

**Ministry of Water Resources and Meteorology,
Ministry of Agriculture, Forestry and Fisheries,
The Kingdom of Cambodia**

**THE STUDY
ON
COMPREHENSIVE AGRICULTURAL DEVELOPMENT
OF PREK THNOT RIVER BASIN
IN
THE KINGDOM OF CAMBODIA**

FINAL REPORT

**Volume - I
Summary**

August 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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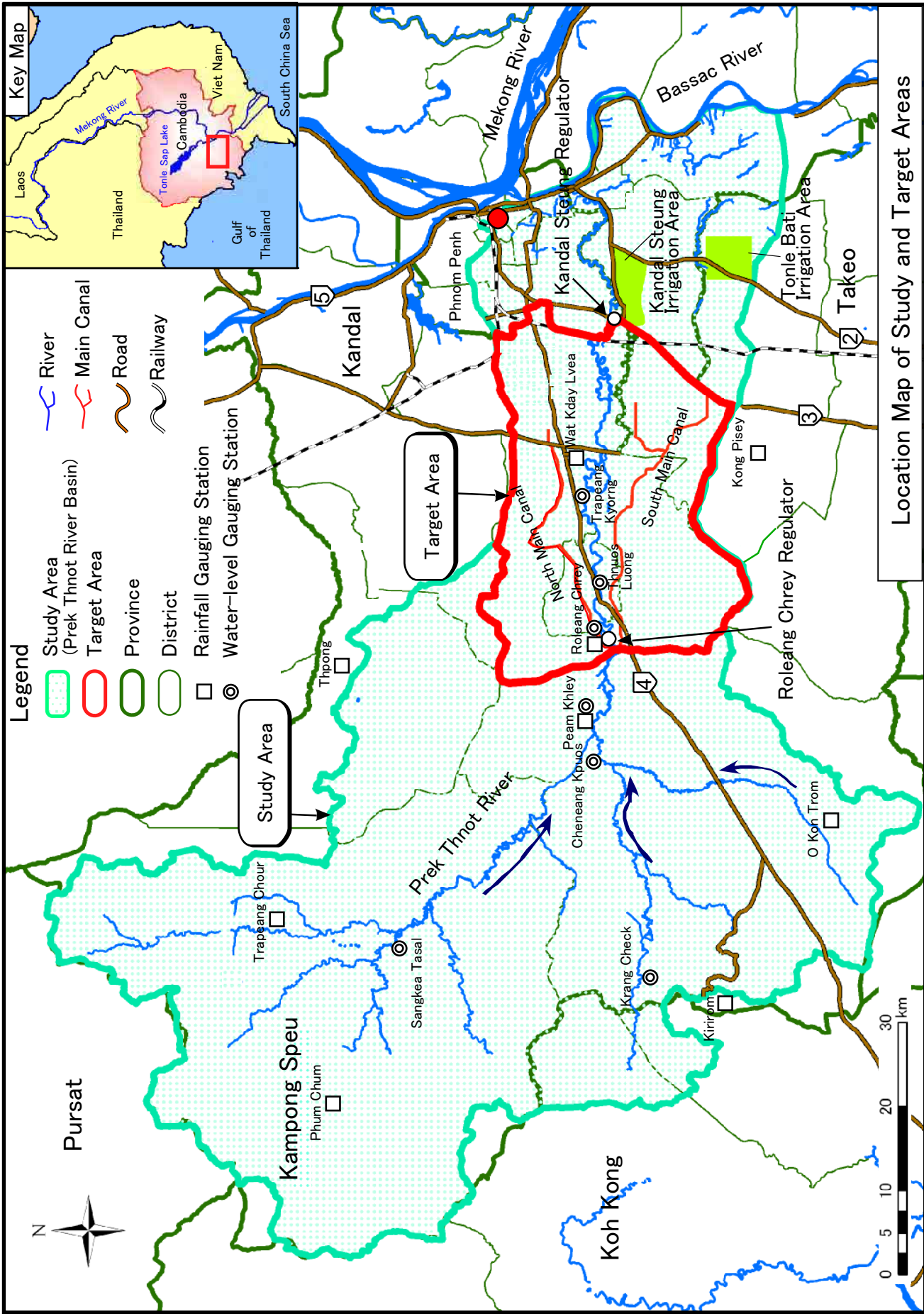
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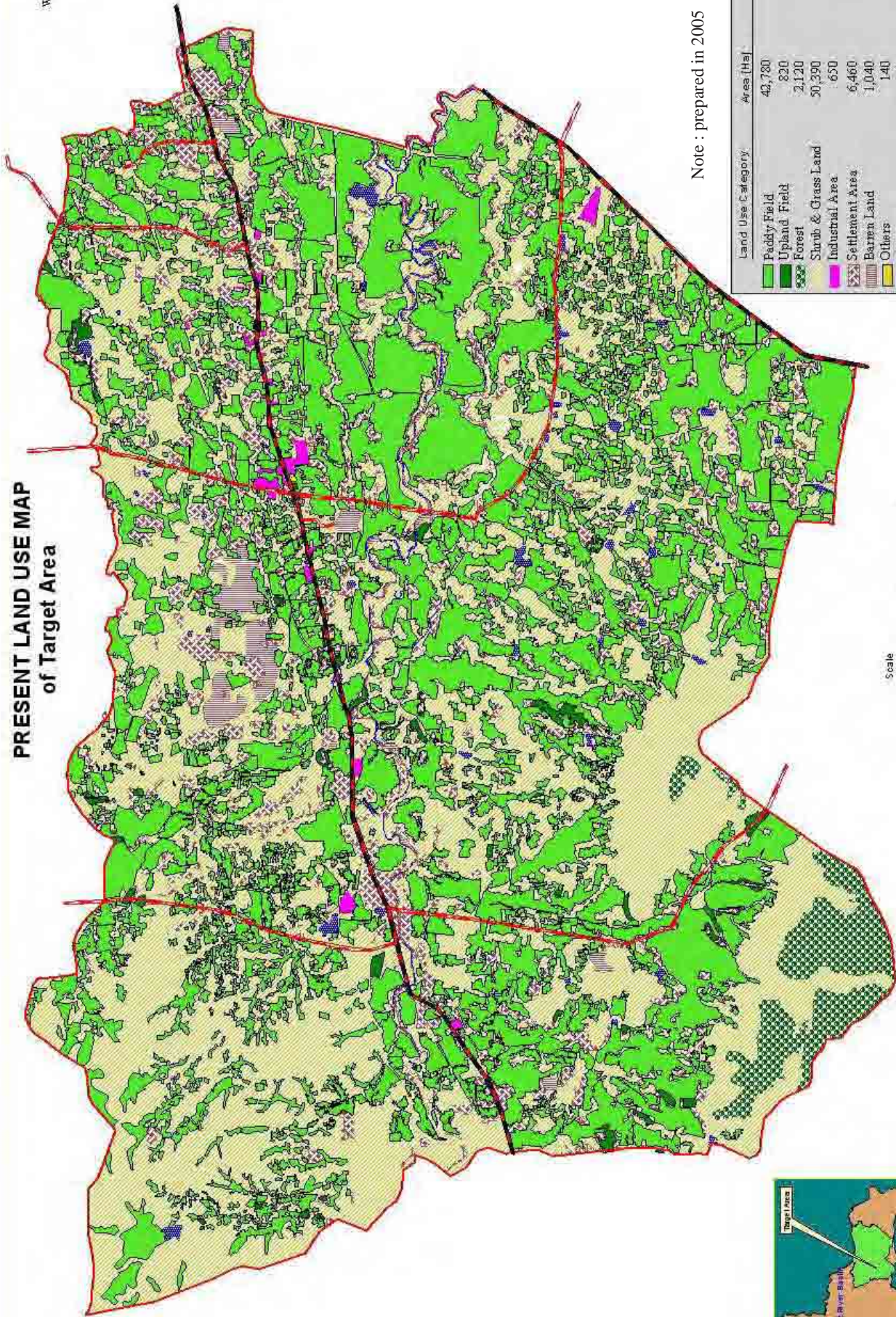
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PRESENT LAND USE MAP of Target Area

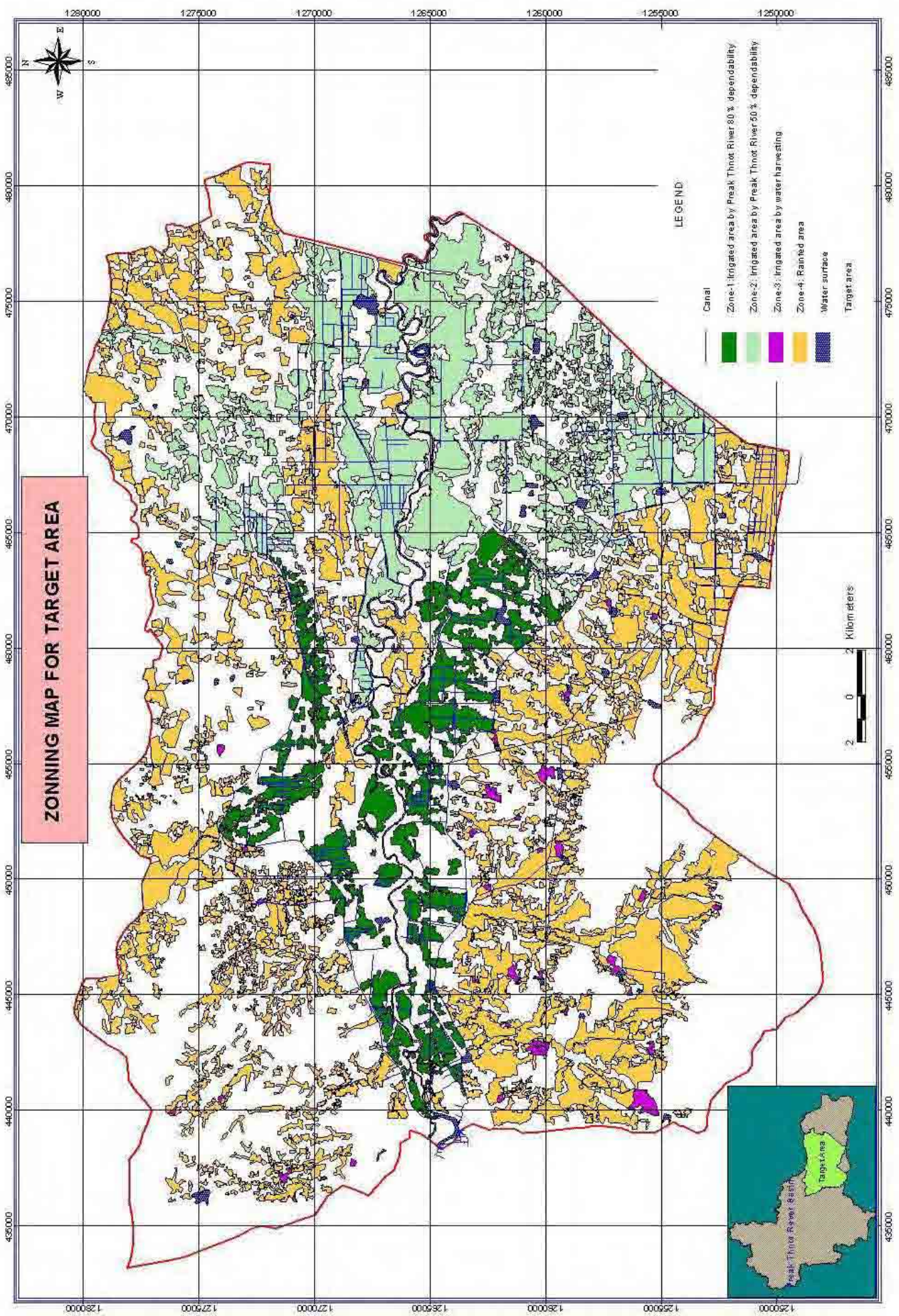


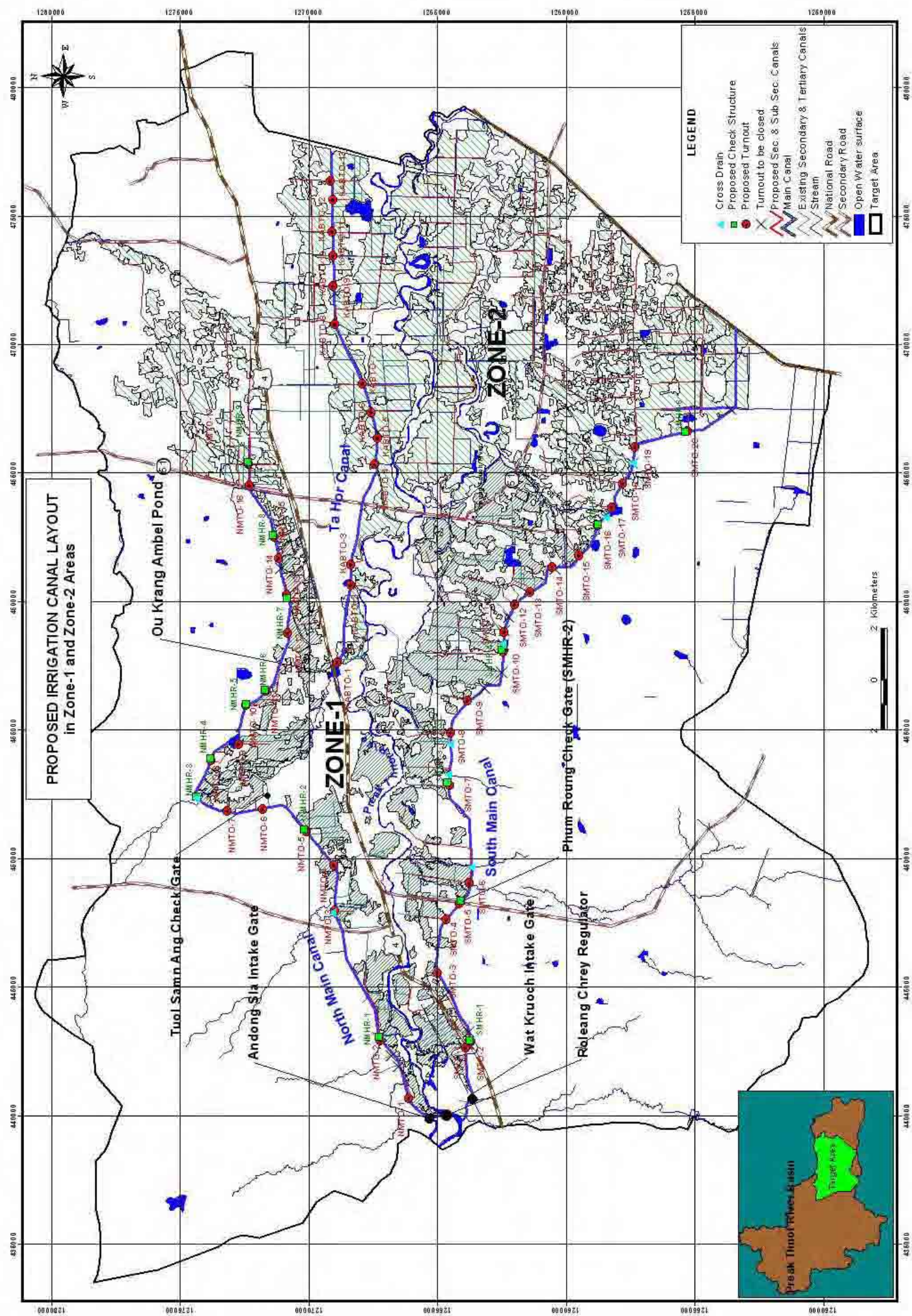
Note : prepared in 2005

Land Use Category	Area (Ha)	%
Paddy Field	42,780	40.7
Upland Field	820	0.8
Forest	2,120	2.0
Shrub & Grass Land	50,390	47.9
Industrial Area	650	0.6
Settlement Area	6,460	6.1
Barren Land	1,040	1.0
Others	140	0.1
Water Surface	800	0.8
Total	105,200	100



ZONNING MAP FOR TARGET AREA





**PROPOSED IRRIGATION CANAL LAYOUT
in Zone-1 and Zone-2 Areas**

LEGEND

- Cross Drain
- Proposed Check Structure
- Proposed Turnout
- Turnout to be closed
- Proposed Sec. & Sub Sec. Canals
- Main Canal
- Existing Secondary & Tertiary Canals
- Stream
- National Road
- Secondary Road
- Open Water surface
- Target Area



480000 470000 460000 450000 440000 430000 420000 410000 400000

1280000 1270000 1260000 1250000 1240000 1230000 1220000 1210000 1200000

0 2 Kilometers

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SUMMARY

VOLUME-II MASTER PLAN

Chapter 1 Introduction

(1) Authority (1.1)

This master plan is a part of the final report which was prepared in accordance with the Scope of Work for the Study agreed between the Ministry of Water Resources and Meteorology, the Kingdom of Cambodia (MOWRAM) and the Japan International Cooperation Agency (JICA) on April 11, 2005. The Report presents results of the master plan study for the target area, which was executed from July 28, 2005 to the end of February 2008.

