDP	2,100	250	30,000 (250 village x 120)
Total	5,880	276 *	33,000 *

Note *: Some villages and beneficiaries will be duplicated within 3 development plans.

II-4.5.2 Prospective Crop Production

Anticipated unit yields of the irrigated crops are estimated on the basis of the actual high yield, results of agricultural research and information of extension workers. The target yields are estimated as shown in the following table, in due consideration of low soil fertility, cropping under lower sunlight conditions in the rainy season, and application of water saving irrigation.

Anticipated Unit Yields of Irrigation Area

Crop	Anticipated yield (ton/ha)		Note
	USP & SRP	PDP *	
Paddy (medium)	2.8	-	Improved local varieties
Paddy (early)	3.3	-	HYVs of IR series
Maize	2.0	-	
Groundnut	0.85	0.68	
Soybean / Mung-bean	1.0	0.80	
Sesame	0.8	0.64	
Vegetables	8.3	6.7	Average of suitable vegetables

Note *: Yields for crops of PDP are assumed at 80% of those of USD and PDP due to manual irrigation. Refer to Table II-4.5.1.

The proposed cropping area and production in the future is shown in Table II-4.5.1. It is expected that paddy production will increase to nearly twice that of the present condition, and diversified crops including vegetables will be major crops in the irrigated area.

Cropped Area, Production and Production Increase in Irrigation Area

Crop	Cropping Area (ha)	Production (ton)	Increment (ton)
Paddy	3,780	11,178	6,654
Maize	86	173	143
Groundnut	520	378	346
Soybean/Mung-bean	1,058	906	823
Sesame	520	356	356
Vegetables	1,980	13,970	12,640
Total	7,944		

Refer to Table II-4.5.1.

The results of analysis on the gross income, production cost, profit and incremental profit in the irrigable areas are shown in Table II-4.5.2 and summarized below.

Estimated Income Increase

(Unit: million Riel)

Plan	Gross income	Profit	Incremental profit	Note
- USP	6,656	4,647	3,621	For 3,500 ha
- SRP	532	372	287	For 280 ha
- PDP	23,382	15,103	3,663	For 39,220 ha
Farm household of median size				
- USP	1.52	1.06	0.83	Median size farmers: 0.8 ha/household
- SRP	1.52	1.06	0.82	
- PDP	0.48	0.31	0.07	Irrigation area: 0.07 ha/household

Refer to Table II-4.5.2.

II-4.5.3 Livestock Production in Paddy-based Farming

Many farmers are raising livestock, such as cattle and pig. In particular, pig raising is a major cash income source of farm households currently. The feed of such animals

depend mainly on by-products of paddy production, such as rice bran and broken rice for pig, and rice straw for cattle. Therefore, the production increase in paddy and diversified crops, would enable farmers to increase potential animal production, and cash income. For this, farmers expect production increase in paddy to solve shortage of animal feed, one of the major limitation of present animal husbandry, and increase their cash income.

II-4.5.4 Improvement of Farming System

Under the rehabilitation and reconstruction of irrigation facilities, the following improvements to farming systems are required for attainment of the development target :

(1) Paddy

- To use improved varieties, i.e. both of HYVs and improved local varieties, and properly renewed seed at farmers level,
- To multiply seed of improved varieties of which stock seed will be supplied from agricultural researches,
- To improve soil productivity through using farm manure, and deeper plowing by tractor if available in the future,
- To improve seeding rate for nursery and plant density of main field for reduction of seed cost and stimulation of plant tilling in the field through the trials. (Current seeding rate is too high, and plant density in the paddy field is too high, namely over-growing),
- To apply the proper amount of fertilizer required for the target yield level containing a proper ratio of N, P and K, and proper timing of application. (At present, in spite of poor fertile soil condition, fertilizer is applied at extremely low level, and farmers do not use potassium nutrient),
- To practice intensive weeding by following present transplanting method, and to dispose of weed-seeds properly after harvest and before plowing in order to avoid utilization of herbicide,
- To apply Integrated Pest Management (IPM) to avoid the use of chemical pesticide, and
- To activate farmers groups at village level to strengthen the above-proposed activities, such as seed multiplication, group buying of inputs, dissemination of improved farming practices, extension of improved varieties, verification in the demonstration plots, group collection and shipping of products and credit service in order to support finance of input cost.

(2) Diversified Crops and Vegetable

- To introduce improved varieties in cooperation with agricultural researchers and seed dealers,
- To apply high-ridge cultivation in the rainy season to avoid water-logging damage,
- To efficiently use water for irrigation of secondary crops,
- To disseminate modern farming practices of vegetables in regard to nursery management, thinning, pruning, fruit-tinning, support sticks preparation, etc.,
- To use farm manure and proper chemical-fertilizers,
- To control quality of products,
- To sort grade and quality of products,
- To improve packing and transportation of products in order to maintain quality and freshness, and
- To activate farmers groups at village level to strengthen the proposed activities.

(3) Livestock (Cattle and Pig)

- To improve utilization of crop's by-products: rice straw, rice bran, plant stalks/stems, and waste products of vegetable fruits and beans/nuts,
- To improve animal breeds for improvement of productivity through introduction of improved breeder-animals. (Regarding cattle, breeds for beef production may be appropriate to cope with mechanization of field work in the future),
- To improve nutrition of animals through feed improvement,
- To improve animal health by vaccination and veterinary services, and
- To improve pen/shed of animals for effective use of animal waste as farm manure, maintenance of animal health, and prevention of animal's grazing field crops.

II-4.6 Rural Road Improvement Program

II-4.6.1 Development Concept

Roads in the Study Area play significant roles of i) access to living necessities and various services, ii) farm road to convey agricultural input, and iii) market road to forward agricultural products to the market.

Taking into account various development constraints to road improvement, namely, i) limited budget for new construction or reconstruction, ii) land acquisition or availability of land, and iii) difficulties in maintenance works, the rural road improvement in the Study Area is proposed in accordance with the following concept.

(1) Rehabilitation of Primary Roads

Target of the plan is primarily set as “rehabilitation of existing road network”. New construction will require a large budget for construction and arrangement for land acquisition. Poor condition of the existing roads will be improved and the access to the primary roads, which connect District Center and Commune Centers and/or main connecting road between provinces. The road width is set at 6 m in total with laterite surfacing.

(2) Rehabilitation of Secondary Roads

Secondary roads provide access to the primary roads. They should be all-season road accessible by car. The target of road improvement of the Study is set; “to provide all the villages with secondary (or primary) roads of good condition at least within two (2) kilometers from the village”. If the development level (target) is raised from “2 km” to “1 km”, many lines of new road should be constructed. Moreover, it is considered that road construction up to 2 km can be managed by villages getting some technical or financial support. The road width is set 5 m in total with laterite surfacing.

(3) Improvement of Access Road to the Primary or Secondary Road

Considering the high construction costs and difficulties in acquisition of land, it is recommended to utilize land for canals for access roads, because it is not under private tenure. Soil materials excavated during canal construction will be utilized for road construction involving some mixture of laterite. This technique is adopted in many road improvement projects conducted by MRD, WFP, etc. The target of the improvement is that all the villages have access to primary or secondary roads in all seasons.

II-4.6.2 Rehabilitation of Primary and Secondary Roads

(1) Primary Road

The following table shows distance between the commune centers and good-condition primary roads that connect to the district centers.

ADB road from National Road No.3 to Kus is under construction, and the primary roads to Angk Kaev and Khvav are located outside the Study Area. Thus, the road from Trapeang Thum Khan Cheung to Trapeang Kranhung (13 km) via O Saray is selected as top priority.

Distance between Commune Center and Good-conditioned Primary Road

Districts/ Commune	Primary Road	Distance (km)
Tram Kak District		
Angk Ta Saom	National Road No.3	0
Cheang Tong	District Road No.33 (ADB-R2)	0
Kus	ADB Road from National Road No.3	1.0
Leay Bour	National Road No.22	0
Nhaeng Nhang	National Road No.3	0
Otdam Souriya	ADB Road (R11)	0
O Saray	District Road No.33 (ADB-R2), at Trapeang Thum Khang Cheung	7.5
Popeel	National Road No.3	0
Samraong	ADB Road (R1)	0
Srae Ronoung	MRD Road	0
Ta Phem	District Road No.33 (ADB-R2)	0
Tram Kak	National Road No.3	0
T.T.K. Cheung	District Road No.33 (ADB-R2)	0
T. Kranhung	District Road No.33 (ADB-R2), at Trapeang Thum Khang Cheung	13.0
T.T.K. Tboung	ADB Road (R1)	0
Samraong District		
Lumchang	National Road No.2	0
Treang District		
Roneam	DRD Road	0
Angk Kaev	National Road No.2	8.0
Khvav	DRD Road (Roneam)	2.0

(2) Identification of Primary and Secondary Roads to be Rehabilitated

The primary or secondary roads in good condition are very sparsely distributed in the Study Area. According to the development level mentioned above, areas covered by the “good primary or secondary road” is delineated as shown in Fig. II-4.6.1.

The extent of rehabilitation of the existing roads was identified to extend their present service or coverage areas. The identified roads are listed in Table II-4.6.1 and their coverage areas are shown in Fig. II-4.6.2.

(3) Prioritization

Length of the identified roads to be rehabilitated is 154.3 km in total length. These roads were prioritized conforming to three criteria; i) coverage of the rehabilitated road, ii) present condition of road (magnitude of need), and iii) road classification (traffic load). Priority was set from the first to third priority according to the total score as follows:

Total Score and Priority

Road Classification	Total Score
1st priority	Over 12
2nd priority	10 ~12
3rd priority	Less than 10

The result of the prioritization is shown in Table II-4.6.1.

(4) Project Implementation and Contribution by the Beneficiaries

The main implementation organization for the rehabilitation of primary and secondary roads will be the Project Office established for the project. Beneficiaries of the project will be involved in both design and implementation. Contribution and participation of the beneficiaries will be achieved through involvement in the construction works, provision of land, soil materials, etc.

II-4.6.3 Improvement of Access Road to the Secondary Road

Improvement of the access road would be proposed by the village or village development committee (VDC) to the Project Office, which will be organized for implementing the project. The villages will submit proposals for the rehabilitation of access roads by using a format prepared by the Project Office. The Project Office will appraise the proposals, give technical guidance and arrange some construction materials and equipment for the village. The villagers are expected to construct the access road by themselves.