(2) Composition of Final Report (1.2)

The Report consists of the following seven volumes:

Volume-I	Summary
Volume-II	Master Plan
Volume-III	Feasibility Study for Priority/Urgent Projects
Volume-IV	Pilot Projects
Volume-V	Hydrological Study and Environmental Management Basic Capacity Strengthening
Volume-VI	Appendixes for Master Plan
Volume-VII	Appendixes for Feasibility Study for Priority/Urgent Projects

(3) Background of the Study (1.3)

Agriculture as the major economic activity in the basin of the Prek Thnot River, relies on erratic rainfall due to limited irrigation system. This results in low and unstable production of crops with some farmers still unable to harvest enough for their self-consumption of rice. The Royal Government of Cambodia (RGC) therefore requested the Government of Japan (GOJ) to extend technical assistance for the Study on Comprehensive Agricultural Development of Prek Thnot River Basin, aiming on improvement of agricultural productivity. Responding to the request, the GOJ dispatched a preparatory study team in January 2005 and finally agreed with the RGC to the said scope of work for the Study.

(4) Objectives of the Study (1.3.2)

- To formulate the master plan on Comprehensive Agricultural Development (M/P) in order to improve agricultural productivity in the Prek Thnot River Basin;
- To implement the Feasibility Study (F/S) on the rehabilitation of existing irrigation and drainage facilities with high priority/urgency primarily associated with improvement of rice cultivation;
- To prepare a flood forecasting and warning plan; and
- To transfer technologies to the counterpart personnel through on-the-job training during the course of the study.

(5) Target and Study Areas (1.4)

The target area of the M/P will cover agricultural land comprising mainly of paddy fields in the Prek Thnot River Basin. The location is in Chabar Mon District, which is part of the Samraong Tong and Kong Pisei Districts in Kampong Speu Province, and part of the Ang Snuol and Kandal Stueng Districts in Kandal Province. It extends from the Roleang Chrey Regulator to the west of National Road No. 3.

The study area includes both the upstream and downstream sections of the basin, from the viewpoint of the collection of hydrological data necessary for analysis.

(6) Technology Transfer (1.6)

Prior to commencement of the study, the JICA study team submitted the technology transfer plan to the MOWRAM on August 6, 2005. In line with this plan, technology transfer to counterpart personnel was carried out mainly through on-the-job training. In particular, presentation of the M/P by the counterpart personnel during a seminar provided them a deeper understanding of the M/P.

(7) Steering Committee Meetings (1.7)

During the Study period, the Steering Committee Meetings were held six times at the MOWRAM office, for the following submitted reports,:

Steering Committee Meetings	Reports Submitted	Date of Meeting
1	Inception Report	August 2, 2005
2	Progress Report (1)	February 22, 2006
3	Interim Report (1)	June 16, 2006
4	Progress Report (2)	February 22, 2007
5	Interim Report (2)	June 14, 2007
6	Progress Report (3)	February 20, 2007

The meetings were attended by staff of MOWRAM, the Ministry of Agriculture, Forestry and Fisheries (MAFF), the Ministry of Economic and Finance (MEF), the Ministry of Environment (MOE), and the Cambodian National Mekong Committee (CNMC). Representatives from the Embassy of Japan and JICA Cambodia Office also attended the meetings. These reports were accepted by the committee after discussion among attendees.

Chapter 2 Background

(8) National Development Policies (2.2)

Current Relevant National Development Policies

- Rectangular Strategy for Growth, Employment, Equity and Efficiency,
- National Poverty Reduction Strategy 2003-2005 (NPRS),
- Second Five Year Socioeconomic Development Plan 2001-2005 (SEDP II)
- National Strategy Development Plan 2006-2010 (NSDP)
- National Water Resources Policy (NWRP)

Common Issues related to the Study

The development of the agricultural sector is given high priority to ensure poverty reduction and economic growth.

(9) Sectoral Development Policies (2.3)

Current Relevant Sectoral Development Policies

- Agriculture Development Plans for Short, Medium and Long Terms 2001-2010,
- Action Program for Development of the Agricultural Sector 2001-2010,

- Strategic Development Plan for Water Sector 2006-2010 (Draft)
- Rehabilitation and Development Plan for Water Resources and Meteorology Sector for the Second Five Year 2001-2005
- Policy for Sustainability of Operation and Maintenance of Irrigation Systems

Common Issues related to the Study

There is a need for improvement of agricultural productivity, and expansion of irrigated area through rehabilitation and construction of irrigation systems.

Chapter 3 Hydrometeorological Analysis on the Study Area

(10) Hydrometeorological Conditions (3.1)

The climate of the Study Area is characterized as tropical monsoon with definite rainy (May to November) and dry (December to April) seasons. Mean temperature has minimal seasonal variation ranging from 26.1°C in December to 30.5°C in April. Relative humidity ranges from 66% to 77% in February and March, and 80% to 90% in September and October. The rainy season accounts for 90% of the annual rainfall. Average annual rainfall in the basin is estimated at 1,225 mm. As of 2005, there are three water level gauging stations on the Prek Thnot River: Peam Khley, Thnuos Luong and Roleang Chrey Regulator. The periods of available data vary by station from 5 years to 9 years.

(11) River Conditions of Prek Thnot (3.2.1, 3.2.4)

The Prek Thnot River consisting of 11 sub-basins, has a catchment area of 4,650 km² at its confluence with the Bassac River. The slope of the river was estimated at 1/2,720 at its upstream, while 1/5,100 at its downstream. The flow capacity ranges from 1,300 m³/sec to 1,500 m³/sec upstream and from 300 m³/sec to 800 m³/sec downstream, in proportion to the river slope. According to the gate operator working at Roleang Chrey Regulator for 38 years, the maximum flood occurred in 1991, with an estimated discharge of 1,369 m³/sec. On the other hand, the results of the topographic survey for the Prek Thnot River indicated that its flow capacity ranges from 1,300 m³/sec to 1,500 m³/sec at the upstream mentioned above. This, data is almost similar to the observation made by the gate operator. With these findings, it could be concluded that the probable flood peak discharge to be considered for design of Roleang Chrey Regulator for its improvement, would be between 1300 m³/s and 1500 m³/s, A conservative range of 1400 m³/s and 1600 m³/s may also be considered provided that any river improvement works in the upstream reaches of the weir site would not increase the river discharge carrying capacity of said reaches.

(12) Low Flow Analysis (3.5.1)

Using the runoff data, a dependable 5-day discharge at the Roleang Chrey Regulator is estimated for irrigation development from those at Peam Khley, proportional to catchment area. The estimated 80 % and 50% dependable discharges are as follows:

Dependable Discharge at Roleang Chrey Regulator

Dependability	Dry Season	Rainy Season
80 %	2.8 m ³ /sec – 51.9 m ³ /sec	9.8 m ³ /sec – 384.4 m ³ /sec
50 %	2.9 m ³ /sec – 51.9 m ³ /sec	20.8 m ³ /sec – 537.7 m ³ /sec

Chapter 4 The Target Area

(13) Administration and Population (4.2)

The target area is administratively related to two provinces, five districts, 42 communes and 761 villages. Chabar Mon District and parts of Samraong Tong and Kong Pisei Districts in Kampong Speu Province are included in the target area. Moreover, the Kandal Stueng District and part of Angk Snuol District, in Kandal Province also form part of the target area.

According to the SEILA Commune Database, 2004, the total population of 340,784 in the target area, consist of 243,944 in Kampong Speu Province and 96,840 in Kandal Province.

(14) Natural Conditions (4.3)

Elevation of the target area ranges from 20 m to 70 m, with a mild upward slope from east to west. The area is divided into northern and southern part by the Prek Thnot River, which flows from west to east. Soils found in the target area mainly consist of medium textured surface layers underlain with finer textured sub-soils. Ninety percent of the target area is classified suitable for crops.

(15) Socio-economic Settings (4.5)

Based on the food balance analysis conducted under the Study, production of paddy by the communes in the target area is roughly 38% lower than consumption. As far as the information from sampled households are concerned, about 80% fall below poverty line (USD 0.46/day/per capita). The Socio-Economic Survey indicates that there is no serious gender equity issue among the sampled households.

(16) Land Tenure and Land Holding (4.7.1)

Land Tenure & Holding Features of Project Communes in Target Area

Indicator	Features
No. of Households (total)	62,100
No. of Farm Households (No. of crop producing households)	55,847
No. of None Farm Households (No. of none crop producing households)	6,253 ^{1/}
No. of Landless Households	
Total Paddy Field in Project Communes	39,688 ha
Average Paddy Field Holding Size per Farm Household	0.71 ha
% of Farm Households with Holding Size Less Than 10ha	4 %
% of Farm Households with Holding Size More Than 3ha	2 %
% of Landless Households	10%

^{1/}: 41 % in Chbar Mon District, which is categorized as an urban area in the SEILA Data Base
Source: Commune Survey on Crops & Livestock, 2003, MAFF & SEILA Data Base 2004

(17) Present Land Use (4.7.2)

Present Land Use of Target Area

Land Use Category	Area (ha)	%	Land Use Category	Area (ha)	%
Paddy Field ^{1/}	42,780	40.7	Settlement/Industrial Land	7,110	6.8
Upland Field	820	0.8	Others	1,180	1.1
Forest	2,120	2.0	Water Surface	800	0.8
Shrub & Grass Land	50,390	47.9	Total	105,200	100

^{1/}: Gross area

(18) Rice Production (4.7.3)

Rice production is the most important agricultural activity in the target area with nearly 100% of farm households engaged in rice cultivation during the rainy season. Paddy field in the target area is divided into the following three categories based on irrigation water supply conditions, namely, irrigated paddy field, supplementary irrigated paddy field and rainfed paddy field. Yield and production of paddy in the project communes estimated as shown below, were based on statistical data of the MAFF and the Provincial Departments of Agriculture (PDAs),:

Paddy Yield & Production in Project Communes

Crop Year	Average Paddy Yield (ton/ha)				Production (1000ton) ^{1/}
	Cropped Area		Harvested Area		
	Rainy Season	Dry Season	Rainy Season	Dry Season	
Communes in Kampong. Speu ^{1/}	1.4	2.4	1.7	2.6	38.0
Communes in Kandal ^{2/}	1.8	2.8	1.9	2.8	17.2
All Project Communes ^{3/}	1.6	2.4	1.7	2.4	62.7

^{1/}: Average of 2003/04 – 2004/05; ^{2/}: 2000/01 – 2003/04; ^{3/}: 2003/04

(19) Food Balance (4.7.4)

Food Balance of Rice in Project Communes

Crop Year	Milled Rice Production (ton)	Milled Rice Requirement (ton)	Food Balance of Milled Rice (ton)	Proportion (%) ^{1/}
2002 – 2003	25,145	45,659	- 20,514	45
2003 – 2004	34,925	46,436	- 11,512	25
2004 – 2005	26,140	40,141	- 21,001	45
Average	28,736	46,412	- 17,676	38

^{1/}: Proportion of deficits to requirements

As shown in the table, it is estimated that production is roughly 38% less than the requirements of the communes, on average. The average deficit of about 17,680 tons of rice corresponds to approximately 32,000 tons of paddy, which is about 62% of the average annual production volume of 51,610 tons.

(20) Gates of Roleang Chrey Regulator (4.8)

The Roleang Chrey Regulator, the key structure for the existing irrigation system in the target area, was constructed in 1974. It is observed that some portions have been damaged due to deterioration. In particular, the water gates, which are indispensable for proper water abstraction and flood control, showed severe condition and is consequently malfunctioning. Thus, urgent repairs/improvement is required to ensure appropriate gate operation.

(21) Irrigation and Drainage (4.9)

Inventory Survey for Existing Irrigation Schemes

The following irrigation schemes were identified in the target area during the inventory survey of the existing irrigation system:

Water Resource	Nos. of Schemes	Inventory Area (ha)	Nos. of Systems with Reservoirs
(1) Prek Thnot River	35	15,207	17
(2) Ou Krang Ambel River	1	498	1
(3) Small Tributaries	49	1,796	49
Total	85	17,501	67

The inventory area mentioned above is estimated without applying the probability concept for water supply, which is generally used for the delineation of irrigable area. This also includes areas which are irrigated only a few days in each crop season, or those which are only irrigated once every few years. Thus, the inventory area does not represent the proposed irrigation area.

Western Phnom Penh Integrated Development Center Project

This project aims for an irrigation development of 24,000 ha in and around the target area, utilizing the water from Prek Thnot River. The project includes construction of 79km of main canals, 19 km secondary canals, 192 km tertiary canals, 95 km drainage canals and more than 150 related structures. Thirty six existing irrigation schemes are included in this project. The project began in 2001 and is about 7 % completed as of date. This project

area will be mostly considered into the present Study, although canal bank heightening and additional structures are also required.

Operation and Maintenance (O&M) of the Roleang Chrey Regulator and other irrigation and drainage facilities should be carried out by Kampong Speu Provincial Department of Water Resources and Meteorology (PDOWRAM) and Farmers Water Users Community (FWUC). However, said agencies failed to function effectively due to lack of technical capacity and budget. Likewise, they have not systematically executed proper water management.

(22) Local Authorities and FWUC/FWUG (4.10.3, 4.10.4, 4.10.5)

Commune Councils (CC) and Village Development Committees (VDC) are being established in the target area, to govern and develop the communes and villages respectively. In addition, 25 FWUCs and their subordinate organizations, Farmers Water Users Groups (FWUGs), have been established, however, mostly are inactive mainly due to limited water resources for irrigation.

(23) SWOT Analysis for Government Agencies (4.10.7)

SWOT analysis was conducted for MOWRAM, MAFF, and PDOWRAMs and PDAs (Kampong Speu and Kandal). It was concluded that the motivation/incentive to work is vital to achieve the missions, and for required cooperation with the other agencies. Improving their motivation will surely contribute to successful implementation of the M/P. It is noted that staff motivation can be boosted by increasing awareness on the significance of the works. Acknowledgement of their efforts from their superiors and external agencies concerned would be one way of motivating the officers.

(24) Agricultural Support Services (4.11)

Agricultural support services in the target area are not effectively executed due to financial constraints, insufficient coordination, and lack of ownership of PDAs. Thus, agricultural support activities in the target area have been mainly implemented by donors and NGOs, instead of PDAs. The strengthening of agricultural support services should be sought through presentation in a well integrated manner, and implementation in a farmer participatory manner.

Chapter 5 *PCM Workshops and RRA*

(25) Project Cycle Management (PCM) Workshops (5.2)

PCM Workshops intended to determine existing problems and corresponding solutions, were conducted for MOWRAM, MAFF, PDOWRAM, and PDA and the farmers, . In conclusion, all stakeholders remarked that the crucial problems were the farmers' small income and agricultural production. As a means of addressing the concerns, agricultural extension services are required to determine ways of improving the present farming methods and ineffective water management.

(26) Rapid Rural Appraisal (RRA) (5.3)

RRA workshops were conducted aiming to grasp the socioeconomic condition of the farmers in the target area. As a result, shortage of water and insufficient irrigation systems are regarded as the preferential subjects to be settled urgently.

Chapter 6 *Water Resources Potential for Agricultural Development*

(27) Water Resources and Probable Irrigation Area (6.2, 6.3 and 6.4)

The available water resources for the agriculture in the target area are (i) Prek Thnot River, (ii) Ou Krang Ambel River and (iii) tributaries. Based on the 5-day dependable discharges and water demand of crops, a water balance study has been conducted. As a result, the

following probable irrigation areas were estimated:

Probable Irrigation Area by Prek Thnot River through Roleang Chrey Regulator

Dependability	Early Rice-1 (ha)	Early Rice-2 (ha)	Medium Rice (ha)
80%	400	400	5,500
50%	3,500	3,500	13,000

Early Rice-1: April to August, Early Rice-2: August to December, Medium Rice: July to December

Probable Irrigation Area by Ou Kurang Ambel River

Dependability	Early Rice-1 (ha)	Early Rice-2 (ha)	Medium Rice (ha)
80%	115	115	430
50%	250	250	700

Probable Irrigation Area by Water Harvesting

Dependability	Early Rice-1 (ha)	Early Rice-2 (ha)	Medium Rice (ha)
80%	-	-	600
50%	-	-	1,200

(28) Application of Different Probabilities in Water Supply (6.5)

At present, the paddy fields located upstream are cultivated with a double cropping pattern, while those downstream could not be sufficiently irrigated through the main canal due to its insufficient and low water level. The proposed irrigation water allocation should not drastically deviate from such present irrigation condition, to avoid disputes between downstream and upstream farmers. In fact, the upstream farmers largely rely on irrigation since they own small land areas. In consideration of such present irrigation condition, limited available water and the future development plan of the on-going Western Phnom Penh Integrated Development Center Project, the target area is divided into two 80 % and 50% dependability areas.

Chapter 7 Lessons Learned from Pilot Projects

(29) Lessons Learned from Pilot Projects (7.1 and 7.2)

The “Irrigated Agriculture On-farm Technology Improvement pilot project” and “Rainfed Agriculture Improvement pilot project” were selected in the M/P and implemented for about 1.7 years, from May 2006 to February 2008. Consequently, a number of lessons related to irrigation, agriculture and institution were learned from said projects.

(30) Feedback to Master Plan (7.3)

Among these lessons learned, the substantial ones mentioned in the M/P were identified as follows:

Field	Selected Lessons Learned for Feedback to Master Plan
(1)Irrigation	<ul style="list-style-type: none"> - Application of rotational irrigation method along tertiary canal - Need of coordination between MOWRAM and MAFF - Collection method of ISF - Need of rainfall observation to predict storage condition of reservoir in water harvesting - Consideration of multi-use of reservoir for development of water harvesting - Water supply based on owing stages of paddy for establishment of proper water management in water harvesting
(2)Agriculture	<ul style="list-style-type: none"> - Execution of on-farm water management by water depth control at field - Application of current prevailing post-harvest practices considering limited availability of threshing machine and need of transport of rice straw for feeding cattle - Need of technology development and field demonstration of upland crops
(3)institution	<ul style="list-style-type: none"> - Involvement of commune chief and Council for strengthening FWUC - Strengthening of FWUC for proper water management and O&M - Need of WUG formation for realization of proper FWUC activities - Coordination of MOWRAM and MAFF - Provincial Departments strengthening

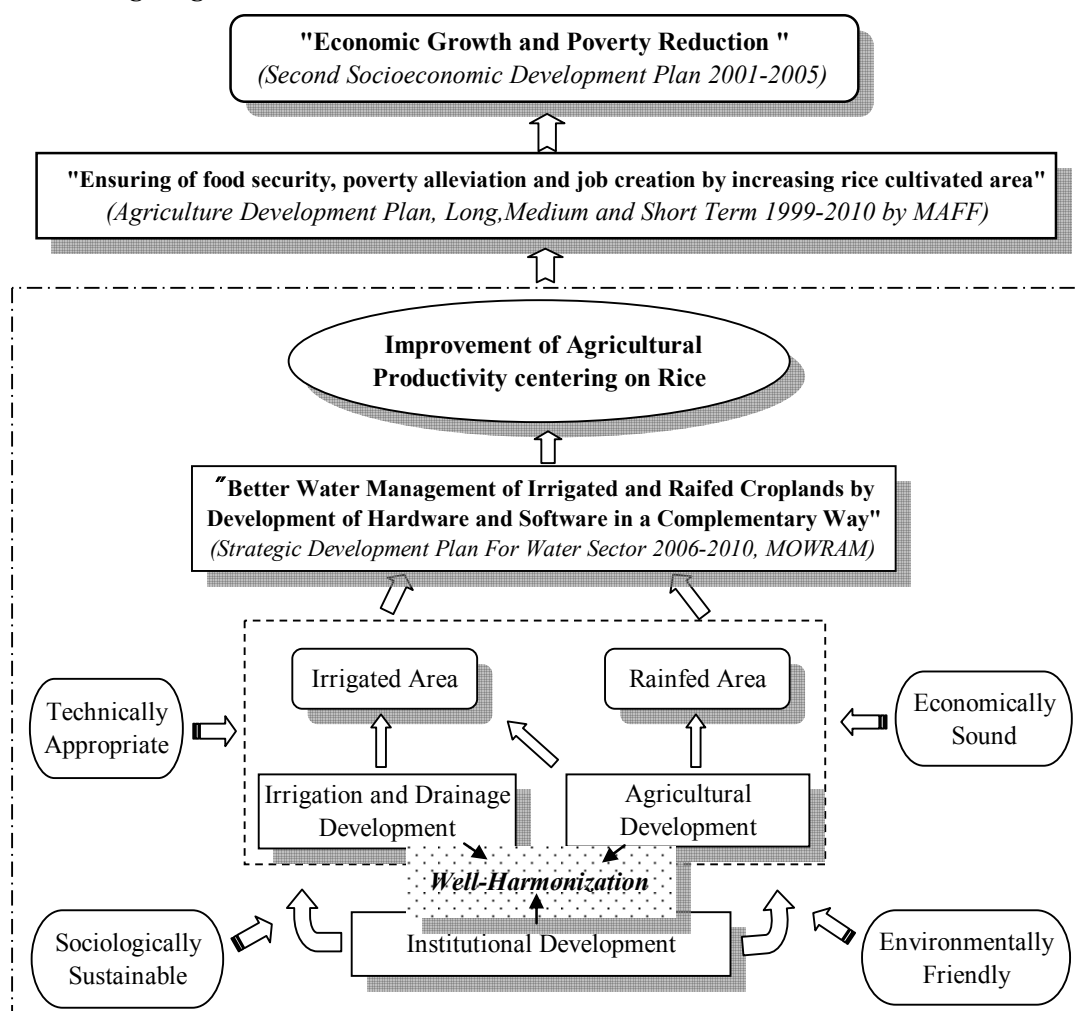
Chapter 8 Basic Concept of and Approach to Master Plan for Comprehensive Agricultural Development

(31) Needs for Comprehensive Agricultural Development (8.1)

The target area suffers from a constant shortage of rice, thus increase of its production is given top priority. In order to resolve such concern, it is essential to expand the irrigable area as well as improve the crop yield through the strengthening of institutional and agricultural support services. Moreover, raising livestock and inland fish culture should also be enhanced to ensure other source of income. The comprehensive agricultural development is therefore a necessity in the Target Area.

(32) Objective and Strategy (8.2)

The objective of the M/P is to present and elaborate strategies of improving the agricultural productivity in the target area by the specific year, considering the existing water resources. Based on the survey and study results, the **“Improvement of Agricultural Productivity centering on Rice”** is selected as the strategic target of the M/P, which will be attained through **“program approach”**, in a concept of **“Well-harmonized Development of Irrigation and Drainage, Agriculture and Institutions”**.



(33) Development Scenario (8.3)

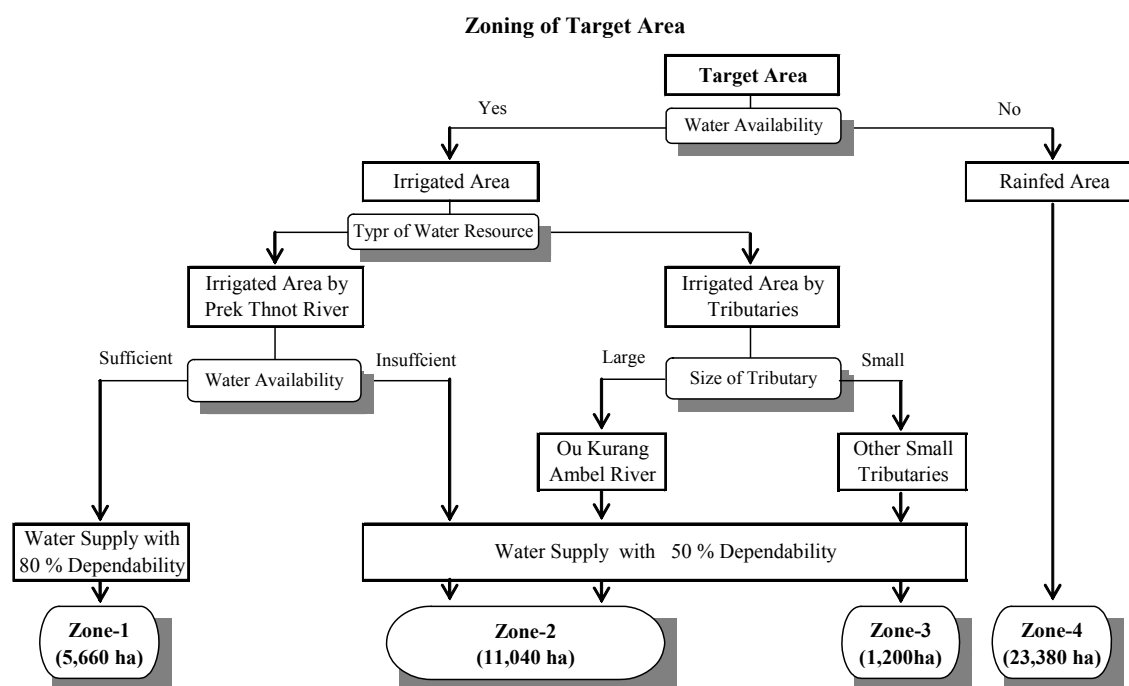
In harmony with the various superior policies and development plans, the M/P is proposed to be define the target medium term of year 2015. Said term is divided into short term (from 2006 to 2010) and medium term (from 2006 to 2015). Following the superior policies,

“decentralization” is selected as a focal point in the short term while “privatization” in the medium term. Thus, the local department-oriented and the farmer-oriented approach are highlighted in the short term and medium term, respectively.

Development Scenario		
	Short Time (2006-2010)	Medium Time (2006-2015)
Overall Strategic Target	Improvement of Agricultural Productivity Centering Rice	
Focus Point in Each Term	Decentralization	Privatization
Irrigation and Drainage Development	Expansion of the irrigated area through effective use of existing water resources and application of appropriate water management.	
Strategic Approach	Expansion of the irrigated area through effective use of existing water resources and application of appropriate water management.	
Focused Main Activities	<ul style="list-style-type: none"> - Improvement of priority/urgent irrigation projects - Execution of proper water management by local department-oriented approach - Execution of O&M of irrigation and drainage facilities by local department-oriented approach 	<ul style="list-style-type: none"> - Improvement of irrigation projects by farmers' participation - Execution of proper water management by farmer-oriented approach - Execution of O&M of irrigation and drainage facilities by farmer-oriented approach
Agricultural Development	Improvement of crop yields through proper farming technology and strengthening of support services, and promotion of inland fish culture and livestock farming	
Strategic Approach	Improvement of crop yields through proper farming technology and strengthening of support services, and promotion of inland fish culture and livestock farming	
Focused Main Activities	<ul style="list-style-type: none"> - Promotion of agricultural development in the priority/urgent irrigation projects - Agricultural support services by local department-oriented approach 	<ul style="list-style-type: none"> - Farmer initiative agricultural development in irrigation project areas and raised areas - Agricultural support services by farmer-oriented approach
Institutional Development	Formation of farmers organization, and capacity development of local department and farmers organization	
Strategic Approach	Formation of farmers organization, and capacity development of local department and farmers organization	
Focused Main Activities	<ul style="list-style-type: none"> - Proper financial and administrative arrangement - Strengthening of coordination between MOWRAM and MAFF - Capacity development of local departments - Formation of FWUCs and other required farmers organization - Commencement of capacity development of FWUCs and other required farmers organization 	<ul style="list-style-type: none"> - Formation of FWUCs and other required farmers organization for remaining irrigation projects and raised projects - Capacity building of FWUCs and other required farmers organization - Monitoring and evaluation of activities of local departments, FWUCs and other required farmers organization

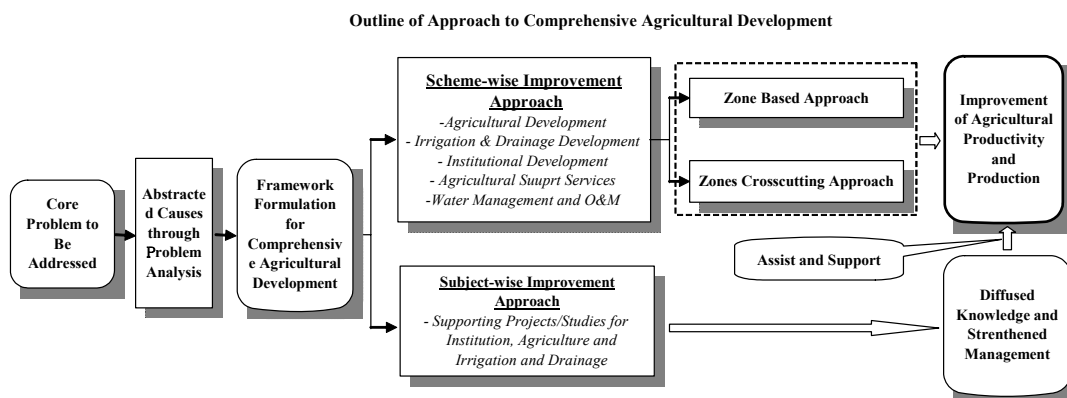
(34) Zoning of Target Area (8.4)

The target area exhibits diversity in terms of water availability and land use. To formulate a comprehensive agricultural development plan that is appropriate to local conditions, zoning is recommended as the suitable approach, especially for crop sub-sectors, which is a main source of farmers’ income in the target area. The following chart shows the resulting zoning of the target area.