II-4.7 Agriculture Support Programs

II-4.7.1 Farmers Groups at Village Level

(1) Village Development Committee (VDC)

Farmers have a sense of belonging to a village, not to Commune. In order to support irrigation-based rehabilitation and reconstruction plans, an organization of Farmers Groups (FGs[3]), which are positioned under a VDC, is necessary. In parallel, FWUCs will be organized, but FWUCs are generally different from FGs because the village boundary does not always coincide with the boundary of the irrigation area.

Before FGs are organized, it is common for international organizations, NGOs and Ministry of Rural Development (MRD) to organize VDC, because VDC have the following important roles and responsibilities for organization of the FGs:

[3] MRD has named the organization as “sub-committee”.

1) The VDC strengthen the FGs' ability to coordinate the needs and aspirations of villagers by enhancing genuine people's participation in planning, execution, monitoring and evaluation of village development action,
2) The VDC should democratically represent villagers in the higher-level rural development committees, such as Commune Rural Development Committee (CRDC), Provincial Rural Development Committee (PRDC), and MRD, in line with the Government's policy of decentralization,
3) The VDC is responsible for all the FGs' activities or programs because the VDC members are elected by villagers who belong to FGs, and
4) The VDC should supervises FGs' activities or programs, and give managerial advice and technical information to FGs, because the VDC members get training from various aid groups and/or higher organizations to do so.

At present, some of the VDCs have no know-how to organize FGs except for VDCs which have been established under support of international organizations, MRD and NGOs for group credit, rice bank, pig bank, etc. Therefore, the support by such organizations is indispensable to organize the VDCs. In view of the present situation that the member of the CRDC consists of representatives of the VDCs, and that the CRDC have not yet been established in most of the Communes, the organization of the VDCs is essential for that of the CRDC.

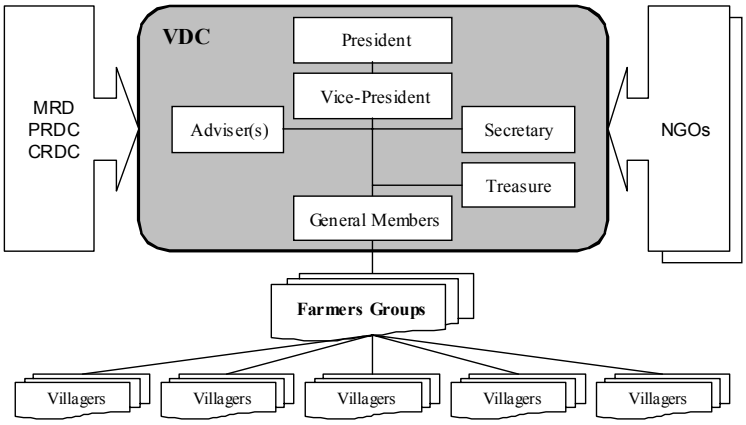
The steps for organization of VDC are as follows:

1) Establishment of VDC

The VDC should consist of more than seven (7)[4] members (at least three (3) female members since the MRD requirement is 40 %). Participation of females to the VDC is minimum condition to reflect female opinions on the committee. The VDC member should be elected by villagers' voting in the following manner:

1) Holding a general meeting of villagers for the election of VDC members.
2) Selection of candidates for VDC members by farmers' recommendation.
3) Establishment of the Commission for Election consisting of members of PRDC, Commune Chief, Village Chief, several elder people, and NGOs.
4) The voting by villagers of 18 years of age and over.

[4] Minimum number is7 for small village (less than 100 HH) and the maximum is 9 for large village (more than 100 HH).



VDC and FGs

The voting and the vote counting should be done on the same day, and the Commission should supervise the voting and the vote counting. After the election, the VDC members should register their VDC into PRDC. Villagers conduct the re-election of the VDC every three years. One village must have only one VDC.

2) Capacity Building of VDC

For capacity building of VDC, that of PRDC is necessary, since the PRDC should be responsible for sustainable training of newly organized VDCs. The PRDC should guide VDCs about reinvestment for new activities, such as credit and marketing, and way to solve problems of VDCs and FGs' activities and programs. According to the Government Decision No. 02 Sar.Sar.Ror dated 01 January 1999, the PRDC has the responsibility to support VDCs, and the Department of Training and Research (DTR) of the MRD is responsible for training PRDC staff. The capacity building of VDC should be implemented in cooperation with the PRDC, foreign aid projects, and NGOs.

(2) FG Organization Program

1) Decision of FG's Activity

Firstly, Participatory Rural Appraisal (PRA) Workshops should be held in a village to listen to opinions of farmers and needs for organization of FGs. If they realize the necessity and want to organize the FG, the VDC calls a farmers' general meeting. In the meeting, farmers should discuss the objective and plan of the FGs' activity or program, and organize FGs, if they agree to it.

2) Organization of FGs

All farmers who want to join the FGs, such as FG for credit and FG for marketing,

can be members of each FG, who should understand and agree to abide by the By-Law made by VDC.

3) Election of Representatives of FG

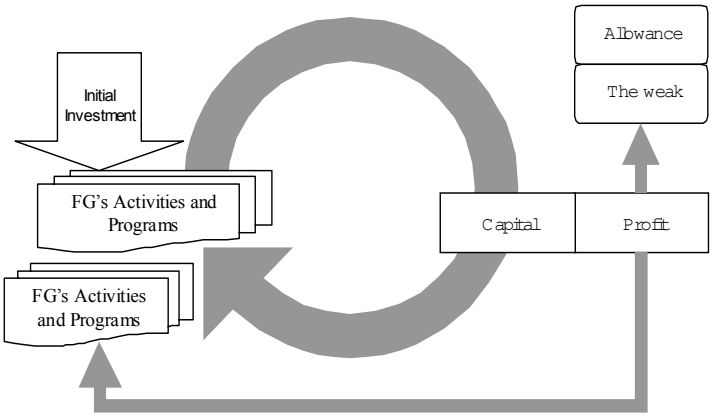
One (1) FG should consist of one (1) representative and one (1) vice-representative. The representatives have to be VDC member. The vice-representative should be elected from the FG members by voting. These representatives should be responsible for forming budget, keeping account and reporting account to the FG member. The VDC members should supervise the FG and be responsible for all the FG's activities or program. Biannual meeting with VDC should be held.

4) Allowance

The VDC members and the (vice-) representatives of each FG should get some allowance from the profit of FG's activity or program due to their heavy responsibility and works. The amounts of allowance for each (vice-) representative should be at the farmers' general meeting, depending on the profit of FG's activity or program and degree of their contribution.

5) Continuation and Sustainability of FG's Activity

The benefit from FG's activity or program should be reinvested for another activity or program, if it is decided by FG's general meeting. The almsgiving to the weak in village as charity and public work in the village will be one of alternatives. The below procedure for organization of FGs should be implemented in cooperation with the PRDC, foreign aid projects, and NGOs.



General Concept of FG's Activity's or Program's Cycle

6) Enlargement of Present FG's Activity or Program

About a half of villages in the upstream area (O Saray, Trapeang Thum Khang Cheung, Trapeang Thum Khang Tboung, and Samraong Communes) already have a few FGs per village for rice bank, credit, etc. at present. For such FGs, they should establish a new FG for another objective, such as extension, marketing, etc. under the VDC based on the present FG's experience and organization.

II-4.7.2 Extension Service of Agriculture and Animal Husbandry

(1) Concept and Procedures of Improvement of Extension Services

The extension services for livestock husbandry and paddy seed multiplication will be executed through farmers groups organized for such purposes as agricultural extension, livestock and seed production. The relationship of each farmers group is illustrated in Fig. II-4.7.1.

1) Agricultural Extension

Agricultural extension service system should be improved to increase production of paddy and diversified crops. DAFF Takeo is providing FFS (Field Farmers School) aiming at training of leader farmers, and District office of DAFF supports field activity the trained farmers. However, the systematic extension activities have not been observed in the Study Area due to the shortage of manpower and budget of DAFF.

Activities such as preparation and distribution of technical booklet, and periodical training and guidance for extension workers by research institutes, should be strengthened further; aiming at i) utilization of results of research institutes such as CARDI for extension activities on the field, ii) establishment of close cooperation and coordination between research and extension activities, and iii) capacity building of extension workers. These activities would be performed by the research institutes getting cooperation of Department of Agronomy and Agricultural Land Improvement (DAALI) for research and Department of Extension for extension.

In order to strengthen the farming practice in the Study Area, it will be necessary i) to train leader farmers for village level extension activities through FFS, ii) to organize a extension farmers group under VDC in which trained farmers perform as group leaders for extension activities, iii) to set up demonstration plots in the village, iv) to multiply and distribute improved paddy seed, and v) to assign field staff (field extension specialists) for technical service of cropping to the farmers groups and coordination with DAFF.

i) Extension farmers group will be organized under VDC. The leaders of the group will participate in FFS provided by DAFF, and they will act as core persons of extension activities in their village using demonstration plots. The group would operates group purchase of farm inputs, such as improved seed and fertilizer in order to reduce transportation costs, to get inputs of good quality, and to lower purchase price by bulk dealing. The extension farmers group will have some potential for expansion of their activities or joint-operation with other farmers groups, for group use of agricultural machinery, group selling of products, group processing of products, group credit, and cooperation with FWUC.

ii) DAFF will provide FFS for training of leader farmers selected from their VDC. FFS will be held at commune office, school or pagoda in around the village every week (1 - 2 days / week) during four months according to the cropping season of target crops (paddy and diversified crops including vegetables). About 30 farmer participants will attend in a session of FFS.

iii) Demonstration plots of major crops (paddy and diversified crops including vegetable) will be provided at farmers' fields in order to demonstrate and verify improved-varieties and improved farming technique, and to examine improved farming technique by the group members. Improved varieties of diversified crops will be planted in the demonstration plots. The seed will be introduced from agricultural researches or seed dealers.

iv) Seed multiplication of paddy is indispensable in the irrigated area in order to distribute improved paddy seeds to farmers. The seed multiplication will be done by seed-growing farmers groups in the irrigated area. DAFF Takeo will give the technical guidance and inspection of produced seed through the farmers groups.

v) The field extension specialists are necessary to activate performance of the extension groups and to coordinate support services from DAFF. They will be recruited from local consultants or participate from local NGOs.