(35) Framework Formulation and Basic Concept for Comprehensive Agricultural Development (8.5)

Many problems and constraints on agricultural development were determined through the PCM workshop, RRA, socio-economic survey and SWOT analysis, as well as through site inspection carried out by the JICA study team. Based on the results of the analysis on these problems and constraints, the following program approach is proposed:



Scheme-wise Improvement Plan

The scheme-wise improvement approach aims at reaping the benefits directly from the projects. The scheme-wise development is divided into zone-based and zone-crosscutting approaches. In the zone-based approach, irrigated agriculture projects for Zones 1 to 3 and a rainfed agriculture project for Zone 4 are formulated aiming at improvement of agricultural productivity centering on rice in the target area. Hence, this will eventually contribute largely to self-sufficiency in rice production in the target area. The zone-based projects should be implemented through integrated hardware and software aspects. In the zone crosscutting approach meanwhile, development of the livestock and fishery sub-sectors related to the whole target area, are carried out in a comprehensive method. The production of livestock and fishery sub-sectors is expected to increase by improving the present extensive system, without due regard to zoning. It is also noted that in the target area, although not predominant, there are marginal level farmers with limited sized land holdings. Income generation for these farmers will also be considered from the viewpoint of poverty alleviation.

Subject-wise Improvement Plan

Well-harmonized development of hardware and software aspects was indispensable for attaining the objective of the scheme-wise improvement, thus, the subject-wise improvement approach was expanded. The subject-wise improvement approach aims to support the scheme-wise improvement projects from the technical, institutional, sociological and environmental viewpoints. As a result, the subject-wise improvement projects/studies will heighten the effect and sustainability of the scheme-wise improvement projects. With this approach, some pilot projects are also included to verify the appropriate technical methods of water management, farming practice and inland fisheries cultivation.

(36) List of Proposed Projects/studies (8.5.2)

Based on the approach mentioned above, the elaborated projects/studies for scheme-wise and subject-wise improvement plans, are as follows:

List of Scheme-wise Improvement Plan and Subject-wise Improvement Plan

Scheme-wise Improvement Plan		
Zone Based Projects (Zone-1),		
1	A.1(1)	Irrigated Agriculture Improvement Model Project
2	A.1(2)	Upper North Main Canal Irrigated Agriculture Improvement Project
3	A.1(3)	Upper South Main Canal Irrigated Agriculture Improvement Project
Zone Based Projects (Zone-2)		
4	A.2(1)	Lower North Main Canal Irrigated Agriculture Improvement Project
5	A.2(2)	Lower South Main Canal Irrigated Agriculture Improvement Project
6	A.2(3)	Ou Krang Ambel Irrigated Agriculture Improvement Project
Zone Based Project (Zone-3)		
7	A.3(1)	Water Harvesting Irrigated Agriculture Improvement Project
Zone Based Project (Zone-4)		
8	A.4(1)	Rainfed Agriculture Improvement Project
Zone Crosscutting Projects		
9	B.1(1)	Roleang Chrey Regulator Gates Urgent Improvement Project
10	B.1(2)	Roleang Chrey Regulator and Intakes Improvement Project
11	B.2(1)	Veterinary Services Strengthening and Livestock Raising Improvement Project
12	B.3(1)	Community Inland Fisheries Development Project
13	B.4(1)	Income Generation Projects for Marginal Farmers
Subject-wise Improvement Plan		
14	C.1(1)	Coordination between MOWRAM and MAFF Strengthening Project
15	C.1(2)	Provincial Departments Strengthening Project
16	C.2(1)	Livestock Sub-sector Development Study
17	C.3(1)	Technical Guidelines Preparation Project
18	C.4(1)	Environmental Management Basic Capacity Development Project
19	C.4(2)	Environmental Management Applied Capacity Development Project
20	C.5(1)	Irrigated Agriculture On-Farm Technology Improvement Pilot Project
21	C.6(1)	Irrigation Facility Maintenance Capacity Strengthening Pilot Project
22	C.7(1)	Rainfed Agriculture Improvement Pilot Project
23	C.8(1)	Community Inland Fisheries Development Pilot Project
24	C.9(1)	River Basin Effective Water Use Awareness Raising Project
25	C.10(1)	Institutional and agricultural Support Services Strengthening Project
26	C.11(1)	Hydrological Observation Strengthening Project
27	C.11(2)	Flood Forecasting and Warning Study

Overall framework for comprehensive agricultural development is shown in Table 1.

Chapter 9 Formulation of Master Plan for Comprehensive Agricultural Development

(37) Program Theory Matrix (9.2)

Twenty seven projects/studies are proposed aiming to achieve the strategic target of **improvement of agricultural productivity centering on rice** in the target area using the program approach. In order to clarify the relation between the overall policy, end outcome, intermediate outcome, output and these projects/studies (activities) in the program approach, Program Theory Matrix (PTM) as shown in Table 2, is prepared to present the logical framework.

Table 1 Overall Framework for Comprehensive Agricultural Development

Core Problem to Be Addressed	Major Causes abstracted from PCM, RRA, Socio-economic Survey, SWOT and Site Inspection	Approach to Improvement	Expected Outcome			
Unstable and Low Production	Scheme-wise Improvement Zone-based Approach (Zone 1)		Proposed Improvement Projects/Studies Zone-based Approach (Zone 1)			
	A-1.1 Limitation of water resources	Efficient use of existing water resource		Irrigated Area		
	A-1.2 Poor or lack of irrigation system	Rehabilitation/Improvement/Development of irrigation system		A.1(1) Irrigated Agriculture Improvement Model Project		
	A-1.3 Insufficient water management	Improvement of water management		A.1(2) Upper North Main Canal Irrigated Agriculture Improvement Project		
	A-1.4 Inappropriate farming practice	Introduction of improved farming practice		A.1(3) Upper South Main Canal Irrigated Agriculture Improvement Project		
	A-1.5 Lack or inactivity of FWUC/FWUG	Formation or empowerment of FWUC/FWUG				
	A-1.6 Insufficient and less coordinated agricultural support services	Strengthening & coordination of agricultural support services				
	Scheme-wise Improvement Zone-based Approach (Zone 2 and 3)					
	A-2.1 Limitation of water resources	Efficient use of existing water resource		Irrigated Area		
	A-2.2 Poor or lack of irrigation system	Rehabilitation/Improvement/Development of irrigation system		A.2(1) Lower North Main Canal Irrigated Agriculture Improvement Project		
	A-2.3 Insufficient water management	Improvement of water management		A.2(2) Lower South Main Canal Irrigated Agriculture Improvement Project		
	A-2.4 Inappropriate farming practice	Introduction of improved farming practice		A.2(3) On Krang Ambel Irrigated Agriculture Improvement Project		
	A-2.5 Low land use intensity	Introduction of crop diversification				
	A-2.6 Lack of or inactive FWUC/FWUG	Formation or empowerment of FWUC/FWUG				
A-2.7 Insufficient and less coordinated agricultural support services	Strengthening & coordination of agricultural support services					
Scheme-wise Improvement Zone-based Approach (Zone 4)						
A-4.1 Limitation of water resources	Efficient use of existing water resource	Rainfed Area				
A-4.2 Inappropriate farming practice	Introduction of improved farming practice	A.4(1) Rainfed Agriculture Improvement Project				
A-4.3 Lack or inactivity of FWUC/FWUG	Formation or empowerment of FWUC/FWUG					
A-4.4 Insufficient & less coordinated agricultural support services	Strengthening & coordination of agricultural support services					
Existence of Marginal Level Farmers	Zones Crosscutting Approach		Subject-wise Improvement			
	B-1.1 Deterioration of Roleang Chrey Regulator	Improvement of Roleang Chrey Regulator		B.1(1) Roleang Chrey Regulator Gates Urgent Improvement Project		
	B-2.1 Losses caused by disease and pest	Strengthening of veterinary services		B.1(2) Roleang Chrey Regulator and Intakes Improvement Project		
	B-2.2 Inappropriate raising practices	Introduction of improved raising practices		B.2(1) Veterinary Services Strengthening and Live stock Raising Improvement Project		
	B-3.1 Less development inland fisheries potentials	Introduction of inland fisheries in stored water		B.3(1) Community Inland Fisheries Development Project		
	B-3.2 Limited introduction of fish culture	Introduction of small scale fish culture				
	B-4.1 Limited land holding size	Introduction of agriculture based income generation methods		B.4(1) Income Generation Projects for Marginal Farmers		
	B-4.2 Limited holding size of livestock					
	B-4.3 Limitation in income sources					
	Lack of Fundamental Knowledge for Agricultural Management and Ineffective Management for Agricultural Development	Subject-wise Improvement		Subject-wise Improvement		
		C-1.1 Insufficient coordination between MOWRAM and MAFF			Strengthening of coordination between MOWRAM and MAFF	C.1(1) Coordination between MOWRAM and MAFF Strengthening Project
		C-1.2 Limited capability of provincial departments			Strengthening of provincial departments	C.1(2) Provincial Departments Strengthening Project
		C-2.1 Seasonal insufficiency of feeds			Identification of development potential	C.2(1) Livestock Sub-sector Development Study
		C-2.2 Poor genetic resources/breeds			Identification of development potential	
C-3.1 Improper plan and design of irrigation system		Capacity development of technical knowledge on planning and design of irrigation system	C.3(1) Technical Guidelines Preparation Project			
C-4.1 Lack or less experience in environmental assessment of MAFF and MOWRAM as executing agency		Capacity development of staff of MAFF and MOWRAM on environmental assessment	C.4(1) Environmental Management Basic Capacity Development Project			
C-5.1 Lack of basic knowledge on water management		Establishment of water management system through model project	C.4(2) Environmental Management Applied Capacity Development Project			
C-6.1 Lack of basic knowledge on system maintenance		Establishment of maintenance system through model project	C.5(1) Irrigated Agriculture On-farm Technology Improvement Pilot Project			
C-7.1 Lack of basic knowledge on farming practice under rainfed condition		Establishment of proper farming practice under rainfed condition	C.6(1) Irrigation Facility Maintenance Capacity Strengthening Pilot Project			
C-8.1 Lack of knowledge on agriculture based income generation		Establishment of appropriate agriculture based income generation	C.7(1) Rainfed Agriculture Improvement Pilot Project			
C-9.1 Unawareness of necessity of effective water use		Awareness raising of effective water use	C.8(1) Community Inland Fisheries Development Pilot Project			
C-10.1 Insufficient agricultural support services		Establishment of institutional responsible for agricultural productivity improvement and strengthening agricultural support services	C.9(1) River Basin Effective Water Use Awareness Raising Project			
C-10.3 Limitation of farmers' participation in services			C.10(1) Institutional and agricultural Support Services Strengthening Project			
C-10.4 Poor coordination among stakeholders						
C-10.5 Lack or inactivity of FWUC/FWUG						
C-11.1 Insufficient hydro-meteorological data	Strengthened observation system on hydrological data	C.11(1) Hydrological Observation Strengthening Project				
C-11.2 Insufficient communication on flood	Strengthened pre-information system on flood	C.11(2) Flood Forecasting and Warning Study				

Table 2 Program Theory Matrix for Comprehensive Agricultural Development Plan

Overall Policy	OP: "Economic Growth and Poverty Reduction"		
End Outcome	EO-1: Ensuring of Food Security, Poverty Alleviation and Job Creation by Increasing Rice Cultivation Area (Agricultural Development Plan, Long, Medium and Short Term 1999-2010, MAFF)		
Intermediate Outcome	IO-1: Improvement of Agricultural Productivity Centering on Rice		
Output	O-1: Better water management of irrigated and rainfed croplands by development of hardware and software in a complementary way (Strategic Development Plan for Water Sector 2006-2010, MOWRAM)		
Activities	O-1-1: Agricultural Development "Improvement of crop yields through proper farming technology and strengthening of extension services, and promotion of inland fish culture and livestock farming"	O-1-2: Irrigation & Drainage Development "Expansion of the irrigated area through effective use of existing water resources and application of appropriate water management"	O-1-3: Institutional Development "Formation of farmers' organization and capacity development of provincial departments and farmers' organization"
(1) Scheme-wise Improvement			
(a) Zone-1			
A.1(1) Irrigated Agriculture Improvement Model Project	○	○	○
A.1(2) Upper North Main Canal Irrigated Agriculture Improvement Project	○	○	○
A.1(3) Upper South Main Canal Irrigated Agriculture Improvement Project	○	○	○
(b) Zone-2			
A.2(1) Lower North Main Canal Irrigated Agriculture Improvement Project	○	○	○
A.2(2) Lower South Main Canal Irrigated Agriculture Improvement Project	○	○	○
A.2(3) Ou Krang Ambel Irrigated Agriculture Improvement Project	○	○	○
(c) Zone-3			
A.3(1) Water Harvesting Irrigated Agriculture Improvement Project	○	○	○
(d) Zone-4			
A.4(1) Rainfed Agricultural Improvement Project	○	—	○
(e) Zones Crosscutting			
B.1(1) Roleang Chrey Regulator Gates Urgent Improvement Project	—	○	—
B.1(2) Roleang Chrey Regulator and Intakes Improvement Project	—	○	—
B.2(1) Veterinary Services Strengthening and Livestock Raising Improvement Project	○	—	○
B.3(1) Community Inland Fisheries Development Project	○	—	○
B.4(1) Income Generation Project for Marginal Farmers	○	—	○
(2) Subject-wise Improvement			
C.1(1) Coordination between MOWRAM and MAFF Strengthening Project	—	—	○
C.1(2) Provincial Departments Strengthening Project	—	—	○
C.2(1) Livestock Sub-sector Development Study	○	—	○
C.3(1) Technical Guidelines Preparation Project	—	○	—
C.4(1) Environmental Management Basic Capacity Development Project	—	—	○
C.4(2) Environmental Management Applied Capacity Development Project	—	—	○
C.5(1) Irrigated Agriculture On-farm Technology Improvement Pilot Project	○	○	○
C.6(1) Irrigation Facility Maintenance Capacity Strengthening Pilot Project	—	—	○
C.7(1) Rainfed Agriculture Improvement Pilot Project	○	—	○
C.8(1) Community Inland Fisheries Development Pilot Project	○	—	○
C.9(1) River Basin Effective Water Use Awareness Raising Project	—	○	○
C.10(1) Institutional and agricultural Support Services Strengthening Project	○	○	○
C.11(1) Hydrological Observation Strengthening Project	—	○	○
C.11(2) Flood Forecasting and Warning Study	○	○	○

(38) Scheme-wise Improvement Plan (9.3)

Thirteen projects are proposed, and compiled in a form of project digest, implementation schedule and PDM. The objectives of these projects are given below:

Code No.	Project Title	Objectives
Zone- based Approach		
Zone-1		
1.A.1(1)	Irrigated Agriculture Improvement Model Project	Demonstration of proper water management and increase of rice production in the model area (570 ha) through good harmonization between agriculture, irrigation and drainage and institution development
2.A.1(2)	Upper North Main Canal Irrigated Agriculture Improvement Project	Increase of rice production in the upper north area (2,210ha) through improvement of irrigation systems and strengthening of agricultural support services and FWUCs
3.A.1(3)	Upper South Main Canal irrigated Agriculture Improvement Project	Increase of rice production in the upper south area (2,880ha) through improvement of irrigation systems and strengthening of agricultural support services and FWUCs
Zone-2		
4.A.2(1)	Lower North Main Canal Irrigated Agriculture Improvement Project	Increase of rice production in the lower north area (1,390ha) through improvement of irrigation systems and strengthening of agricultural support services and FWUCs
5.A.2(2)	Lower South Main Canal irrigated Agriculture Improvement Project	Increase of rice production in the lower south area (6,750ha) through improvement of irrigation systems and strengthening of agricultural support services and FWUCs
6.A.2(3)	Ou Krang Ambel Irrigated Agriculture Improvement Project	Increase of rice production in the Ou Krang Ambel area (2,900ha) through improvement of irrigation systems and strengthening of agricultural support services and FWUCs
Zone-3		
7.A.3(1)	Water Harvesting Irrigated Agriculture Improvement Project	Increase of rice production in Zone-3 area (1,200ha in total) through improvement of irrigation systems and strengthening of agricultural support services and FWUCs
Zone-4		
8.A.4(1)	Rainfed Agriculture Improvement Project	Improvement of rainfed agriculture productivity and increased production of rice in Zone-4 in the Target Area
Zone Crosscutting Projects		
9.B.1(1)	Roleang Chrey Regulator Gates Urgent Improvement Project	Ensuring proper gate operation for irrigation water supply and flood water.
10.B.1(2)	Roleang Chrey Regulator and Intakes Improvement Project	Supply of stable irrigation water to main canals by improving the Roleang Chrey Regulator, Andong Sla intake and Vat Kroch Intake
11.B.2(1)	Veterinary Services Strengthening and Livestock Raising Improvement Project	Recruit new Village Livestock Agents (VLAs) or empower existing VLAs in each village to provide animal health and livestock extension services
12.B.3(1)	Community Inland Fisheries Development Project	- Promotion of inland fish culture in the water bodies for the Water Harvesting Irrigated Agriculture Improvement Project - Placing of income from the inland fisheries in common fund for the FWUC responsible for the O&M of the subject irrigation system
13.B.1(1)	Income Generation Project for Marginal Farmers	Increase income of marginal farmers and improvement level of food resources, thereby contributing to human security and reduction of vulnerability of target groups.