2) Extension Services on Livestock Husbandry

Improvement of livestock husbandry is the responsibility of the Extension Section and the Animal Production Section of DAFF Takeo, for extension of animal husbandry and for vaccination/veterinary services, respectively. However, the service activities are not sufficient due to the shortage of staff and budget. Some NGOs are working on livestock husbandry in their targeted villages. The executing agency of the project should recruit field livestock specialists from local consultants or collaborate with NGOs in Cambodia. Extension on livestock husbandry will be required for the beneficiaries of two irrigation development plans, namely Upper Slakou River Irrigation Reconstruction Plan and Small Reservoir Rehabilitation Plan.

The activities will consist of i) training of model livestock farmers (demonstration plots) FFS on target animals, and ii) importation of improved breeding stock from researchers or progressive areas in Cambodia. The model farmers would be leaders of livestock farmers groups. The leader farmers will be trained in improved animal husbandry techniques, such as feeding, animal pen/hut facilities and animal health in FFS provided by DAFF. The model farmers will demonstrate improved animal husbandry, and the leader farmers will supply young animals of improved breed to the group members, and disseminate raising technique to farmers in the village.

(2) Implementation Schedule of Extension Improvement

Improvement of extension services by the extension farmers groups will be done in accordance with the implementation schedule of irrigation facilities. The setting of demonstration plot and training of leader farmers will be executed from construction stage of each development plan.

Training of the seed-production farmers groups will commence with the construction stage of the irrigation facilities. DAFF and seed-company will give technical guidance and seed inspection to the seed production farmers group in the field and training program.

The livestock extension service will start after the completion of irrigation facilities of each stage of irrigation plan. The program includes importation of improved breeding stock and training of model livestock farmers.

(3) Required Inputs for Extension Improvement

The required inputs for extension improvement are as follows :

Agriculture Extension

- Inputs of demonstration plots (fertilizer and seeds),
- Training of leader farmers,
- Field level extension specialists (to be recruited from local consultants or NGOs),
- Senior extension specialist / Trainer for field level extension specialists, and
- Extension facilities and equipment including transportation and communication facilities.

Seed Multiplication

- Importing improved breeder seeds, and
- Training of seed growing farmers.

Livestock

- Improved breeding stock (cattle and pig),
- Simple facilities and equipment for animal pen/hut for model farmers,

- Vaccine and medicine for animals,
- Field livestock specialists (to be recruited from local consultants or NGOs),
- Senior livestock specialist / Trainer for field level livestock specialists, and
- Livestock extension facilities and equipment including transportation and communication facilities.

II-4.7.3 Credit Service

(1) Concept of Credit Service

There is no governmental institutional credit system in Cambodia. Instead of governmental system, institutional micro-credit system has become relatively well developed through the support of ADB and other donors. Several micro-credit services run by NGOs are available in villages of the Study Area. The production costs for the future production program has been prepared on the condition that inputs will increase to about three times present inputs. The current financial capacity of farmers is insufficient for proper investment in farm inputs. In order to attain targets of the program, agricultural credit system is indispensable for farmers, and collaboration with NGOs will be essential. In addition, credit farmers groups should be organized under VDC in villages so that farmers can easily receive group credit and savings in collaboration with the NGOs. The farmers groups are obligated to repay the credit with the collective responsibility. The groups should be acquainted with cash/fund management, accounting by group and group management of credit leading to self-management of self-fund from NGOs.

A target of credit service program is self-management/ operation of farmers group fund with self-operation skill. Furthermore, the following are proposed:

- To establish their own revolving fund for group savings, benefit of group business, savings from labor fee of the construction work under the implementation of development plans, loan or grant by donors,
- To operate credit services with other farmers groups, and
- To accumulate margin of in-kind credit such as rice bank, pig bank, in-kind distribution of farm inputs.

The micro-credit system in the rural area is important not only for agricultural inputs but also for other purposes such as investment in rural business, improvement of housing or living situation, emergency needs for disease and education, and investment in land and animals.

(2) Training of Farmers Group on Credit and Savings

The following training of credit farmers groups are proposed:

- Encouragement of farmers group to accumulate savings,
- Training of leaders in the operation of group credit and accounting/bookkeeping, and
- Technical services for establishment and management of credit system.

II-4.7.4 Agro-Processing and Marketing

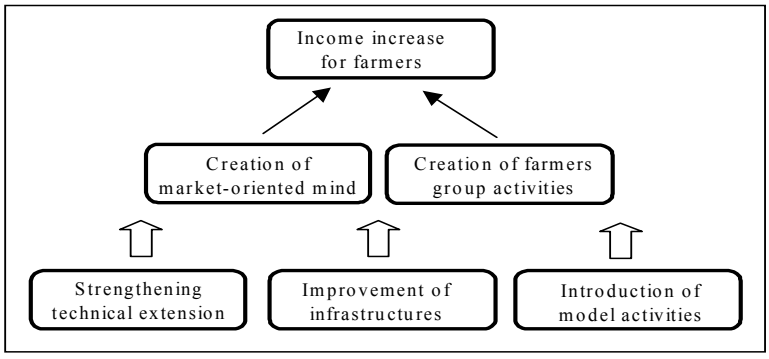
(1) Development Concept

The agro-processing and marketing development program was developed by reference to the agriculture production program for the three (3) irrigation development plans, the present condition of agro-processing facilities, and related information obtained in the Study Area. The objective of the program is to increase farm income in the irrigation area, and for this, the following are necessary:

- Creation of a market oriented attitude in farmers according to the proposed agriculture production program, and
- Creation or activation of farmers group activities for agro-processing and marketing in conformity with the free-market policy of RGC.

Under the free-market economy, competitiveness and value-added agro-product will be crucial for increasing income. The strategies for the agro-processing and marketing development program are set as follows:

1) Strengthening the technical extension to farmers,
2) Introduction of model farmers group activities, and
3) Improvement of infrastructures.



(2) Development of Rice Processing and Marketing

The development potential for rice processing and marketing is less than that of diversified crops, since the agriculture production program basically aims at rice self-sufficiency in the Study Area. The development programs shall be formulated as follows:

Post-harvest processing at farmer level

- Extension of post-harvest processing technology to the farmers for reduction of losses[5], and
- Provision of credit in order to enlarge and/or establish facilities for storing the increased rice production to be generated by the project.

Processing and marketing

- Establishment of assembling capability and facilities for selling surplus rice production in order to promote trading between producers and buyers, such as traders and consumers,
- Extension of advanced processing technologies to the millers for reduction of losses,
- Improvement of road conditions in the area for the effective distribution of agricultural inputs and products and reduction of transportation costs,
- Establishment of a security system for the rice deficit farmhouses in the area by supplying paddy from the increased rice production area, and
- Commencement of activities by FWUC for marketing the paddy collected as in-kind irrigation service fee (ISF).

External requirements

- Establishment of a rice quality standard and inspection system.

(3) Development for Diversified Crops Processing and Marketing

The diversified crop production aims to increase the cash income of farmers. The following programs are proposed:

Farmer level

- Extension of technologies for management, accounting, marketing, processing, and quality control, and
- Provision of the credit needed for the farmers to initiate and expand their business activities.

Processing and marketing

- Establishment of assembling capability and facilities to attract buyers form outside areas,
- Improvement of road condition to improve accessibility between farm and market and to reduce transportation cost and losses,

[5] : Since these losses are caused by the practice not only in the post-harvest processing but also in cultivation, it is advisable that this training be included in the agricultural extension program.

- Provision of technical and financial support to initiate and expand processing and marketing activities by farmers groups, and
- Provision of the financial assistance to encourage trading activities in and out of the Study Area.

External requirement

- Improvement of the main road network out of the area,
- Strengthening the activities of the vocational training school,
- Improvement of the market infrastructures,
- Improvement of the communication infrastructures,
- Improvement of the utility supply condition,
- Improvement and strengthening the market information system (MIS), and
- Elimination of illegal condition such as smuggled commodities in the market and the road block (security tax), etc.

(4) Development of Farmers Group Activities

Farmers group activities have several advantages for improvement of post-harvest and marketing activities through effective extension activities, creation of competitiveness, and increasing bargaining power.

The following activities are proposed to be initiated by the farmer groups and the details are given in Table II-4.7.1.

- Production of edible oil and animal feed,
- Group assembling,
- Activities as the commission agent for the farmers, and
- Processing and marketing of the local products.

(5) Priority Programs

The priority programs for improvement of agro-processing and marketing in the Study Area are summarized as follows:

1) Program of Group Assembling Activities (See Table II-4.7.1.)

Objectives: - Income increase
-Creation of a mechanism for assembling for the surplus products
- Demonstration and extension to the farmers groups in the other areas

Target: Farmers producing diversified crops (and rice in the increased production area)

Location: The location of the assembling places will be along the District

Road No. 33 from Angk Roka to O Saray and the ADB road from Samraong to T. Kranhung in the area for the Upper Slakou River Irrigation Reconstruction Plan, and along the National Road No. 3 and District Road 22 and 33 in the area for the other two Plans. The Angk Ta Saom Market will have the central assembling function in the area.

Implementation: Farmers group

Supervising agency: Development Committee in District / Village

Supporting agency: MOWRAM

Activities: - The stage-wise activities are shown in Fig.II-4.7.2.

2) Rice Marketing Activities in the FWUC (See Table II-4.7.2.)

Objectives: - Increase in income for rice selling
- Strengthening the financial condition for maintenance and management of the irrigation facilities

Implementation: FWUC

Supervising agency: MOWRAM

Activities: - Storing and marketing the paddy collected from members in payment of their irrigation service fee (ISF). Milling is recommended to increase sales margins.

II-4.8 Institutional Development Program

II-4.8.1 Farmers Water User Community

(1) Organization of FWUC

RGC issued Circular No.1 on the Implementation Policy for Sustainable Irrigation System in January 1999. This policy is regarded as an essential factor to formulate the implementation programs of irrigation development and to manage the programs in an effective and sustainable manner throughout the country. The policy is based on the following basic principles.

- Legal status of FWUC,
- Involvement of FWUC in system development,
- Obligation of farmers in paying operation and maintenance cost and emergency cost for O & M,
- Permanent maintenance and improvement of the existing irrigation systems,
- Arrangement of equitable water delivery in equality, and
- Support and assistance provided by MOWRAM for technical backstopping, managing, monitoring, etc.