(39) Subject-wise Improvement Plan (9.4)

Fourteen projects are proposed, and compiled in the form of a project digest, implementation schedule and PDM. The objectives of these projects are given below:

Code No.	Project Title	Objectives
1.C.1(1)	Coordination between MOWRAM and MAFF Strengthening Project	Strengthening of coordination between MOWRAM and MAFF for efficient and smooth implementation of irrigated agriculture projects
2.C.1(2)	Provincial Departments Strengthening Project	Strengthening of Provincial Departments for efficient and smooth implementation of irrigated agriculture projects

Code No.	Project Title	Objectives
3.C.2(1)	Livestock Sub-sector Development Study	Formulation of an integrated livestock sub-sector development plan in the Target Area for medium and long term development scope
4.C.3(1)	Technical Guidelines Preparation Project	Preparation of irrigation related technical guidelines such as i) Irrigation Planning, ii) Irrigation Design, iii) Irrigation Construction Supervision, and iv) Irrigation System Operation and Maintenance.
5.C.4(1)	Environmental Management Basic Capacity Development Project	Strengthening of basic capabilities of the relevant staff of MOWRAM and MAFF regarding EIA and environmental management
6.C.4(2)	Environmental Management Applied Capacity Development Project	Follow-up of environmental management activities and redeeming of capabilities of the relevant staff of MOWRAM and MAFF
7.C.5(1)	Irrigated Agriculture On-farm Technology Improvement Pilot Project	Establishment of on-farm level efficient water use model in irrigated agriculture areas
8.C.6(1)	Irrigation Facility Maintenance Capacity Strengthening Pilot Project	Establish a good model for irrigation facility maintenance in an irrigated agriculture area
9.C.7(1)	Rainfed Agriculture Improvement Pilot Project	Development of an improved rainfed rice production system in the zone.
10.C.8(1)	Community Inland Fisheries Development Pilot Project	Establishment of a productive community inland fishery model
11.C.9(1)	River Basin Effective Water Use Awareness Raising Project	Raising awareness and knowledge of farmers on efficient use of the river basin water, by presenting the result of the "Irrigated Agriculture On-farm Technology Improvement Pilot Project"
12.C.10(1)	Institutional and Agricultural support Services Strengthening Project	<ul style="list-style-type: none"> - Establishment of an institutional set-up at the initial stage of the M/P responsible for promotion of agricultural improvement centering on rice - Further development and extension of improved and sustainable farming technologies on rice production - Further development and extension of irrigation water management and O&M technologies and practices for sustaining the irrigation systems - Formation and empowerment of FWUC, FWUGs, WUGs and other farmers' organizations.
13.C.11(1)	Hydrological Observation Strengthening Project	Strengthening hydrological data acquisition system for water resources related projects
14.C.11(2)	Flood Forecasting and Warning Study	Preparation of a flood forecasting and warning system plan for mitigation of flood damage in the downstream basin of the Prek Thnot River basin

(40) Implementation Plan (9.5)

Twenty seven projects/studies should be implemented in proper order so as to further the effects and/or benefits as planned. In elaborating the implementation plans, the following criteria are applied:

- The first 5 years, from 2006 to 2010, will focus on "decentralization", while the succeeding 5 years, from 2010 to 2015, on "privatization". The proposed projects/studies will be implemented with due consideration to these focal points.
- Out of 27 proposed projects/studies, 4 pilot projects are to be undertaken as bridgeheads to obtain and realize the lessons learned from subsequent large scaled irrigated and/or rainfed agriculture improvement projects. Thus, the pilot projects should be implemented at an early stage.
- As mentioned, an integrated approach for hardware and software is essential for achieving the targets as planned. This matter should also be taken into consideration during preparation of the implementation plans.
- For purposes of improving of irrigated agriculture, implementation should proceed from upstream to downstream, to ensure project benefits as early as possible. This procedure should also be introduced into the implementation plan.

(41) Project Cost (9.6.1)

The project cost for the 27 projects/studies, including price contingency, is estimated at US\$ 75,153,000, with the annual disbursement given below:

Project Cost

Projects/Studies		Total Cost	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
(Unit: US\$000)												
(1) Scheme-wise Improvement												
(a) Zone-1												
A.1(1)	Irrigated Agriculture Improvement Model Project	1,679				737	917	10	11	4		
A.1(2)	Upper North Main Canal Irrigated Agriculture Improvement Project	11,332						710	2,732	5,453	2,187	250
A.1(3)	Upper South Main Canal Irrigated Agriculture Improvement Project	9,871						549	2,103	4,467	2,397	355
(b) Zone-2												
A.2(1)	Lower North Main Canal Irrigated Agriculture Improvement Project	3,190							965	1,554	671	
A.2(2)	Lower South Main Canal Irrigated Agriculture Improvement Project	15,183						3,040	4,728	3,152	2,249	2,014
A.2(3)	Ou Krang Ambel Irrigated Agriculture Improvement Project	7,219							3,038	3,590	591	
(c) Zone-3												
A.3(1)	Water Harvesting Irrigated Agriculture Improvement Project	7,427					129	1,447	2,160	2,117	832	742
(d) Zone-4												
A.4(1)	Rainfed Agricultural Improvement Project	2,975				595	595	595	595	595		
(e) Zones Crosscutting												
B.1(1)	Roleang Chrey Regulator Gates Urgent Improvement Project	75	75									
B.1(2)	Roleang Chrey Regulator and Intakes Improvement Project	4,786				382	2,710	1,694				
B.2(1)	Veterinary Services Strengthening and Livestock Raising Improvement Project	377				76	75	75	75	76		
B.3(1)	Community Inland Fisheries Development Project	413						79	79	81	84	90
B.4(1)	Income Generation Project for Marginal Farmers	679				91	108	149	166	165		
Sub-total		65,206				1,881	4,534	8,348	16,652	21,254	9,011	3,451
(2) Subject-wise Improvement												
C.1(1)	Coordination between MOWRAM and MAFF Strengthening Project	98					98					
C.1(2)	Provincial Departments Strengthening Project	330					330					
C.2(1)	Livestock Sub-sector Development Study	1,551				1,551						
C.3(1)	Technical Guidelines Preparation Project	1,725				690	863	172				
C.4(1)	Environmental Management Basic Capacity Development Project	70	35	35								
C.4(2)	Environmental Management Applied Capacity Development Project	520							156	104	104	156
C.5(1)	Irrigated Agriculture On-farm Technology Improvement Pilot Project	800	300	400	100							
C.6(1)	Irrigation Facility Maintenance Capacity Strengthening Pilot Project	909				345	460	104				
C.7(1)	Rainfed Agriculture Improvement Pilot Project	100	45	45	10							
C.8(1)	Community Inland Fisheries Development Pilot Project	110				50	60					
C.9(1)	River Basin Effective Water Use Awareness Raising Project	633				253	316	64				
C.10(1)	Institutional and agricultural Support Services Strengthening Project	2,928					293	586	586	586	586	291
C.11(1)	Hydrological Observation Strengthening Project	53	26	27								
C.11(2)	Flood Forecasting and Warning Study	120		120								
Sub-total		9,947	406	627	110	3,317	1,992	926	742	690	690	447
Total		75,153	406	627	110	5,198	6,526	9,274	17,394	21,944	9,701	3,898

(42) Project Evaluation (9.7)

Economic evaluation was carried out for the selected nine projects from the scheme-wise improvement projects. This directly generates benefits and also contributes to the strategic target of the M/P. Seven projects, excluding the “water harvest” and “rainfed” projects, are combined as core of “Roleang Chrey Regulator and Intakes Improvement Project” with another 5 projects, placing priority on upstream side development. The EIRR calculated for the respective development scenarios of the nine projects are as follows:

**Economic Irrigation and Drainage Benefit of
9 Evaluated Projects' Implementation Scenarios**

Evaluated Projects/Sets of Projects	EIRR (%)	NPV in Million Riel (7% discount rate)			
		Benefit	Cost	B-C	B/C
1. RC	13.6	21,996	15,560	6,436	1.4
2. RC + UNMC	4.7	31,216	39,149	-7,933	0.8
3. RC + Ou Krang Ambel	9.4	38,098	30,715	7,383	1.2
4. RC + UNMC + Ou Krang Ambel + LNMC	6.2	55,367	60,785	-5,418	0.9
5. RC + IAIMP	10.6	26,232	20,513	5,719	1.3
6. RC + IAIMP + USMC	6.2	37,430	40,637	-3,207	0.9
7. RC + IAIMP + USMC + LSMC	7.4	73,866	70,414	3,472	1.0
8. Water Harvest	0.4	5,216	15,766	-10,550	0.3
9. Rainfed	17.6	35,032	8,762	26,270	4.0

Note: RC : Roleang Chrey Regulator and Intakes Improvement Project

UNMC: Upper North Main Canal Irrigated Agriculture Improvement Project

Ou Krang Ambel: Ou Krang Ambel Irrigated Agriculture Improvement Project

LNMC: Lower North Main Canal Irrigated Agriculture Improvement Project
IAIMP: Irrigated Agriculture Improvement Model Project
USMC: Upper South Main Canal Irrigated Agriculture Improvement Project
LSMC: Lower South Main Canal Irrigated Agriculture Improvement Project

Farm economic analysis of typical farms on net returns from paddy fields under the present and "with-" project conditions have been conducted, for purposes of financial analyses of irrigated and rainfed agriculture improvement plans. As a result, the anticipated increase in net returns from paddy fields under the with-project condition is estimated in the range of Riel 299,000 to 445,000. This estimate is based on the present levels of the irrigated agricultural improvement projects, and increase in net returns in the rainfed agriculture improvement project in Zone-4, estimated as Riel 236,000.

(43) Food Balance in Target Area (9.7.4)

The future food balance of rice in the target area under the M/P (with-project and without-project condition) was examined and is summarized below:

Food Balance Study in the Target Area

Year		Rice Sufficiency Rate	
		With-project	Without-project
2005	Present Status	-	68%
2015	Final Year of Medium Term ^{1/}	93%	55%
2020	Full Development Year ^{2/}	93%	50%

^{1/}: Final year of the Master Plan period

^{2/}: Full development stage of the agricultural improvement plans is attained

As shown in above table, self-sufficiency in rice in the target area, which is the basic goal envisaged in the M/P, can be nearly achieved in 2015. (final year of the master plan). The rate is evidently significant compared to the 55% deficit under the without-project condition.

Chapter 9 Environmental Assessment

(44) Initial Environmental Examination (IEE) Study for the M/P (10.2.4)

The conclusions of the IEE study for the M/P are as follows;

- The M/P would have overall benefit toward the environment and is judged to be acceptable from an environmental viewpoint.
- Some of the likely negative impacts on both social and natural environment were pointed out through the IEE study. However, the magnitude of negative impacts is not considered serious and most of which can be avoided/ mitigated with identified corresponding countermeasures.
- Various projects are intended for the local residents. Therefore, it is important to consider how to involve the people into the projects, including considerations such as venue, time, methods, invitees and discussion agenda. A careful approach should be taken specially for land acquisition and/or involuntary resettlement.

Chapter 10 Conclusions and Recommendations

(45) Conclusions and Recommendations (11.1, 11.2)

The M/P Study proposes completion of the development framework by 2015, aiming at improvement of agricultural productivity centering on rice, which is its strategic goal. The proposed development framework includes the scheme-wise improvement approach consisting of 13 projects and the subject-wise improvement approach consisting of 14 projects/studies, based on the concept of good harmonization of hardware and software aspects. The successful implementation of the M/P will contribute to self-sufficiency in rice production in the target area, and increase the farm income by about 1.5 to 2.0 times the

present income. It is thus recommended that the M/P be implemented as early as possible.

In connection with the implementation of the M/P the recommendations are i) Arrangement of financial resources for the M/P, ii) Need for urgent improvement of Roleang Chrey Regulator and Intakes, iii) Need for inter-ministerial coordination between MOWRAM and MAFF, iv) Need for strengthening of environmental management for Executing Agencies, v) Need for monitoring of implementation of M/P, vi) Need for study on new water resource development, vii) Need for strengthening of Provincial Authority for technical and financial aspects, and viii) Need of timely updating of master plan.

VOLUME-III FEASIBILITY STUDY FOR PRIORITY/URGENT PROJECTS
Part A: General Information
Chapter A-1 Introduction
(1) Selection of Priority/Urgent Projects for Feasibility Study (A-1.3.2)

The M/P proposed 27 projects/studies for achieving the strategic target. Out of these, two projects were selected as priority/urgent, considering related technical, economical, sociological and environmental factors. This is also with due consideration to the urgent implementation of the M/P and early realization of project benefits. The selected two priority/urgent projects were the (i) Roleang Chrey Regulator and Intakes Improvement Project and (ii) Irrigated Agriculture Improvement Model Project.

(2) Conduct of Public Consultation Meeting (A-1.5)

On February 1, 2007, a public consultation meeting was held aimed to report and explain the results of the pilot projects and the Feasibility Study for the Roleang Chrey Regulator and Intake Improvement Project and the Irrigated Agriculture Improvement Model Project. The meeting was attended by 60 participants, including staff of MOWRAM, MAFF, PDOWRAM and PDA, members of Ou Veang and Phoum Roum Rpung FWUCs, and Commune Chiefs. As a result, the proposed development plans are in principle accepted, regardless of complaints about gratis offer on land for the construction of tertiary canals and watercourses.