The above policy is designed to transfer of management responsibility to the FWUCs. The FWUCs will have to operate on service-at-cost community base. They shall have a well developed financial and water delivery record keeping program, a water management workforce, and a governing board elected through secret ballot.

Formation of FWUC in the project area is the following tier structure system:

1) Water course committee at water course level,
2) Tertiary canal committee at tertiary canal outlets,
3) Secondary canal committee at secondary canal outlets,
4) Main canal committee at reservoir intake or headwork, and
5) Apex Committee and Board at project level.

All farmers whose land are situated in the selected irrigation area will be members of committee. A series of community or village level meetings are to be conducted to launch the program. The farmers of irrigation systems are informed of the objectives of the program as well as the sequence of activities that will be followed in the future. The FWUC is responsible for managing the main canal, secondary, tertiary, and the reservoir intake or headwork.

In the process of FWUC formation, election by members representing all the farmers is a usual practice, so that representation from all levels of members could be considered. The Board of FWUC is responsible for maintaining the checks and balances in the FWUC activities. The Board of the FWUC is to set water rates, develop and ratify FWUC structure, elect the Committee members of the FWUC, and scrutinize and approve the budget and expenditures.

A draft statute is available from the government which can be used to discuss the provisions, make necessary modifications, and finally submit for ratification by the Board of FWUC and for approval by MOWRAM.

With the above steps, formation of the FWUC will be finished at different levels of the irrigation system and it will possess the Statute. The Board of FWUC would then apply to the relevant government agency for registration in order to establish the legal status of the FWUC. Finally, the FWUC shall get recommendation from MOWRAM and will have an agreement with MOWRAM. The concerned agencies under MOWRAM will issue the organization registration certificate to the FWUC Committee. The formation process for FWUC is shown in Fig. II-4.8.1. The organization of FWUC, and the relationship between them and supporting governmental organizations are shown in Fig. II-4.8.2.

(2) Training of Members of FWUC

In order to attain the objectives of the irrigation plans, FWUC should function as described above. For this, training of members of FWUC is essential. MOWRAM is proposed to provide the following training to them:

i) Pre-Construction Stage

- FWUC rules and regulations;
- Responsibility ;
- Land titling; and
- Field layout and water distribution system.

ii) Construction Stage

- Understanding the agreements;
- Estimation of workdays and labor, and labor requirement by seasons;
- Participation in construction;
- Labor and work management; and
- Selection of group leaders for water management training.

iii) Post-construction

- Organization of meeting;
- Organization of one committee for each main, secondary, tertiary canals and water course; and
- Developing rules/regulations for O & M and collection of ISF.

iv) O & M stage

- Planning the O & M of the systems;
- Monitoring and conflict resolving;
- System maintenance: reservoirs and intake, main, secondary and tertiary canal systems for distribution of water during wet and dry season; and
- Leadership training.

II-4.8.2 Capacity Building of MOWRAM

(1) Role and Responsibility of MOWRAM and DRWAM

The roles and responsibilities of MOWRAM and Department of Water Resources and Meteorology at Takeo (DWRAM, Takeo) for implementation of projects are as follows :

Role and Responsibility of MOWRAM and DWRAM

Activity	Small Scale (up to 200 ha)	Medium Scale (200 ha to 5000 ha)	Large Scale (Above 5000 ha)
Planning and Survey	DWRAM *	MOWRAM & DWRAM	MOWRAM & DWRAM
Construction and Repair	FWUC**	MOWRAM & DWRAM	MOWRAM
O & M	FWUC	DWRAM & FWUC	MOWRAM & FWUC
Organization of FWUCs	DWRAM	MOWRAM & DWRAM	MOWRAM

* : under supervision of MOWRAM, ** : under technical support of DRWAM

(2) Present Capacity of DWRAM

The proposed irrigation plans under the master plan are small to medium scale. The main executing agency is MOWRAM including DWRAM, Takeo. Capacity building of DWRAM, Takeo and concerned personnel of MOWRAM is required. DWRAM, Takeo, consists of five sections, i) Irrigation, ii) Water Supply, iii) Hydrology and Meteorology, iv) Water Resources Management and v) Administration Sections as shown in Fig.I-2.2. DWRAM, Takeo, mainly deals with i) survey, planning, design of small gravity and pump irrigation schemes; ii) supporting the formation of FWUC and coordination of their activities; iii) construction and supervision of irrigation schemes; v) ground water development for irrigation and domestic purposes; and vi) collection of data from two meteorological stations and seven hydrological stations. There is a total of 102 staff at the DWRAM, Takeo in 2001, of which the professional staff consists of only 8 engineers and 21 technicians as shown in Table II-4.8.1.

According to the Development Plan of Takeo Province for 2000, the provincial government planned to restore or construct 80 irrigation and drainage schemes with about 479 km length of canals that cost about US$ 2.6 Million equivalent. Of these schemes, only about 18 % were accomplished by the end of 2000 mainly due to a shortage of funds and limited capacity for engineering support. In addition, DWRAM, Takeo, has five restoration schemes for canals and reservoirs with approximately 52 km length of canals supported by international organizations planned for 2001. DWRAM,Takeo, is an executing body for the plan. Under such status, DWRAM, Take, has no room for implementation of new medium to large scale irrigation projects, such as USP.

(3) Strengthening of Capacity

In order to implement the new medium to large scale irrigation projects smoothly, the following capacity building of DWRAM, Takeo and concerned personnel of MOWRAM will be required.

1) Strengthening Capacity of Planning, Design and Construction Management

Since MOWRAM and DWRAM have a limited number of engineering staff to be assigned to the new project, additional engineering staff particularly for planning, design and construction management need to be newly assigned to meet the requirements of implementing new project.

2) Assignment of Specialist for FWUC and O&M

Beneficiary-based participatory organization of FWUC and their management assistance are crucial for sustainable irrigation development. No specific staff in charge of FWUC and O&M of the schemes are assigned in DWRAM. Based on the requirement for the new projects, specialists for FWUC and O&M need to be deployed in DWRAM.

3) Training of Staff

There is a need to training to the staff of DWRAM and concerned personnel of MOWRAM. The main subjects for the training are as follows :

- Participatory diagnosis of farmers' needs and assessment of their capacities (Participatory Rural Appraisal method);
- Planning of irrigation project;
- Design of irrigation facilities;
- Construction supervision;
- Transfer of O & M to FWUC;
- Water charges calculation; and
- Monitoring and evaluation.

4) Establishing Meteoro-Hydrological Stations and Strengthening Staffs

Meteorological stations (rainfall, evaporation, temperature and humidity) in and around the project area and river gauging stations for the Slakou river need to be installed to meet the information requirements of the following WMO (World Meteorological Organization) recommendation:

- Rainfall observation station per 100 to 250 km^2
- Evaporation observation station per 5,000 km^2
- Run-off measurement station per 300 to 1,000 km^2

For this purpose, one (1) specialist of meteoro-hydrology responsible for the Slakou river basin and three (3) supporting technicians need to be deployed.

5) Office and Equipment

In order to cope with the new project implementation and increase their work efficiency, the following additional office and equipment need to be facilitated :

- New office with conference and lecturing rooms;

- Office equipment including the photo copy machines;
- Computers, printers, attachments and software;
- Generator;
- Survey and meteoro-hydrological equipment; and
- Vehicles and motor-bikes.

II-4.9 Environmental Conservation Program

(1) General

The following two Environmental Conservation Programs were prepared based on i) the existing condition in and around the Study Area, ii) characteristics of main components of the Master Plan, and, iii) the results of IEE as mentioned in Chapter II-5, and the content of such programs are given below :

1) Program for Minimizing and Controlling Negative Impacts
2) Program for Ensuring Environmental Sustainability

(2) Program for Minimizing and Controlling Negative Impacts

This program is composed of the following three (3) activities:

Water-related Hazard Prevention

The objective of this activity is to prevent or minimize the water quality contamination and other impacts related to water pollution or water-bodies existence. This activity should include i) preparation and implementation of action for reducing the risk of such water-borne diseases as malaria, ii) proper application of fertilizer, drainage, and livestock raising in collaboration with farmers groups for water quality control, and iii) management and enhancement of fishery resources.

Affected Households Assistance (AHA)

The objective of this activity is i) to minimize the socially negative impacts on people whose houses will be relocated or whose land-use status will be changed, and ii) to restore their former living condition, from the view point that beneficiaries of the project should be maximized. In order to meet the above objectives and to facilitate implementation of components of the Master Plan, establishment of an AHA Committee is proposed. The committee will be composed of representatives executing and other agencies related to the Master Plan, provincial departments, and concerned districts / communes / VDCs. The scope of committee's work should cover i) identification of affected households including illegal land occupants, ii) investigation of their existing living condition and of issues to be considered, minimized and restored, iii) preparation and implementation of optimum AHA menus,

iv) consultation with affected households and other stakeholders, and v) follow-up observation on effectiveness of adopted menus.

Environmental Monitoring

The objective of this activity is to facilitate the development of necessary and effective countermeasures through monitoring of environmental elements on which negative impacts are likely to occur. The monitored results and stored data will be fully utilized to develop the measures both for early environmental mitigation and for prevention of any impacts from worsening. Within this framework, monitoring and evaluation of other major activities is also included. Items to be monitored should include i) water-related environmental issues, such as quality, pollutants, diseases, and fish, ii) conditions of forest resources and hinterlands in and around the Study Area, and iii) structural conditions causing environmental problems, such as slope failure, erosion and canal bank stabilization.

(3) Program for Ensuring Environmental Sustainability

This program is composed of the following two (2) activities:

Watershed Management

This activity mainly aims at prolonging the sustainable contribution of the USP by focusing on reducing sedimentation of the irrigation system, through properly managing the upper watershed of Tumnup Lok and Kpob Trobek reservoirs, including Noreay Mountain range. Work flow of the activity is proposed as i) identification of the area to be managed and selection of priority micro-watershed, ii) preparation of plan and design including such measures as reforestation and civil-engineering works, iii) procurement of necessary materials and equipment, and implementation of plan in micro-watershed, and iv) promotion and expansion of the plan to other identified areas in line with lessons obtained from micro-watershed. Application of a participatory approach is recommendable in order to involve VDCs, Farmers Groups, and individual farmers in the activity.

Forest Resource Conservation

The objective of this activity is to conserve the forest resources around the Study Area from excessive logging and exploitation for timber and firewood, by means of reducing the human-activities pressure on forest areas. To meet this objective, residential forest around the village or individual houses will be formed by aggressive planting for timber and firewood demand. The activity includes i) option for income generation by fruit tree planting, and ii) enhancement and conservation of existing reforestation projects in and around the Study Area. A participatory approach

should be applied in order to make the activity effective, and to involve more farmers in the acting body.

II-4.10 Implementation Schedule

II-4.10.1 Overall Implementation Schedule

In order to implement the proposed plans and programs smoothly and attain the objectives of the Master Plan, the overall implementation schedule shown in Table II-4.10.1 was prepared based on the following conditions:

(1) Composition of Implementation Stage

The target year of the Master Plan is 2010. From the beginning of 2001 to early 2002, the Master Plan and Feasibility Study will be conducted. Then the Project will be started in mid 2002.

The stages will consist of; i) design and preparation phase, ii) construction and activity phase, and iii) operation and extension phase.

The design and preparation phase will include;

- survey, basic and detail design,
- explanation of the project to beneficiaries,
- organizing of VDCs, FWUC, and other farmers groups, and
- appraisal of applications for participating in the project from beneficiaries, VDCs, FWUC, the farmers group, etc

The construction and activity phase will consist of;

- construction works,
- preparation of operation, i.e., training, guidance to the organizations and groups,
- preparation for credit services (registration),
- recruiting and training of village extension workers, and
- training of trainers on O&M (MOWRAM and DWRAM staff)

The operation phase will be composed of ;

- on-the-job training for MOWRAM and DWRAM staff, FWUC, the farmers groups and other groups,
- extension and guidance on agriculture by the village extension workers,
- credit services,
- support for input supply, and
- support for agro-processing and marketing

(2) Implementation Schedule

The implementation schedule consists of three (3) stages as shown in Table II-4.10.1. The first stage is regarded as the "pilot development stage" which should establish the foundation of the Project. Work volume of each plan is kept small so that feed-back from the initial implementing process can be applied to the further stages.

The second stage is considered to be the "intensive development stage". The extension of the Upper Slakou River Irrigation System is included in this stage. The work volume in terms of the number of reservoirs and ponds, length of the rural roads to be developed, will be larger in this stage.

The third stage is considered to be the "self supportive development stage". Even for this stage, support for O&M of the Upper Slakou River Irrigation System will be conducted by DWRAM. Remaining works of the small reservoirs and rural roads will be implemented by the project. The small reservoirs will be developed by VDCs and the village extension workers, which would have been trained through the former stages.

II-4.10.2 Upper Slakou River Irrigation Reconstruction Plan

Upper Slakou River Irrigation Reconstruction Plan (USP) will be constructed in two stages as shown in Table II-4.10.2 and summarized follows:

Stage and Period of USP

	Development Area	Period
Stage-1	800 ha	Mid 2002 – Early 2006
Stage-2	2,700ha	End 2003 – Mid 2008
Total	3,500 ha	

Construction of Kpob Trobek Reservoir, and irrigation system including tertiary development will be done over two consecutive dry seasons or 1.5 years in total. At the design stage, farmers groups and FWUC will be organized, and the training or guidance to the farmers groups and FWUC will be done during the construction and operation stages.

Agricultural extension and credit services will be started during the construction stage. Training of village extension workers will be done before the commencement of cultivation.

Facilities for agro-processing and marketing activities will be designed and constructed, and necessary equipment will be procured at the initial stage.

Training of MOWRAM and DWRAM staff will be started from the beginning of

Stage-1. The training will be carried out for two years only during Stage-1. Training and/or guidance to FWUC will be continued even after Stage-2 in order to ensure the irrigation system can be handed over to FWUC in the target year of 2010. MOWRAM and DWRAM will support FWUC for that period. The environmental conservation program will be conducted at all stages.

II-4.10.3 Small Reservoir Rehabilitation Plan

Rehabilitation of 15 existing small reservoirs nominated in the Master Plan and supporting programs will be implemented in three stages as follows:

Stage and Period of SRP

	Development Area	Period
Stage-1	2 reservoirs	Mid 2002 – Early 2005
Stage-2	7 reservoirs	End 2003 – Mid 2008
Stage-3	6 reservoirs	Mid 2006 – End 2010
Total	15 reservoirs	

The construction works of each reservoir can be completed within one year (dry season). Since the reservoirs are all located within a village, all the arrangements and coordination will be done at VDC level. For smooth construction, the farmers group and FWUCs will be organized and operated in close relation with VDCs. The implementation schedule is shown in Table II-4.10.3.

II-4.10.4 Small Pond Development Plan

The implementation schedule is shown in Table II-4.10.4.

One group-type pond and five individual ponds will be constructed per village as pilot development. At the initial stage, standard design by type, application form and appraisal procedures will be prepared and established. According to site conditions, the standard design will be modified and adopted. The project will support the group.

The number of ponds constructed or involved by each stage will be as follows:

Stage and Period of PDP

	Development Area	Period
Stage-1	6 ponds/village	Mid 2002 – Early 2006
Stage-2	24 ponds/village	End 2003 – Mid 2008
Stage-3	42 ponds/village	Mid 2006 – End 2010
Total	72 ponds/village	

Most of the management for the individual-type ponds will be conducted by VDCs

and trained village extension workers, while the group-type pond will be technically supported by the project staff during Stage-1 and Stage-2. All the construction works and supporting works will be conducted by VDCs and the village extension workers in Stage-3.

II-4.11 Cost Estimate

II-4.11.1 Conditions for Cost Estimate

Project cost was estimated in order to evaluate the economic viability of the Master Plan on a preliminary basis. The project cost of three main plans, namely, Upper Slakou River Irrigation Reconstruction Plan, Small Reservoir Rehabilitation Plan, and Small Pond Development Plan, was estimated on the basis of the following conditions and assumptions:

1) Project cost was estimated for the best alternative of USP, three small reservoirs out of 15 for SRP, and three types of pond in the case to irrigate 5ha of land for each type for PDP.
2) Cost estimate refers to the prices as of May 2001.
3) Unit prices of labor, construction materials, engineering works, etc., were collected from MOWRAM and MRD.
4) All construction work, except PDP, will be carried out by contractors selected through international competitive bidding (ICB).
5) Price escalation was evaluated based upon 2.5% per annum for foreign currency portion and 3.0% per annum for local currency portion.
6) A physical contingency of 10% of the Project cost is included.
7) Construction equipment is used on rental basis for the O&M works.
8) Project cost consists of; i) preparatory works, ii) direct construction cost, iii) O&M equipment cost, iv) institutional development cost, v) administration cost, vi) engineering service cost, and vii) physical contingency.
9) The institutional development cost includes the cost for training, extension, and other supporting services identified in the supporting programs.
10) Certain percentage or unit cost was assumed for the preparatory works, institutional development, engineering service and physical contingency.
11) Conversion rate among Cambodian Riel, US Dollars (US$) and Japanese Yen (¥) was assumed at US$ 1.0 = Riel 3,835.38 = ¥ 123.32 (as of May 15, 2001).

II-4.11.2 Project Cost

(1) Upper Slakou River Irrigation Reconstruction Plan

The optimal development alternative for the reconstruction plan was selected in Section II-4.2 taking into account economic viability and other factors. Consequently, the alternative for irrigating 3,500 ha with Tumnup Lok Low (Dike Top EL.43 m) and Kpob Trobek Low (EL.39 m) was selected. The estimated project cost for the selected alternative is Riel 71,460.7 million.

(2) Small Reservoir Rehabilitation Plan

The Master Plan identified 15 reservoirs for construction in three priorities and/or stages[6]. The reservoirs of higher priority are supposed to have higher economic viability in terms of smaller construction scale and larger irrigation area. In order to make a preliminary evaluation of the Plan, the project costs for the two reservoirs in the first priority and a reservoir in the third priority were estimated, assuming that the project costs of the remaining reservoirs remain in that range. The project cost of the reservoirs is summarized below.

Project Cost of the Representative Small Reservoirs

Name of the Reservoir	Priority	Irrigation Area(ha)	Project Cost* (Thousand Riel)
Kim Sei	1st	21	395,870
Ang 160	1st	21	379,100
Trapeang Lean	3rd	10	261,030

*: Price contingency is excluded.

(3) Small Pond Development Plan

The project costs were estimated for three types of model ponds, namely, i) pond managed by farmers group, ii) pond utilizing canal and managed by the farmers group (canal pond), and iii) pond managed by individual farmers (family pond). It is assumed that the construction works will be done manually by the farmers group or family labor. The earthwork volume of the canal ponds was estimated to be smaller than that of the group ponds taking the existing canal section into account.

The project cost per 5 ha by pond type was estimated as a prototype of development for evaluation and in order to make a comparative study, assuming that the project costs of the remaining ponds remain within the estimated cost range. The results are summarized below:

[6] Two reservoirs for the first priority, seven for the second and five for the third.

Project Cost of the Small Pond Development

Type of Pond	Effective Volume (m^3)	Irrigation Area/no. (ha)	Nos. of ponds	Irrigation Area(ha)	Project Cost* (Thousand Riel)
Pond (Group Management)	846	0.34	15	around 5ha	129,380
Canal Pond (Group Management)	846	0.34	15	around 5ha	97,550
Pond (Individual Management)	184	0.07	72	around 5ha	154,830

*: Price contingency is excluded.

II-4.12 Project Evaluation and Selection of Priority Projects

II-4.12.1 Evaluation Objectives and Procedures

The selected priority projects from the following three irrigation-based development plans were evaluated :

1) Upper Slakou River Irrigation Reconstruction Plan (USP)
2) Small Reservoir Rehabilitation Plan (SRP)
3) Small Pond Development Plan (PDP)

Objectives of the master plan evaluation are clarification of economic viability using EIRR and effects on the farmers' economy applying farm budget analysis in order to assure viability of the projects selected for further detailed study, i.e. feasibility study. Viability among the above three irrigation-based development plans and their priority projects were not discussed in the evaluation analyses because there is difference in development approaches, development potential, degree of economic impact, etc.