Part B: Roleang Chrey Regulator and Intakes Project
Chapter B-1 The Project Site
(1) Location (B-1.1)

The Roleang Chrey Regulator is located on the Prek Thnot River, about 100 km upstream from its confluence with the Bassac River. The Andong Sla and Vat Kruoch Intakes are provided at the heads of the North Main Canal and South Main Canal, respectively, where they branch off from the Prek Thnot River upstream from the Roleang Chrey Regulator.

(2) Topography (B-1.2)

The right bank of the Roleang Chrey Regulator has an elevation of 39.65 m above mean sea level. The longitudinal survey shows that the longitudinal slope of the upstream portion of the Prek Thnot River, where the Roleang Chrey Regulator is located midway, is 1/2720. This is slightly steeper than the 1/3000 average from the confluence with the Bassac River to Peam Khley (113.4 km in distance).

(3) Flood (B-1.3.3)

The gate operator for the Roleang Chrey Regulator, who had been working in the area for 38 years, reported that the maximum flood occurred in 1991, with an estimated discharge of 1,369 m³/sec. On the other hand, the results of topographic survey for the Prek Thnot river indicated that its flow capacity ranged from 1,300 m³/sec to 1,500 m³/sec for its upstream reach. This was similar to that observed by the gate operator. With these findings, the probable flood peak discharge established and used for the design of the Roleang Chrey Regulator improvement ranged between 1300 m³/s and 1500 m³/s. From a more conservative viewpoint, however, values between 1400 m³/s and 1600 m³/s would be more appropriate.

(4) Roleang Chrey Regulator (B-1.4)

The Roleang Chrey Regulator was constructed in 1974. Its components such as the retaining walls, gate piers, operation deck and bridge remain stable. However, its downstream

protection works need to be improved to protect the regulator. Furthermore, rehabilitation of the severely deteriorated rollers equipped with gate leaves should be implemented since this may lead to sudden malfunction. Moreover, a smaller supplementary water release facility should be added since the existing large gates can not be adjusted accurately enough to discharge low flow to the downstream reaches.

Meanwhile, the gates and accessories, excluding those for the gate leaves and guide frames, are severely damaged and should accordingly be replaced .



*Downstream View of Gate
Roleang Chrey Regulator*

(5) Andong Sla Intake and its Approach Channel (B-1.5)

The Andong Sla Intake was constructed in 1974 together with the Roleang Chrey Regulator. The related facilities such as gate piers, operation deck and bridge do not exhibit severe conditions. Its downstream protection works however are severely damaged.

Meanwhile, the existing steel radial gate leaks excessively through the seal and wire rope holes. In addition, the hoist wires are also damaged. The steel radial gate also exhibit structural deficiencies such as instability due to the extremely slender gate leaf, susceptibility to corrosion of the structural components, difficulty of maintenance due to being constantly submerged, and perennial difficulty in sealing.



*Leakage through Gate Top Seal
Andong Sla Intake*

The approach channel does not require any improvement since it has adequate flow capacity and show no indications of serious erosion.

(6) Vat Krouch Intake and its Approach Channel (B-1.6)

Although the approach channel from the Prek Thnot River to the Vat Krouch Intake is not large enough to accommodate the design discharge, no serious erosion is observed on its side slopes. The Vat Krouch Intake constructed in 2002 appears structurally stable, however, its downstream portion is also severely eroded. The intake is equipped with one steel radial gate with four sealing edges. This induces large head loss, which is one of the constraints of gravity irrigation.



Temporary Measure for Wire Rope

(7) O&M (B-1.7)

The Kampong Speu PDOWRAM, under the support of the Department of Irrigated Agriculture, MOWRAM, is directly in-charge of O&M for the Project facilities. However O&M is not being carried out effectively, mainly due to financial constraints and lack of staff.

(8) Environment (B-1.8)

The bridge constructed at the Roleang Chrey Regulator is vital for the residents of the three villages in the Project site vicinity, since there are no other bridges nearby that cross the Prek Thnot River. The local residents also complain that the varieties of fish in the Prek Thnot River are diminishing due to use of electric fishing gear and motivated raising of exotic species.

Chapter B-2 The Project

(9) Need for Improvement (B-2.1.1)

The Roleang Chrey Regulator and the Andong Sla Intake, both constructed in 1974, are severely deteriorated and are not functioning efficiently. The Vat Krouch Intake meanwhile, which was constructed in 2002, is also subjected to various operational deficiencies such as excessive head loss, damage to its wire ropes, severe erosion downstream, and the lack of a measuring device. If these conditions are left unattended, the water supply for each related area would become a serious concern due to malfunctioning facilities. Consequently, the strategic target for the M/P aiming for *improvement of agricultural productivity centering on rice*, will not materialize by 2015. Thus, to ensure stable water supply and to achieve the said strategic goal, related urgent improvement works is required.

(10) Purpose and Development Concept (B-2.1.2)

The Project aims to provide a stable water supply to the North Main Canal, the South Main Canal and the downstream area. In consideration of the current conditions and importance of the existing facilities for the development of irrigated agriculture and to attain the stated goals, the JICA study team has initiated a development concept for “**Realization of Proper Gate Operation through Provision of Appropriate Facilities**” for the Project. Thus, the improvement plan for each facility should be developed considering said concept.

(11) Roleang Chrey Regulator Improvement Plan (B-2.2)

The improvement plan for the Roleang Chrey Regulator was developed in consideration of i) optimized use of existing facilities, ii) ease of maintenance, iii) ease of operation, iv) ensuring safety for the regulator and v) suitable discharge to the downstream area.

The planned civil works for the Roleang Chrey Regulator, which were designed based on a design flood of 1,600 m³/sec, are i) provision of downstream apron, ii) provision of retaining wall, and iii) construction of by-pass for releasing low water to the downstream reach. Improvement of the hydro-mechanical works includes, i) repair of wheels, ii) painting, iii) repair of rubber seal, iv) replacement of hoist, and v) adoption of a remote control system.

(12) Andong Sla Intake Improvement Plan (B-2.3)

The improvement plan for Andong Sla Intake was developed taking into account i) the on-going command area development plan, ii) reduction of the hydraulic impact to the downstream portion, iii) selection and replacement of appropriate gate type, and iv) backwater effect of floods. In particular, the on-going command area development plan, Western Phnom Penh Integrated Development Center Project (WPPIDCP), should be considered for determining the size and number of intake gates. Resulting from the review of this matter, the improvement of the intake gates should be planned accordingly based on the following approach; i) design the four gate portions, ii), install two gates out of the four as soon as possible to ensure the ability to discharge 10.4 m³/sec, and iii) provide a concrete wall for the remaining two gates to facilitate installation of the remaining gates in the future. Based on the aforementioned approach, civil works such as retaining walls, gate piers, bridge and downstream apron were designed.

As for the hydraulic works, a study was made on three viable gate types, namely, radial gates, fixed wheel gates, and slide gates. As a result, the fixed wheel type was selected based on technical and economical viewpoints, with special considerations on ease of operation and higher reliability. Upgrading to a remote control system connecting the Roleang Chrey Regulator site with the Andong Sla Intake is proposed to synchronize operation.

(13) Vat Krouch Intake Improvement Plan (B-2.4)

The improvement plan for the Vat Krouch Intake and its approach channel was prepared in view of the i) on-going WPPIDCP, ii) application of appropriate gate type and iii) backwater effect of floods. Upon review of the M/P Study and WPPIDCP, it was found that the required

intake discharge for WPPIDCP (17.4 m³/sec) is 1.1m³/sec greater than that for the M/P Study (16.3 m³/sec). Such minimal discrepancy does not influence final determination of the number and sizes of gates. Thus, it was planned to install two gates, each measuring 5.0 m high and 4.0 m wide.

In relation to the new design intake discharge and reduction of head loss, the proposed civil works are i) construction of upstream and downstream aprons, ii) construction of gate piers and box culvert, iii) protection of upstream and downstream canals, and iv) rehabilitation of the approach channel. A remote control system to connect with the Roleang Chrey Regulator site was likewise adopted for the Vat Krouch Intake to facilitate synchronized operation.

(14) O&M Plan (B-2.5)

In the operation plan for Roleang Chrey Regulator, gate operation during both normal and flood conditions was explained. The proposed procedure for gate operation under normal conditions is: i) check upstream water level, ii) control upstream water level to El.35.7 m, iii) operate intake gates, iv) record intake flow rate, and v) record release discharge. Gate operation during rising and receding floods was discussed. For both cases, the sequence of gate operation was studied and proposed. by observing the upstream water level and maintaining it at El 35.7 m.

As for the intake gates of Andong Sla and Vat Krouch under normal condition, the operation shall be performed in accordance with the irrigation service plan. To simplify the gate operation, it is proposed to prepare in advance a graph showing the relationship between the upstream and downstream water levels, gate opening and discharge.

In order to undertake maintenance work effectively, the maintenance plan for Roleang Chrey Regulator, Andong Sla and Vat Krouch Intakes, proposes i) daily inspections, ii) periodic inspections, iii) an annual maintenance program, iv) required maintenance work, and v) emergency repairs.

(15) Environmental Considerations (B-2.6)

In the process of preparation of various improvement plans, a number of environmental issues were investigated in order to implement the Project in a more environmentally friendly and sustainable manner. The significant points under the Project are i) water availability during the construction phase for agriculture, ii) lining method of approach channels for their eroded portions due to dispersible soils, and iii) air pollution from construction vehicles.

(16) Implementation Plan (B-2.7)

The Project works consist of engineering services, tendering, construction and environmental monitoring. The planned duration for Project implementation is 45 months, from August 2007 to April 2011. The implementation schedule of the Project works is presented on the following page.

MOWRAM is the overall executing agency for Project implementation, while its Engineering Department will be responsible for the design and construction stages. For effective construction supervision, it is proposed to establish a construction office at Kampong Speu PDOWRAM. Upon completion of construction works, the Kampong Speu PDOWRAM, under the support of the Department of Irrigated Agriculture, will be directly in-charge of the O&M for the improved facilities. In this connection, an O&M office for the Project facilities should be established in Kampong Speu PDOWRAM, to strengthen the overall O&M activities.

Implementation Schedule of Project Works

Activities	2008				2009				2010				2011				2012																											
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A							
(1) Survey, Design and Preparation of Tender Documents																																												
(2) Tendering, Evaluation, Award and Signing																																												
(3) Construction																																												
(a) Mobilization																																												
(b) Roleang Chrey Regulator																																												
Hydro-mechanical Works																																												
- Stoplog																																												
- Wheel																																												
- Gate Leaf																																												
- Hoist																																												
Civil Works																																												
- Downstream Apron																																												
- Side Slope Protection																																												
- By-pass																																												
(c) Andon Sla Intake																																												
Hydro-mechanical Works																																												
- Removal of Existing Gats																																												
- Installation of New Gates																																												
Civil Works																																												
- Gate Piers and Retaining Wall																																												
- Downstream Apron																																												
- Side Slope Protection																																												
- Bridge																																												
(d) Vat Krouch Intake																																												
Hydro-mechanical Works																																												
- Removal of Existing Gats																																												
- Installation of New Gates																																												
Civil Works																																												
- Gate Piers and Retaining Wall																																												
- Box Culvert																																												
- Downstream Apron																																												
- Side Slope Protection																																												
- Approach Channel																																												
(4) Environmental Monitoring																																												
Season																																												
	← Rainy →				← Dry →				← Rainy →				← Dry →				← Rainy →				← Dry →																							

(17) Environmental Examination (*B-2.8*)

Initial environmental examination of the Project concludes as follows:

- As a whole, the development plan of the Project was judged as acceptable from an environmental viewpoint, if the proper mitigation measures presented are undertaken.
- Some of the likely negative impacts on both the social and natural environments, such as limitations of access and water availability during construction, were identified. Therefore, proper management with the proposed measures and monitoring plan should be implemented in order to avoid/mitigate the anticipated negative impacts.

(18) Cost Estimate (*B-2.9*)

The total investment consisting of i) engineering service cost, ii) construction cost, iii) administration cost, iv) environmental monitoring cost, and v) physical and price contingencies, is estimated to be US\$ 4,991,000 (Riel 20,263,460). The replacement cost for gates and accessories is estimated at US\$ 1,374,200 (Riel 5,579,252,000), which will be implemented on the 25th year upon completion of the improvement work. Annual O&M cost is estimated to be US\$ 9,300 (Riel 37,758,000).

(19) Project Evaluation (*B-2.10*)

The EIRR for the Project was estimated at 14.8 %. The B-C and B/C at 7% discount rate were estimated as Riel 7,646 million and 1.6, respectively. These economic indicators show that the Project is economically feasible. The sensitivity analysis reveals that the Project is relatively more sensitive to the benefit reduction rather than cost increase, though it can accommodate considerable changes in both these variables.

A budget analysis of typical farms on net returns from paddy fields under the present ‘with’ and future ‘without’-project conditions, was carried out with the financial analysis of the Project. The results of the analyses are summarized in the following table.

Results of Farm Economic Analyses (unit: Riel)

Zone/Project	1. Present (with-project)	2. Without-project	Increase (saving of the loss) per farm (1 - 2)
	Net Return from Paddy Field per Farm	Net Return from Paddy Field per Farm	
Zone-1 ^{1/}			
- Model Project	791,000	424,000	367,000
- UNMC	552,000	417,000	135,000
- USMC	486,000	417,000	68,000
Zone-2	469,000	417,000	51,000

^{1/}: Irrigated Agricultural Improvement Model Project

Upper North Main Canal Irrigated Agricultural Improvement Project (UNMC)

Upper South Main Canal Irrigated Agricultural Improvement Project (USMC)

As shown in the above table, the anticipated increase in net return, i.e. return to-be-saved from losses caused by complete malfunctioning of the regulator, (from paddy fields under the with-project condition) are estimated to range between Riel 367,000 to 51,000 per farming household. In terms of proportion, 10% to 46% of the total farming income per household is at stake due to the impending malfunction of the regulator.

(20) Conclusions and Recommendations (B-2.11)

The Feasibility Study revealed that the Project is technically feasible and economically viable. From the social and natural environmental aspects, it was also realized that the Project is generally sound. Implementation of the Project would accomplish the following principal objectives: i) provide stable water supply for 16,700 ha of agricultural land, which leads to an increase of 3,285 tons of rice, ii) contribute to reduction of flooded areas through proper gate operation and iii) ensure reliable water discharge to the downstream area. Thus, it is concluded that the Project should be implemented urgently.

In connection with the implementation of the Project, the following are recommended: i) strengthening of O&M and ii) establishment of a communication system between the Peam Khley Observation Station and Roleang Chrey Regulator Site, which are both significantly important in terms of proper management and sustainability of the Project.

Part C: Irrigated Agriculture Improvement Model Project**Chapter C-1 The Project Area****(1) Location and Topography (C-1.1.1 and C-1.1.2)**

The Irrigated Agriculture Improvement Model Project (the Project) is located about 25 km west of Phnom Penh. The Project area extends over the right riparian area of the Prek Thnot River, situated between the river and the upstream portion of the South Main Canal. The national road Route No.4 crosses the Project Area. The Project area has a slope of approximately 1:2,000 from west to east.

(2) Meteorology (C-1.1.3)

The Project area is characterized as a tropical monsoon climate, with definite rainy season from May to October, and a dry season from November to April. Mean temperature shows minimal seasonal variation from 26.1°C in December to 30.5°C in April. Relative humidity ranges from 66% to 77% in February and March, to 80% to 90% in September and October.

(3) Soils and Land Suitability (C-1.1.4)

Approximately 45.5 % of the Project Area consists of Gleyic Acrisol medium textured phase (GAm2) and Gleyic Acrisol medium to fine textured phase (GAf), which are classified as moderately suitable (S2) for crops. The remaining 54.5% of the Project

Area consisting of Gleyic Acrisol coarse to medium textured phase are classified as marginally suitable (S3).

(4) Administration and Population (C-1.2.1)

The Project Area is administratively comprised of 18 villages, 3 communes, and 2 Districts in Kampong Speu Province. According to the SEILA Commune Database in 2005, the population of the Project Area was about 10,000. Out of that population, the working bracket consisting of 15 to 64 years old, was approximately 6,000.

(5) Food Supply Conditions (C-1.2.2)

According to the socio-economic survey, over 90% of the sampled farmers (100 samples) reported a surplus or sufficient rice production. However, production of cereals, beans and vegetables is extremely limited compared to household demands. The promotion of upland crops should be implemented. This is primarily aimed to fulfill family consumption requirements as well as produce surplus for market selling, through initiating cultivation during the early rainy season.

(6) Land Use (C-1.3.1)

The Project commands 600 ha, out of which, 580 ha is net irrigated rice field. On the basis of the detailed irrigation survey conducted by the JICA study team, the Project Area was classified into the following two categories of irrigated rice fields, based on current irrigation status:

Present Land Use (irrigation Status)

Category	Area (ha)	Proportion (%)	
		To Net	To Gross
Fields irrigable for single cropping of rice	377	65	63
Fields irrigable for double cropping of rice 1/	203	35	34
Sub-total (net area)	580	100	97
Right of ways	20	-	3
Total	600	-	100

1/: Including negligible extent of triple cropped area of 2ha Source: JICA Study Team

(7) Land Tenure and Land Holding in Project Area (C-1.3.2)

According to the socio-economic survey, the average holding size of all rice fields in the Project Area is around 0.84 ha. Among these, the irrigated rice fields and rainfed area are roughly estimated to be around 0.60 ha and 0.24 ha, respectively. The rainfed area is located outside the Project Area. The same survey results indicate that 98% of the sampled farmers in the Project Area are owner/operators, and that sharing of cropping of farm land is seldom practiced.

(8) Cropping Calendar and Patterns (C-1.3.3)

The prevailing cropping patterns in the Project Area depend on irrigation water availability, and are categorized into single and double cropping of rice as shown below. Crops other than rice are hardly cultivated in the Project Area.

Prevailing Cropping Patterns in the Project Area

Cropping Pattern		Area (%)
Rice cropping: single	Rainy season rice – fallow	377 ha (65)
Rice cropping: double	Early rainy season rice - rainy season rice – fallow	203 ha (35)
Total	-	580 ha (100)

Source: JICA Study Team

(9) Cropped Area and Cropping Intensity (C-1.3.3)

The current cropped area and cropping intensity of rice in the Project Area is estimated as follows:

Estimated Cropped Area and Cropping Intensity of Rice in Project Area

Land Use Category	Area (ha) (net)	Indicator	Cropped Area & Intensity		
			ERS	RS	Annual
Fields irrigable for single cropping of rice	377	Cropped Area (ha)	0	377	377
		Cropping Intensity (%)	-	100	100
Fields irrigable for double cropping of rice	203	Cropped Area (ha)	203	203	406
		Cropping Intensity (%)	100	100	200
Project Area	580	Cropped Area (ha)	203	580	783
		Cropping Intensity (%)	35	100	135

Source: JICA Study Team

(10) Cropped Yield and Production (C-I.3.3)

Unit yields of paddy in the Project Area are estimated at 2.3 ton/ha for the medium/late variety of rice, and 2.4 ton/ha for the early variety of rice. Annual production of paddy in the Project Area is estimated at 1,821 tons, applying the estimated cropped area and yields.

(11) Present Farm Economy (C-I.3.9)

Farmers in the Project Area are largely classified into two groups; double cropping farmers (Type A) and single cropping farmers (Type B). The present farm economy of these typical farms is presented in the following table. As shown, there is no large difference of net surplus between these two types, however, these are economically at their lowest levels.

Present Farm Economy (unit: '000 Riel)

Description		Type A	Type B	Difference (A-B)
Gross Incomes	Rice Production	1,302	680	622
	Other Farm Income (livestock, fishery and crops other than rice)	1,066	1,145	- 79
	Non-farm Income	2,267	1,959	308
	Total Income	4,635	3,784	851
Expenditures	Production Costs of Farm Products	1,076	797	279
	Other Expenditures	3,017	2,483	534
	Total Expenditures	4,093	3,280	813
Net Surplus (Capacity to Pay)		542	504	38

Source: JICA Study Team

(12) Irrigation Canals and Related Structures (C-I.4.1)

The Project Area is served by irrigation systems consisting of 7.8 km of SMC, 4.0 km of secondary canals and 15.9 km of tertiary canals, with 38 related structures. All the canals are unlined, and are generally not well maintained, resulting in severe erosion. The structures, except for some timber bridges, are made of reinforced concrete, but are not fully functional. Thus, rehabilitation and/or improvements are required, especially for turnouts and check structures.

(13) Irrigation Type (C-I.4.2)

The water supply systems in the Project Area are provided through gravity, portable pumps or combination of both. The inventory survey delineates the areas according to respective irrigation types: 306 ha by gravity, 190 ha by portable pumps, and 84 ha by combination of both.

(14) Drainage Canals and Related Structures (C-I.4.4)

There are no artificial drainage systems in the area. The excess water is eliminated field by field, and eventually drained into low-lying places and/or natural streams. In some cases, the existing canals have a dual function of irrigation and drainage. As drainage related structures, two cross drains, made up of pre-cast concrete pipes, have been buried under the canal .

(15) O&M (C-1.4.5)

The inventory survey and information collected from the Kampong Speu PDOWRAM indicates that the responsibilities for O&M of the irrigation systems in the Project Area, shared by the Kampong Speu PDOWRAM and FWUCs, are as follows:

Share of Responsibilities for O&M for the Irrigation Systems

Facility	Kampong Speu PDOWRAM	FWUCs*
(a) South Main Canal	In-charge	X
(b) Secondary Canals	Jointly executed	
(c) Tertiary Canals	X	In-charge
(d) Watercourses	X	In-charge

Note: Ou Veang FWUC and Phoum Rong FWUC

O&M for irrigation facilities are not being properly carried out by Kampong Speu PDOWRAM and FWUCs, mainly due to financial constraints and lack of experienced staff.

(16) Water Management (C-1.4.6)

Based on the socio-economic survey of 100 households in the Project Area, 83 households commented that irrigation water, when requested, is supplied intermittently. The main reasons for this are that the water level in the South Main Canal frequently becomes lower due to lack of check structures, improper operation of the Vat Kruoch Intake Gates, and reduced pump operation to save fuel consumption.

(17) Farmer Water Users Communities (C-1.5.3)

There are two Farmer Water Users Communities (FWUCs) in the Project Area: Ou Veang FWUC and Phoum Rong FWUC. Both FWUCs were organized through the initiative of Kampong Speu PDOWRAM and donors (PRASAC for Ou Veang and WB for Phoum Rong). Presently, these FWUCs are managed by a committee consisting of four members: the Chief, 1st Deputy Chief, 2nd Deputy Chief and an Accountant. Both FWUCs are still weak institutionally, and have various problems on finance, administration and physical infrastructures such as non-availability of offices and cadastral maps.

(18) Other Farmers' Organizations (C-1.5.4)

Based on the results of a rapid questionnaire survey on farmers' organizations, 36 organizations are identified in 15, out of the 18 villages in the Project Area. It was realized that they were commonly organized after 2000, through the initiatives of external groups such as NGOs (CEDAC, CGA, CWPD, RHAC), micro-finance institutions (AMRET, ACLEDA Bank), and donors (PRASAC, SEILA) or government projects (IPM promoted by MAFF). Thus, it can be concluded that most of the organizations are only an assembly of farmers who willingly joined the activities and/or the training provided by the donors.

(19) Agricultural Supporting Services (C-1.6)

The agricultural support services available for the Project are i) research and technical development from CARDI, State Farms and experimental stations, ii) extension services from PDA, iii) seed production and supply by CARDI, State Farms and commercial seed producers/growers, iv) farm input supply from the private sector., and v) farm credit from the Micro Finance Institute and NGOs. Generally, these supporting services mostly depend on programs supported by donor agencies and NGOs due to financial constraints of government agencies like PDA.

(20) Environment (C-1.7)

The environmental issues directly related to the Project include domestic water use, land loss and use of fertilizer. According to the socio-economic survey conducted in 2005, about 9 % of sampled households use reservoir or pond water as drinking water, and about 40% use these sources for domestic water during the dry season. More than 95% of the sampled

households complained that fertilizer prices are too expensive. However, around 20% informed that since adequate doses of fertilizer is effective for improvement of rice productivity, there will be a tendency to over use resulting in contamination of river water or nearby reservoir, and pond water. Regarding land loss, 46% of the interviewees living in the Project Area replied that in case their land is taken, they will need compensation. Among them, 63% favored land-for-land compensation, while 37% preferred monetary compensation.

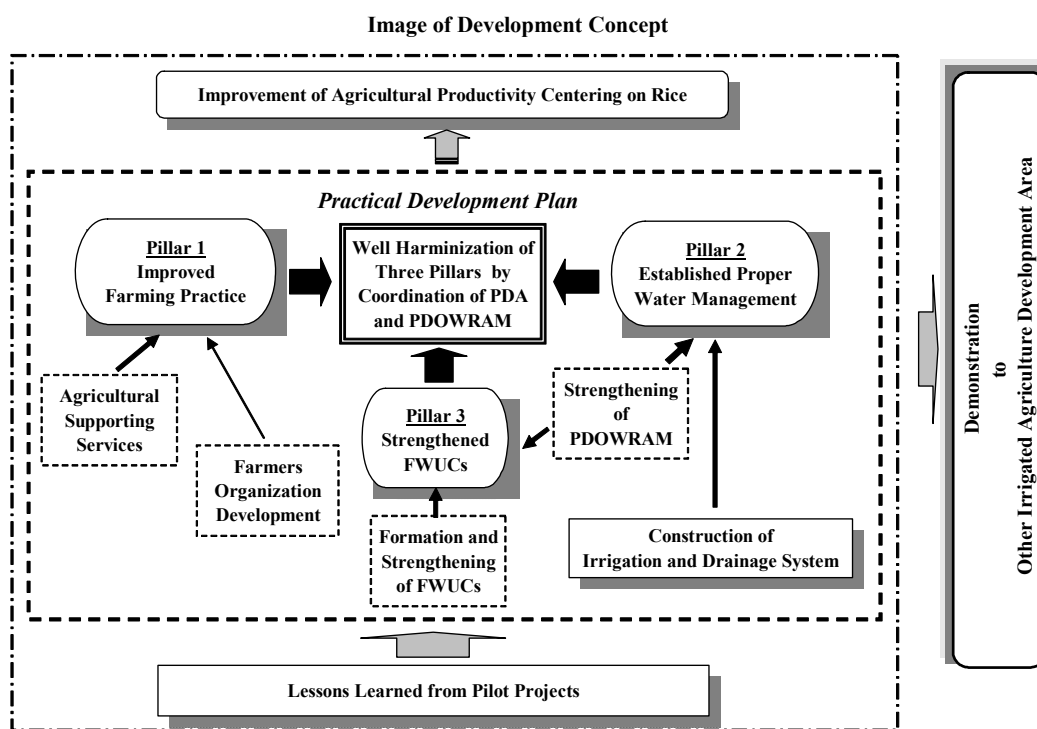
Chapter C-2 The Project

(21) Need of Implementation of Model Project (C-2.1.1)

Irrigated agriculture in the target area is still in the primitive stage on farming practices, water management and FWUC. In order to improve the situation and establish a mechanism to enhance agricultural productivity, the M/P Study proposed to utilize a stepwise development. As a first step, irrigated agriculture at on-farm level should be developed as the pilot project. In this pilot project, water management, farming practices and FWUC activities are to be improved. As a second step, the total irrigation system management from main canal to on-farm facilities should be established for a wider area. Then, proper water management, improved farming practices and strengthened FWUC activities should be promoted and demonstrated as the model project for the remaining large irrigated agricultural area. The first step has already commenced under the Study. It should also be noted that it is now the right time to proceed with the second step.

(22) Purpose and Basic Concept (C-2.1.2)

The Project aims to demonstrate proper water management and increase rice production through well harmonized development on agriculture, irrigation and drainage, as well as the development of related institutions. To attain this aim, an elaborated basic strategy for Project development will be the **“preparation of a practical development plan focusing on dissemination of improved farming practices, established proper water management and strengthened FWUCs”**. This is also in consideration of the lessons learned from the on-going pilot projects. An illustration of the development concept for the Project is shown below:



(23) Agricultural Development Plan (C-2. 2)

(a) Development Concept

The proposed approach is intended for the irrigated agricultural development, aiming at: i) improvement of productivity and increased production of rice, ii) improvement of land use intensity by introducing double cropping of irrigated rice and iii) improvement of land use intensity through introduction of upland crop cultivation. The development strategies in order to meet these aims are the i) introduction of double cropping of rice as much as possible, ii) strengthening of agricultural support services through farmer participatory concept, iii) introduction of water- saving rice cultivation, and iv) introduction of a cropping pattern for production of upland crops and vegetables.

(b) Proposed Cropping Pattern, Cropped Area and Cropping Intensity

Based on the development strategies mentioned above, the following cropping pattern, cropped area and cropping intensity are proposed:

Proposed Cropping Pattern, Cropped Area & Cropping Intensity (units: ha & %)

Crop	Early Rainy Season		Rainy Season		Annual		Present		Cropped Area (ha)	Cropping Intensity (%)
	Area	Intensity	Area	Intensity	Area	Intensity	Area	Intensity		
Early Rice	285	50	285	50	570	100	203	35	+367	+65
Medium Rice	-	-	285	50	285	50	580	100	-295	-50
Rice Total	285	50	570	100	855	150	783	135	+72	+15
Upland Crops 1/	30	5	-	-	30	5	-	-	+30	+5
Total	315	55	570	100	885	155	783	135	+102	+20

1/: including vegetables

(c) Annual Cropped Area, Crop Yield and Crop Production under Present and With-project Condition

On the basis of the planned cropped area and target yields of crops, the crop yield, and crop production under the present and with-project conditions are estimated as follows:

Annual Cropped Area, Crop Yield and Crop Production under Present & With-project Conditions

Crop	Item	Present	With Project	Increase ^{1/}	
				Area/Prod.	%
1. Early Rainy Season Rice (early rice)	- Cropped Area (ha)	203	285	+ 82	+ 40
	- Crop Yield (ton/ha)	2.4	3.8	+ 1.4	-
	- Production (ton) ^{2/}	487	1,083	+ 596	+ 122
2. Rainy Season Rice (early rice)	- Cropped Area (ha)	-	285	+ 285	-
	- Crop Yield (ton/ha)	-	3.8	-	-
	- Production (ton) ^{2/}	-	1,083	+ 1,083	-
3. Rainy Season Rice (medium rice)	- Cropped Area (ha)	580	285	- 295	- 51
	- Crop Yield (ton/ha)	2.3	3.3	+ 1.0	-
	- Production (ton) ^{2/}	1,334	941	- 393	- 29
4. Rice Total	- Cropped Area (ha)	783	855	+ 72	+ 9
	- Crop Yield (ton/ha)	2.4	3.8	+ 1.4	-
	- Production (ton) ^{2/}	1,821	3,107	+ 1,286	+ 71
5. Upland Crops ^{3/}	- Cropped Area (ha)	-	30	+ 30	-
	- Crop Yield (ton/ha)	-	0.7	-	-
	- Production (ton)	-	21	+ 21	-

^{1/}(present/with project) x 100 ^{2/}: Paddy production ^{3/}: represented by mungbeans

As indicated in the above table, the Project is aimed for the following:

- Efficient use of limited water sources through improvement of water management and

rehabilitation of existing irrigation and drainage facilities. Stabilization of rainy season paddy through supplemental irrigation, and expansion of cropping area and irrigation area of early rainy season rice by means of saved irrigation practice (203 ha to 285 ha)

- Improvement of production and crop yield (early rainy season rice: 2.4 ton/ha to 3.8 ton/ha for early rice; 2.3 ton/ha to 3.3 ton/ha for medium rice; 3.8 ton/ha for early rice),
- Crop diversification and improvement of crop intensity through introduction of upland crops.