USP was formulated as the most appropriate development project. The SRP as a whole was evaluated by selecting the highest two and single lower one priority projects in order to clarify the range of viability among the 15 SRP projects. The PDP was evaluated for three (3) types of small ponds, i.e. farmers' group operated small pond, individual farmer operated small pond, and small pond utilizing existing canal in order to develop a unit irrigated farm area (5 ha), respectively.

II-4.12.2 Economic Evaluation

(1) Evaluation Procedures

All prices were expressed in constant prices as of May, 2001 applying the official exchange rate of US$ 1.0 = Riel. 3,835 = ¥ 123.32. The economic life of the project is assumed to be 50 years for USP and SRP, 30 years for PDP, beginning from the year 2002, which is assumed to be the commencement year for construction.

Economic farm gate prices of traded agricultural inputs and outputs were based on their export or import parity prices derived from the World Bank Commodity Price

Forecasts as of May 2000.

Transfer payment such as tax, duty, subsidy, interest, etc., were excluded in estimating the economic costs and benefits. Financial construction costs were converted into economic values using the construction conversion factors (CCFs).

(2) Economic Benefit

Irrigation and drainage benefit will be accrued from increase in cropping areas and productivity of target crops comprising paddy, maize, soybean/mungbean, groundnut, sesame, and vegetables. The irrigation and drainage benefit (increment of net production value) of the respective projects for USP, SRP and PDP was estimated as follows:

Economic Irrigation and Drainage Benefit

Project	Project Area (ha)	Cropping Intensity (%)		Net Production Value (Riel Million)		
		Without Project	With Project	Without Project	With Project	Increment
1. USP	3,500	95	130	2,222.1	7,825.8	5,603.7
2. SRP						
Kim Sei	21	95	130	13.33	46.95	33.62
Ang 160	21	95	130	13.33	46.95	33.62
Trapeang Lean	10	95	130	6.35	22.36	16.01
3. PDP						
Pond (Group)	5 (57.1)	95	95.3 *	3.17	13.05	9.88
Canal Pond (G)	5 (57.1)	95	95.3 *	3.17	13.05	9.88
Pond (Individual)	5 (57.1)	95	95.3 *	3.17	13.05	9.88

Note : * % to the area (57.1 ha) including rainfed area

Existing farm lands will be acquired and used for the construction of irrigation and drainage facilities. The agricultural production foregone defined as the annual net production value without project was accounted for negative benefit in the evaluation.

(3) Economic Cost

The economic project cost was classified by i) direct construction cost, ii) O&M equipment cost, iii) institutional development cost, iv) administration cost, v) engineering cost, and vi) physical contingencies. The economic project investment cost was estimated by applying relevant conversion factors to the components of financial foreign and local currency cost comprising equipment, materials and labor. The total economic project investment cost was estimated as follows :

Economic Investment Cost

Project	Project Area (ha)	Investment Cost (Riel Million)	Cost per ha (Riel '000)
1.USP	3,500	50,232.1	14,352
2.SRP			
Kim Sei	21	317.4	15,114
Ang 160	21	305.9	14,567
Trapeang Lean	10	208.8	20,880
3.PDP			
Pond (Group)	5	75.5	15,100
Canal Pond (G)	5	57.1	11,420
Pond (Individual)	5	90.3	18,060

The financial O&M cost was converted to economic value by applying relevant conversion factors to the components of financial foreign and local currency costs same as the project investment costs. The project facilities and equipment with shorter useful life than those of respective projects need to be replaced after the assumed working life is over. The replacement cost was estimated by applying the conversion factors to the respective financial cost for replacement.

(4) Economic Evaluation

The economic cost and benefit stream comprising i) the cost for project investment, O&M and replacement, and ii) irrigation and drainage, and negative benefit was prepared for the economic life of the respective projects for USP, SRP and PDP. Economic internal rate of return (EIRR) and other indicators were calculated and summarized as follows :

Economic Efficiency of the Projects

Item	USP	SRP			PDP (Per 5 ha)		
		Kim Sei	Ang 160	Trapeang Lean	Pond (Group)	Canal Pond	Pond (Individual)
EIRR (%)	10.0	9.4	9.8	6.6	10.5	14.4	7.7
NPV (Riel Million) (6.5% discount rate)							
Benefit	59,380	417	417	199	102	107	98
Cost	40,780	302	291	197	72	59	88
B - C	18,600	115	126	2	30	48	10
B / C	1.5	1.4	1.4	1.0	1.4	1.8	1.1

II-4.12.3 Financial Evaluation

(1) Farm Budget Analysis

Farm budget analysis was made by assuming the anticipated change in income and expenditure for the median size farm operation (0.8 ha in the Study Area). The household income was estimated to increase by 155% for the USP and SRP area and

17% for the PDP area as follows:

Farm Budget Assessment (Median Size 0.8 ha)

(Unit : Riel '000)

Item	USP and SRP Area	PDP Area
Without Project		
Income	789.2	789.2
Expenditure	784.6	784.6
Net Reserve	4.6	4.6
With Project		
Income	2,011.6	923.1
Expenditure	1,081.6	804.4
Net Reserve	930.0	118.7
Increase (%)		
Income	155	17
Expenditure	38	3
Net Reserve	20,117	2,480

(2) Capacity to Pay for O&M Cost

The annual requirement of O&M cost of the respective projects in the case of the median size farmers (0.8 ha) was estimated and compared to the respective incremental net income. The O&M cost requirement will be below 10% of the incremental net income for USP and SRP areas and below 20% for PDP area as follows:

O&M Cost Requirement and Share to Net Reserve

Project	O&M Cost (Financial)		
	Per ha (Riel '000)	Per 0.8 ha (Riel '000)	Share to Incremental Net Reserve(%)
1.USP	76.7	61.4	7
2.SRP			
Kim Sei	96.0	76.8	8
Ang 160	96.0	76.8	8
Trapeang Lean	96.0	76.8	8
3.PDP		(0.07 ha)*	
Pond (Group)	152.0	10.6	9
Canal Pond (G)	268.0	18.8	16
Pond (Individual)	258.0	18.1	16

Note : * Irrigated area per median farmer (0.8 ha)

II-4.12.4 Justification of Priority Projects

Evaluation indicated that the Upper Slakou River Irrigation Reconstruction Project (USP) has sufficient economic and financial viability. It is expected to increase farm income sufficiently to finance the future O&M cost of the project facilities.

Regarding the Small Reservoir Rehabilitation Plan (SRP) comprising 15 projects, economic viability of those projects indicated EIRRs between 6.6% and 9.8%. The lower ranking priority project, i.e. Trapeang Lean SRP is still affordable for implementation because there are no other alternative measures at the area to

increase farm income through water resources development.

Pond Development Plan (PDP) indicated a higher viability in terms of EIRR, but the magnitude of impact to the farm economy in terms of incremental net income is comparatively smaller than those of USP and SRP.

The viability of the three development approaches (USP, SRP and PDP) in the Study Area were justifiable as the master plan. Three types of development approaches as model projects were considered applicable for other areas under similar climate and topography.

II-4.12.5 Selection of Priority Projects for Feasibility Study

The priority projects for the feasibility study were selected for the proposed three irrigation development plans (USP, SRP and PDP) as follows :

1) Upper Slakou River Irrigation Reconstruction Plan (USP) : 3,500 ha

2) Small Reservoir Rehabilitation Plan (SRP)

   Based on technical soundness, degree of beneficiary participation and availability of water source, the following two priority projects should be studied at feasibility level as model SRP:

   1. Kim Sei SRP
   2. Ang 160 SRP

3) Small Pond Development Plan (PDP)

   There are three types of ponds in the plan, i.e. pond operated by individual farmers, ponds operated by farmers groups, and canal ponds operated by farmers groups. In order to formulate the small pond development project at feasibility level, at least one development plan for each pond type needs to be studied as a model PDP at one village. A canal pond has higher EIRR than the others, and availability of existing canal having potential water is a key factor. Based on the consideration of the following factors, one village in Nhaeng Nhang commune covering the canal No.8 shall be selected as a site for the feasibility study :

   1. The area is not covered by the USP and SRP and irrigation water is short.
   2. Canal No.8 has potential for using drained water from the upstream after construction of the canal pond.
   3. High demonstration effects are expected.
   4. Accessibility to the markets, i.e. Tramkak and Takeo along the national road No.3 is good and sale of vegetables to be produced by using the pond water be easy.

Together with the above priority projects for the feasibility study, implementation of

the rural road improvement program is crucial to realize the benefits of development of USP. The USP area including the access road to Tumnup Lok reservoir has poor accessibility. The following three priority roads with total length of 24.5 km were selected for the feasibility study :

1. Trapeang Thum Khang Cheung to Trapeang Kranhung (13 km),
2. O Saray to Slakou river (5.5 km), and
3. Kpob Svay road (6.0 km).

The following support programs for the selected priority irrigation projects should also be studied at feasibility level in order to assure the irrigation development impact and other associated effects, specifically for the improvement of farmers' living standard :

1. Agricultural Production Program,
2. Agricultural Support Program,
3. Institutional Development Program, and
4. Environmental Conservation Program.

II-4.13 Results of Participatory Rural Appraisal Workshops

II-4.13.1 General

The "Participatory Rural Appraisal Workshops (PRA Workshops)" were carried out in the Study Area on sub-contract basis. Objectives of the workshops were i) explanation of the draft Master Plan to anticipated beneficiaries, ii) hearing of their opinions, and iii) confirmation of acceptability of the Plan for them. The PRA procedure was adopted for these purposes.

The twenty workshops were conducted during a period of four (4) days from June 13 to June 16, 2001; twelve with farmers or beneficiaries, six with local administration staff (commune (vice-) chief and village (vice-) chief), one with related NGOs acting in the Study Area and one with related local governmental organizations. The workshops were operated by facilitators who were well trained by the Study Team prior to the workshops.

The participants of farmers or beneficiaries and village (vice-) chiefs were selected from villages, which are covered by proposed three (3) plans (USP, SRP and PDP) of the draft Master Plan. The participants of commune (vice-) chiefs were selected from communes consisting of such villages. The participants selected from local governmental offices and international organizations are Department of Environment, DWRAM, WFP (World Food Program supported by UNICEF), Department of Agricultural Extension, WID (Women in Development supported by MRD). Those selected from related NGOs acting in the Study Area are MCC (Mennonite Central Committee), CRS (Christian Relief Service), EMT (Credit for Rural Area) , etc.

The total participants for the workshops were more than 280 people. The number of participants for each workshop was around fifteen. Most of the workshops were conducted with average participatory rate of female of about 40 %.

II-4.13.2 Beneficiaries' Opinions for the Draft Master Plan

The draft Master Plan was accepted as a whole by participants of the workshops. Some requests and opinions were given at the workshops. The outstanding opinions which do not always mean the majority, are summarized below :

(1) Establishment of FGs

- Participants approves of establishment of FWUC and FGs, and payment of allowance to representatives of each FWUC and FGs.
- Some of participants agree to pay members' contribution only for running cost (not including allowance) for FG's activities.
- Amount of the allowance should be decided by members' meeting.
- A certain participant (village chief) of Nhaeng Nhang commune shows negative opinion against establishment of VDC because PRDC and MRD did not succeed in the past.

(2) Credit Service

- Participants wish to use the credit service at monthly interest of 4 %. (The interest rate of 4 %/month is the same as that of NGO's).
- Some participants request that interest rate should be less than 4 %/month because poor farmers can not repay even at present NGO's interest of 4 %/month.
- Participants want to repay their credit after harvesting.
- Participants think everybody will be able to repay if higher yield is ensured.
- FG members for the credit service will persuade a debt farmer to repay by themselves.
- If a debt farmer does not repay, FG members for the credit service agree to repay instead of him, and the debt farmer has to give his land to FG for the credit service. In this case, the debt farmer can not use the credit service any more.

(3) ISF

- Participants appreciate MOWRAM policy (20 % of increased yield for ISF).
- If irrigation water benefits for increase of yield and the ISF is invested to irrigation facilities, participants are willing to pay ISF.
- If scheduled irrigation water volume does not come, the ISF should be decreased depending on actual volume of irrigation water.

(4) O&M

- Participants agree to participate to O&M works. The working volume should be decided by members' meeting.
- Some participants prefers additional payment to actual O&M works.

(5) Evacuation or Removal from the Reservoirs and the Canals

- Participants recognize that land inside the reservoirs and canals belongs to property of the country.
- Participants are willing to remove themselves from the reservoirs and the canals if construction or rehabilitation work starts.
- Some participants of Nhaeng Nhang commune oppose to abandon present land in small reservoir area because his total land including land in small reservoir is too small although they recognize the land still belongs to the country.

(6) Donation of Land for Irrigation Facilities

- Beneficiaries are ready to pay money or donate a part of their land to land-losers of the project.
- A village chief of T.T.K. Tboung commune strongly opposed to donate his land.

(7) Tertiary Development

- Participants agree to undertake tertiary development by themselves.
- They will share land loss for tertiary canal with FWUC members by paying money or donating their land.

(8) Access Road

- Participants are willing to join construction works for the access road without any allowance.
- Participants are ready to share land loss for the access road with villagers by paying money or donating their land.

(9) Cropping Pattern

- Some participants like to undertake a double or triple cropping a year if irrigation water is available.
- Some participants say that variety of vegetables should be determined by market demand.

(10) Forestation Plan

- Participants need some supports that they can buy nursery at low price.
- Since deforestation is caused by cutting for money, they will stop the cutting after getting enough income from on-farm activities.
- The variety of nursery should be decided by farmers choice.

(11) Collaborations with the JICA project

- Most of the NGOs providing credit service will collaborate with the JICA project.
- Certain NGOs want to collaborate with the JICA project. They wish to expand their activity to distribution of nursery for forestation plan if JICA provides some fund.
- Direction of MOE has a proper understanding about usage of agricultural chemicals that suitable usage of agricultural chemicals will result in high yield, but negative impact for environment is still anticipated.

CHAPTER II-5 ENVIRONMENTAL ASSESSMENT

II-5.1 Main Components Necessary for IEE

In accordance with JICA Environmental Consideration Guideline, main components of the Master Plan are listed in Table II-5.1.1. Among these, USP, SRP, PDP, Rural Road Improvement Program, fertility use and livestock husbandry were selected for Initial Environmental Examination (IEE), considering the characteristics of each component of the Master Plan. Other main components, such as i) drainage, ii) change of farming system, iii) farming groups, iv) agricultural extension, v) credit, vi) agro-processing &marketing, vii) FWUC, and viii) capacity building, were screened out, because it is obvious that they will cause no negative impacts.

It is expected that negative impacts during the construction period will be low, since i) construction period will be relatively short, and ii) construction work including equipment operation will be within a limited area.

II-5.2 Initial Environmental Examination (IEE)

In accordance with the JICA guideline, environmental elements, namely social and natural environments were selected for IEE. The detailed items of each environmental element are shown in Table II-5.2.2.

Based on the data and information related to the current environmental conditions (summarized in Table II-5.2.1) and the potential impacts of each component, the significance and magnitude of the impacts were preliminarily examined using a matrix checklist for IEE of the JICA guideline. The results of IEE are presented in Table II-5.2.2, and the likely negative impacts are summarized below:

(1) Social Environment

1) Relocation and Land Expropriation

Although USP, SRP, and RIP will cause the relocation and land expropriation, the magnitude of impacts will be relatively small because, i) the main activities of these components are rehabilitation or improvement of existing infrastructure, ii) scale and dimension of the existing facilities will be maintained in design, and iii) facilities and structures to be newly constructed are small in shape and limited in number. However, adequate consideration including the compensation should be given to the households affected by relocation and land expropriation, since the main economic activities of local people are agriculture using the land resource.

Some small houses are observed in the ruined reservoirs and canals which are State-owned lands. Their illegal activities will be limited or restricted at the commencement of USP, and they will not be entitled to compensation. However, such vulnerable households as widow-headed or disabled-headed should be given support and assistance to a certain extent in order not to lower their living standard.

2) Water-borne Diseases

Malaria is currently a common water-borne disease especially near the mountain area at the upstream of the Study Area. Rehabilitated reservoirs and canals as new habitats for mosquitoes will increase the risk from malaria. Local people living near the developed small ponds will be newly put into the same risk. It is therefore recommended that a proper program be prepared and provided.

(2) Natural Environment

1) Degradation of Forest Resource

At present, most of the Study Area is covered by paddy field and secondary crop land. Forest area in the Study Area is limited to reforestation project areas and the Noreay mountain range. Thus, no serious impacts on forest will be caused directly by implementation of the components, whereas the reforestation project and Noreay mountain range should be conserved or managed adequately.

However, USP, SRP, and RIP would accelerate forest resources degradation by further logging pressure of local people. And this may lead to devastation of the upper watershed of the Study Area. Attention should be paid to these issues even if they are outside the Study Area.

2) Impacts on Fisheries

As a result of past development of irrigation facilities and systems during the Pol Pot Regime in the Study Area, the regional migration of fish was heavily disrupted due to little consideration on structural design for fish migration. Therefore, additional or incremental impacts on the current fishery conditions in the Study Area will be negligible from the structural view point. Moreover, expansion of water bodies by USP, SRP, and PDP will play a positive role as new fishery resources and opportunities for local people.

On the other hand, existing water bodies for fish habitat in the Study Area, such as rivers, streams, and small swamps, could be damaged by water quality contamination mainly due to increased fertilizer use. Increment of water pollution load by improvement of irrigation system may also cause a negative impact on existing fish habitat. It is recommended that these likely impacts be monitored carefully.

Change of surface water hydrology in the Slakou River would also occur downstream of the rehabilitated reservoirs. However, it is expected that negative impacts on fish habitat will be small, since i) the decrease in discharge will be mitigated to a certain extent by Stung Kat Phluk which is one of the main tributaries of the Slakou River, and ii) the affected stretch of the Slakou River is limited.

3) Soil Erosion and Sedimentation

At present, many slope failures and soil erosion are observed along the remaining dikes of reservoirs, slopes of canals, and embankment roads. To protect from slope failure and erosion, and to avoid the impact of sedimentation, proper countermeasures, such as local materials improvement and slope protection method, should be considered and applied in the design.

4) Contamination of Water Quality

It is anticipated that water quality contamination could be caused by encouragement of fertilizer use, increase in livestock husbandry, and improvement of irrigation system. This means that i) suitability of drinking water resources for local people could further suffer from water pollution, and ii) fish habitat would be affected.

At present, no serious impacts on water quality from agricultural chemicals will occur, since i) no application of agricultural chemicals is proposed in the Master Plan, and ii) the volume and frequency of chemical use in the Study Area are very limited. However, most agricultural chemicals available in local markets are highly toxic, classified as IA or IB by WHO, indicating extremely or highly hazardous. Thus, the monitoring and evaluation of chemical utilization will be required.

II-5.3 Conclusion

The environmental impacts caused by implementation of the components of the Master Plan will not be serious on the whole, as Table II-5.2.2 shows that the magnitude of impacts on a number of environmental elements will be low or negligible. However, since the following issues are recognized as likely negative impacts, it is recommended that an environmental conservation program be developed in order to cope with these issues.

- Deterioration of water-related environment mainly due to the components of USP, SRP, PDP, and fertilizer use,
- Social impact of relocation and land expropriation, and
- Accelerating degradation of forest resources and devastation of watershed.

PART III ALTERNATIVE STUDY ON THE IRRIGATION AREA OF USP

CHAPTER III-1 BACKGROUND

The Upper Slakou River Irrigation Reconstruction Plan (USP), which was selected as a priority project in the course of the Master Plan Study (Phase-I), aims at irrigating 3,500 ha by reconstruction of; two reservoirs located on the the Slakou River and its tributary, a diversion canal between the two reservoirs, two main canals (Canal 33 and Koh Kaek Canal) and Canal 24, which start at Kpob Trobek Reservoir, and their secondary canals.

In the Master Plan, development alternatives of the reservoirs and diversion facilities were examined for improvement of agricultural production and living standard in the Study Area by means of rehabilitation and reconstruction of the existing irrigation facilities. Consequently, the irrigable area of 3,500 ha that would be commanded by the best alternative, was allocated proportionally to the existing command areas of the two main canals and Canal 24.

In the course of the Master Plan Study, it was clarified through survey works that the existing canal bed of Koh Kaek Main Canal (No.2) irregularly varies along canal profile in some stretches. However, when interview survey and hearing meetings were conducted, residents along the canal and local government officers said that Koh Kaek Main Canal had functioned as an irrigation canal to convey irrigation water from the reservoirs to fields when the canal was constructed. Furthermore, irrigation structures, such as intake, off-take and check structures for the canal were identified at site, and residents near and along the canal strongly demanded the rehabilitation and reconstruction of Koh Kaek Main Canal. It was, therefore, decided that the rehabilitation and reconstruction of Koh Kaek Main Canal would have significance as a model project. Based on this consideration, the USP, which included the rehabilitation and reconstruction of Koh Kaek Main Canal, was selected as a priority project for feasibility study in Phase-II.

At the initial stage of Feasibility Study (Phase-II), more detailed survey works were conducted along Koh Kaek Main Canal (longitudinal profile and cross-sectional survey every 200 meters), and soil mechanical tests were undertaken on soil samples from several test pits to examine stability and proper treatment of the expected deep and wide cut slopes of the canal. In addition, a new 1:10,000 topographic map with 1-meter contour interval was prepared for the priority area of USP.

After the results of the survey / tests, and the map, it has been judged that the existing Koh Kaek Main Canal was not adequately constructed along the high elevation area on the west mountain foot, and it did not function as a canal even right after the construction. As shown in Fig. III-1.1, the elevation of the existing canal bed varies along the canal profile, which would make cut depth to be 6 to 7 m at the maximum for reconstruction of the canal. Moreover, the amount of construction required for the excavation, treatment of the cut slope and drainage facilities would be very large and the maintenance cost would also be high. Thus the rehabilitation of the existing Koh Kaek Main Canal was not considered as a "suitable model plan of rehabilitation and reconstruction".

It has, therefore, been proposed that the Study Team undertake "alternative study on the irrigation area of USP, 3,500 ha" in Phase -II in order to select the optimal irrigation development plan.

CHAPTER III-2 ALTERNATIVE STUDY ON THE IRRIGATION AREA OF USP

III-2.1 Alternative Study

(1) General

The following two alternative plans for the irrigation area were examined:

The first alternative follows the Master Plan to irrigate 3,500 ha covered by Canal 33, Canal 24 and Koh Kaek (Fig. III-2.1), while the second alternative excludes the area of Koh Kaek Canal and extends Canal 24 and the secondary canals of Canal 33 to irrigate the area equivalent to that commanded by Koh Kaek Canal (Fig. III-2.2).

Prior to the comparison of alternatives, the "New Koh Kaek Main Canal", which is considered to be technically and economically better than the rehabilitation of the existing Koh Kaek Main Canal (the alternative proposed in the Master Plan), was examined for Alternative-1.

(2) Alternative-1

1) Comparison of New Koh Kaek and Existing Koh Kaek

According to the results of the survey works conducted at the initial stage of Phase-II, the rehabilitation cost of the existing Koh Kaek Canal (11.4 km) and the construction cost of the new Koh Kaek Canal (11.5 km) were compared. The new canal starts from Canal 33 at 1,200 m from Kpob Trobek Reservoir, and the alignment and longitudinal gradient were determined to cover as much of the existing irrigation area of the original Koh Kaek Canal as possible.

The construction costs of the two canals are given in the following table.

Construction and Rehabilitation Cost of Existing and New Koh Kaek Canals

Unit: US$ 1000

Canal/Works	Cost
Rehabilitation of Existing Koh Kaek Canal	2,554
Construction of New Koh Kaek Canal	2,171

The construction cost of New Koh Kaek Canal is lower than the rehabilitation cost of the existing Koh Kaek Canal due to the smaller earthwork volume. Moreover, it was judged that the maintenance cost of the new canal should also be lower.

Consequently, the new Koh Kaek Canal was considered as the main canal for the command area of Alternative-1.

2) Alternative-1

The New Koh Kaek Main Canal would irrigate about 1,600 ha via seven existing secondary canals and direct diversion from the main canal to tertiary blocks. The command area of Canal 33 (1,900 ha) is irrigated through Canal 33 and six existing secondary canals. The length of the two main canals totals 17.6 km, while that of the secondary canals totals 36.5 km. With some of the tertiary canals being directly commanded by the New Koh Kaek Canal, the total length of the secondary canals is shorter than that of Alternative-2. The irrigation system of Alternative-1 covers a similar area to the Master Plan, benefiting 41 villages in six communes which comprise about 4,750 households and 24,000 people.

(3) Alternative-2

Instead of the 1,600 ha covered by the New Koh Kaek Canal, the irrigation area is extended to the downstream part of the six secondary canals of Canal 33 as Alternative-2 (Fig. III-2.2). The length of the Main Canal 33 is the same as that of Alternative-1, i.e., 7.3 km, while the length of the secondary canals totals 44.7 km. In this alternative, additional 13 villages in Ta Phem and Cheung Tong Communes are included and 32 villages in five communes, which have about 4,020 households and 21,000 people, would be benefited. The capacity of the main and secondary canals would increase according to the extension of the irrigation area, but no new canal would be proposed.

(4) Comparison of Alternatives

1) Construction Cost

Using the results of supplemental survey and the 1:10,000 topographic map prepared in Phase-II, preliminary design of the alternative plans was made and construction costs were estimated. The irrigation system in the extension area, which is located out of the mapping area, was designed using the 1:50,000 map, the results of the inventory survey conducted in Phase-I, site reconnaissance, and the design of the irrigation system on the upstream.

The construction cost of the irrigation system is given in the following table[7].

[7] The construction costs consist of direct construction cost of the irrigation system but do not include the cost for the reservoirs and the diversion canal.

Construction Cost of Alternative Plans

Unit: US$ 1000

Item	Alternative-1	Alternative-2
Main Canal 33	675	797
New Koh Kaek Main Canal	2,171	
Sub-total	2,846	797
Secondary and Tertiary System	4,078	4,781
Total	6,924	5,578
Per ha cost *	2.0	1.6

* Calculated with 3,485 ha excluding direct command area of Tumnup Lok.

The costs for the main canals largely differ because of the high cost of the New Koh Kaek Canal. The cost of Canal 33 of Alternative-2 does not increase drastically from that of Alternative-1 because the capacity of Canal 33, which ranges from 3.2 m^3/s to 1.0 m^3/s is to be maintained to have a capacity of 2.0 m^3/s regardless of the irrigation requirement, in order to maintain the capacity as a "drain".

2) Socio-economic Condition

The following table shows the economic condition of farm households in Samraong Commune (command area of Koh Kaek Canal of Alternative-1) and Ta Phem Commune (extension area of Alternative-2), obtained through social environmental survey conducted in Phase-I.

Economic Condition by Area

Item	Samraong (Alternative-1)	Ta Phem (Alternative-2)
Land Holding Size (ha)	0.78	0.83
Cash Income by Crops (1000 Riel/year)	51	46
Agricultural Cash Income* (1000 Riel/year)	257	365
Non-agricultural Cash Income (1000 Riel/year)	95	157
Total Cash Income (1000 Riel/year)	352	522

* : including income of livestock

Ta Phem Commune is located along the main district road No.33 where there is an active market. Non-crop agricultural income and non-agricultural income of Ta Phem (Alternative-2) are higher compared with those of Samraong Commune (Alternative-1). However, the agricultural income from crops remains lower in Ta Phem Commune (Alternative-2) than in Samraong Commune (Alternative-1).

3) Evaluation as Development Model and Priority

From the viewpoint of five selection criteria of priority projects in the Master Plan Study, namely, construction cost, technical soundness, negative benefit, government intention and beneficiaries' intention, the two alternatives were evaluated.

First, in terms of the construction cost, Alternative-2 takes a significant advantage to Alternative-1. It must be primarily considered that the burden on the Cambodian government and beneficiaries in the form of investment cost and O&M cost should be alleviated as much as possible in promoting similar rehabilitation and reconstruction projects in the future, and such consideration might give a sufficient reason to adopt Alternative-2.

From the viewpoint of technical soundness, there is little difference between the two, although New Koh Kaek Canal requires intensive construction supervision on canal lining[8].

As for negative benefit, New Koh Kaek Canal requires land acquisition of existing paddy field of 18 ha, while the rehabilitation of Canal 33 does not affect the existing paddy field, which is also an advantage of Alternative-2 to Alternative-1.

The intention and needs of local administration and assumed beneficiaries of the two alternative areas are similar in their desire for irrigation development of the areas. However, some officials pointed out the difficulties for acquisition of land for the new canal. The closer to the area (village, commune), the stronger such comments become. Prior to examining the alternatives, the Study Team explained to the district office of Tram Kak that the alternative with higher economic viability would be selected, and the district office agreed with that point.

It is pointed out in Part-IV of this report that marketing and O&M activities by FWUC would play a great role in promising successful operation of USP. In this viewpoint, the command area of Alternative-2, which takes advantage of better road condition and market environment, would be given higher priority both in terms of higher development potential and suitability as the development model.

Taking the above into consideration, it is proposed to conduct the feasibility study on Alternative-2.

III-2.2 Possible Irrigation Development of Koh Kaek Canal Command Area

The irrigation area could not be extended to the command area of Koh Kaek Main Canal by USP due to water resource limitations. In the Master Plan, it was proposed to cover the whole study area by either USP, SRP or PDP. The command area of Koh Kaek Canal could also be covered by SRP or PDP. In this section, possible irrigation development of the Koh Kaek command area is discussed.

[8] New canals are designed with earth lining and/or soil cement lining.

(1) Development by SRP and PDP

Apart from Ang 160 reservoir, there are eight small reservoirs proposed in the Master Plan in the command area of Koh Kaek Canal. They have good potential and early implementation is expected.

The height of the bed of Koh Kaek Canal fluctuates in the longitudinal profile, and there are a number of depressions along the canal where inflow from the Noreay Mountain Range gets stagnant and stored, then flows eastward. Thus, Koh Kaek Canal has certain possibility to be utilized as a "canal pond" which was proposed in PDP.

(2) Utilization of Natural Streams from the Noreay Mountain Range

Koh Kaek Canal has a catchment of 30 km^2 to the west in the Noreay Mountain Range, and several natural streams flow eastward. These streams are mostly seasonal, but can be utilized for irrigation of diversified crops cultivated before and after the rainy season. It is estimated that a few hundred hectares of area could be irrigated by utilizing of these streams and the storage function of Koh Kaek Canal.