(d) Farm Household Economy

The results of the economic analysis of typical farms {farm families having double cropped rice field (Type A) and having only a single cropped rice field (Type B)} are presented as follows:

Farm Economy under With-project Condition (unit: '000Riel)

Description		Type A		Type B	
		After Project	Difference between before and after Project	After Project	Difference between before and after Project
Gross Incomes	Rice Production	1,986		1,385	
	Other Farm Income ^{1/}	1,066		1,145	
	Non-farm Income	2,267		1,959	
	Total Income	5,319	+ 684	4,489	+ 705
Expenditures	Production Costs of Farm Products	1,291		1,054	
	Other Expenditures ^{1/}	3,017		2,483	
	Total Expenditures	4,308	+ 215	3,537	+ 257
Net Surplus (Capacity to Pay)		1,011	+ 469	952	+ 448

Source: JICA Study Team, ^{1/}:Livestock, fishery and crops other than rice

(e) Proposed Methods for Improvement of Marketing

To cope with the low and unstable market price of paddy and the issue related to limited number of market destinations compared to the expected increase of production (resulting from project implementation), the proposed methods are the i) improvement of productivity and quality through advancement of farming practices, ii) formation of farmer groups with the introduction of group economic activities such as, group purchasing of farm inputs and technology transfer within a group and among groups, iii) introduction of contract growing or partnership arrangements, iv) intensification of group economic activities toward cooperative shipment and cooperative marketing and v) formation of cooperatives by uniting the groups.

(24) Irrigation and Drainage Improvement Plan (C-2.3)

(a) Development Concept

The Project aims to demonstrate proper water management and increase of rice production in the Project Area, which are accomplished through good harmonization of agriculture, irrigation and drainage, and institutional development. To achieve said aim, an irrigation and drainage improvement plan has been designed in line with the following basic strategies.

Irrigation Improvement Plan	- Maximum use of existing facilities
	- Minimum rehabilitation/improvement works
	- Use of suitable borrow materials for canal embankments
	- Application of gravity method
	- Suitable density of tertiary canals and watercourses
Drainage Improvement Plan	- Establishment of independent drainage systems
	- Use of natural small streams and degraded areas as drains

(b) Canal Layout

In addition to the basic strategies, the canal layout for the Project Area was designed considering the following; i) Size of command Area of the tertiary canals, ii) Length of

tertiary canals, iii) Size of command area of the watercourses, and iv) Each tertiary block being defined by only one tertiary canal. As a result, the designed lengths of the South Main Canal, secondary canals, tertiary canals and watercourses were determined as 7.8 km, 4.67 km, 18.34 km and 142.5 km, respectively. For the drainage canal systems, the established design lengths of the tertiary, secondary and main drains are 15.1 km, 8.0 km and 0.3 km respectively.

(c) Design Discharge

In the preparation of the irrigation and drainage improvement plans, the estimated unit design discharge shown below was adopted. In particular, the design discharge for irrigation was estimated based on the concept of water-saving irrigation.

- 1) Unit Design Discharge for Irrigation (5-year probable return period: overall irrigation efficiency 66% for rice and 53% for upland crops)
 - Main canal : 1.60 lit/sec/ha
 - Secondary canal : 1.41 lit/sec/ha
 - Tertiary canal : 2.10 lit/sec/ha (application of rotational irrigation)
- 2) Unit Design Discharge for Drain
 - 5 lit/sec/ha (three draining days for 3-day consecutive rainfall, with an approximate 5-year probable return period)

(d) Design of Canals and Structures

All canals are designed as unlined with trapezoidal sections. The number of structures to be newly constructed or rehabilitated for the irrigation system are 3 intakes, 17 turnouts, 7 checks, 3 spillways, 4 bridges, one box culvert, 15 pipe culverts, 3 footpath bridges, 3 drainage inlets and 89 division boxes. The required number of cross drains and junction structures are 32 and 18, respectively.

(25) O&M Plan and Water Management (C-2.3.4 and C-2.3.5)

Taking into consideration the present O&M policy, current capability of the FWUCs, size of respective canals and importance of the facilities for project management, the following division of responsibilities is proposed:

Proposed Division of Responsibilities for O&M

Responsible Organization	In-charge	Canal	O&M Responsibilities
Government	Project Office*	South Main Canal	South Main Canal and control of gates to the Secondary Canals
Ou Veang FWUC and Phoum Rong FWUC	FWUG	Secondary Canals	Secondary Canals and control of gates to the Tertiary Canals
	Sub-FWUG	Tertiary Canals	Tertiary Canals and control of division boxes/off-takes to the Watercourses
	WUG	Watercourses	Watercourses and control of water distribution to each field

Water supply to the South Main Canal and secondary canals shall be continuous throughout the year except in the two months, February and March. For the tertiary canals, rotational water supply is proposed so that water is delivered to the tail reaches. Gates for each canal shall be operated in accordance with the irrigation service plan.

In parallel with the proper operation, suitable and continuous maintenance of project facilities is indispensable to ensure suitable and steady function, and realization of full economic life of the facilities. The maintenance works generally consist of:

- Regular maintenance works performed regularly, to maintain and improve the project facilities;
- Periodic maintenance works which include repairs of minor damages;
- Emergency repair works which include repairs of unexpected damages to the project

- facilities caused by flood, heavy rainfall or other causes; and
- Annual maintenance which involves either significant work quantity or requirement of special skills.

(26) Agricultural Support Services Strengthening Plan (C-2.4)

(a) Basic Approach

To tackle development constraints in the Project Area, considering its relevance as the model project, strengthening of agricultural support services is essential to ensure attainment of project targets at an early stage. Thus, agricultural support services should be strengthened with the objectives of i) development and extension of improved and sustainable farming technologies on rice production, enhancement of productivity of the primary agricultural activity in the Project Area, ii) empowerment of extension personnel by way of learning through doing, iii) promotion of farmer-to-farmer technology transfer and iv) development and dissemination of technologies for upland crops and vegetable farming practices and v) establishment of an institutional set-up responsible for the promotion of agricultural productivity improvement in and around the Project Area during the initial stage of the Project.

(b) Proposed Plan

The agricultural support services required for the promotion of the proposed farming practices and for attaining the project target cropping patterns, cropping intensity and crop yields at an earlier stage, are as shown in the following table.

Proposed Agricultural Support Services

Activity	Program Required
Field Extension Programs	Plot & area demonstration, adaptability tests, seed propagation
Farmer/Farmers' Group Training Programs	Training programs, farmer field schools, study tours, village extension agent training & deployment
Mass Guidance/Workshops	Mass guidance/workshops
Farmer-to-Farmer Extension Support ^{1/}	Farmer-to-farmer extension support
Staff Empowerment	Staff training, logistical strengthening

^{1/}: Provision of support for farmer-to-farmer extension by village extension agents

(27) Institutional Strengthening Plan (C-2.5)

Institutional strengthening is one of the indispensable factors for achieving the strategic target of the M/P, which is the “improved agricultural productivity centering on rice”. In this Project, the following four strengthening plans were developed, focusing on its relevance as a model project:

(a) Kampong Speu PDOWRAM Strengthening

The objective of Kampong Speu PDOWRAM strengthening is to improve the working capacity and capability of PDOWRAM in achieving said strategic target. To realize such objective, the proposed methods are i) conducting participatory SWOT workshop, ii) conducting capacity building activities through provision of training courses, initiating study tour, and on-the-job training (OJT), iii) continuation of regular inter-offices meetings and, iv) monitoring and evaluation

(b) Strengthening the Coordination between Kampong Speu PDA and Kampong Speu PDOWRAM

“Strengthening the Coordination between PDA and PDOWRAM” aims to build up the relationship between the two provincial departments with regard to the development of irrigated agriculture. To achieve this aim, a Project Office will be established, to undertake the following activities; i) continuation of regular meetings, ii) publishing of a newsletter on the Project, and iii) monitoring and evaluation.

(c) FWUC Strengthening

The objective of “FWUC Strengthening” is to develop the function of the FWUCs, in compliance with its statute and the concept of Participatory Irrigation Management and Development. This will also be based on the experience earned from the pilot project. The proposed methods for strengthening each FWUC are as follows:

Ou Veang FWUC	Phoum Rong FWUC
(1) Preparation of land owner and landholding map of Ou Veang FWUC’s management area	(1) Completion and updating of the land owner and landholding map of Phoum Rong FWUC’s management area
(2) Re-selecting of representatives of FWUG, Sub-FWUG, and WUG by canal layout.	(2) Selecting of representatives of WUG for newly constructed water courses
(3) Conducting various fields of training required to manage FWUC starting with ways to organize and facilitate meetings.	(3) Distribution of illustrative magazines to disseminate information regarding FWUC activities.
(4) Construction of FWUC office buildings.	(4) Conducting the training on preparation of proposals
(5) Conducting intensive training on financial management.	(5) Provision of continuous capacity building training and support service by PDOWRAM.
(6) Distribution of illustrative magazines to disseminate information regarding the FWUC activities.	
(7) Government institutions concerned take the initiative for Management Transfer Agreements, with the cooperation of the FWUC Committee	
(8) Conducting the training on simple feasibility study, cost estimate, and preparation of proposals.	
(9) Provision of continuous capacity building training and support service by PDOWRAM.	

(c) Farmers’ Organizational Development

In the Project Area, there are four CEDAC’s and two IPM’s savings groups, which are currently the only farmers’ groups being democratically managed by their members. It is proposed to develop these savings groups to become the foundation of the preliminary agricultural cooperative, which will deal with i) joint purchase of agricultural inputs such as fertilizers, pesticides, and farming equipment, ii) collective shipment and sale of agricultural products, and iii) savings and credit in the future. The proposed activities related to development of the current savings groups are; i) clarification and review of the existing regulations, ii) maintaining and improving of financial transparency, iii) increase of capital funds, and iv) preparation for developing into a preliminary agricultural cooperative.

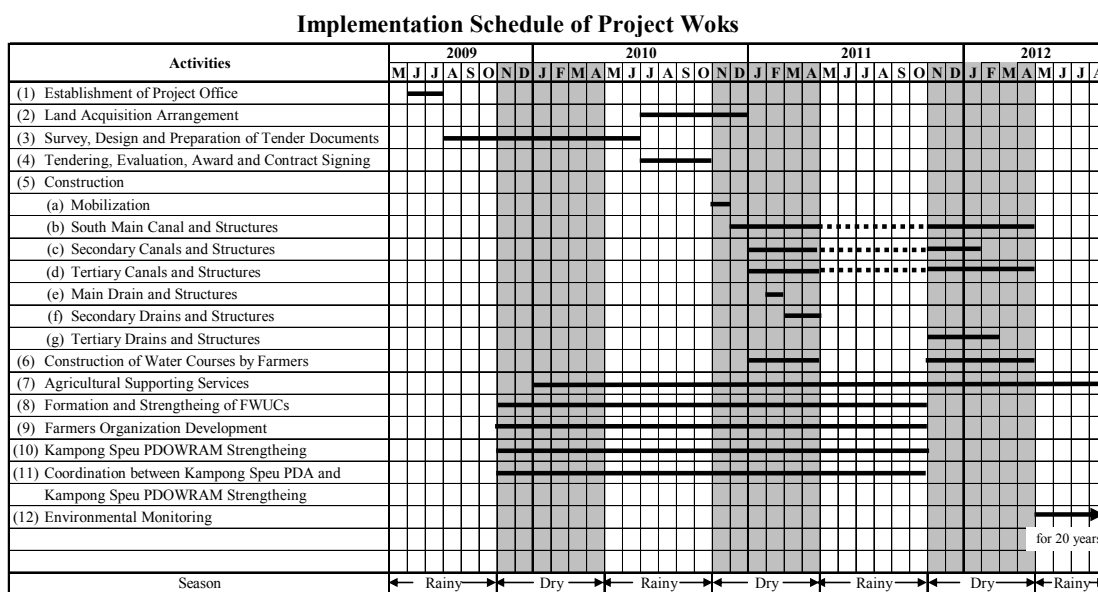
(28) Environmental Considerations (C-2.6)

In the process of preparation of various improvement plans, a series of environmental considerations were investigated to implement the Project in a more environmentally friendly and sustainable manner. The environmentally significant issues under the Project are i) water availability during the construction phase for agriculture, ii) lining method for the canals at eroded portions due to dispersible soils, and iii) dusts caused by construction vehicles.

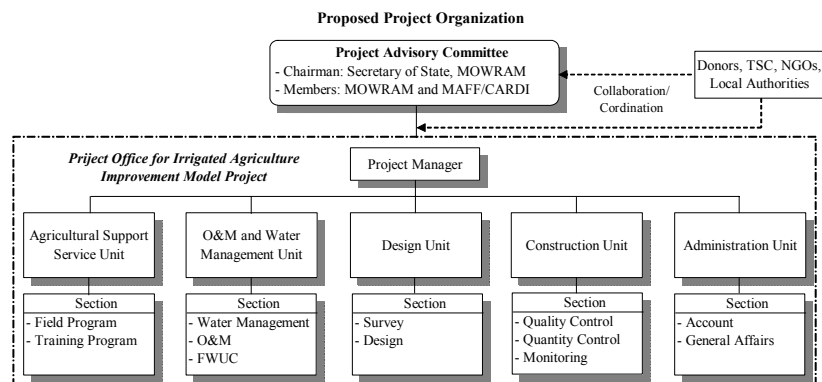
(29) Implementation Plan (C-2.7)

The Project works consist of i) establishment of a Project Office, ii) land acquisition arrangements, iii) engineering services, iv) tendering, v) construction, vi) construction of watercourses by farmers, vii) agricultural support services, viii) formation and strengthening FWUCs, ix) farmers organizational development, x) Kampong Speu PDOWRAM strengthening, xi) strengthening the coordination between PDA and PDOWRAM, and xii) environmental monitoring. The anticipated duration for Project implementation is 39 months, excluding 20 years of environmental monitoring. The implementation schedule for the

Project works is shown below:



MOWRAM is the overall executing agency for the project implementation. The purpose of the Project is to demonstrate proper water management and increase rice production through harmonization of agriculture, irrigation and drainage and institutional development. This means that close coordination between PDOWRM and PDA is essential. In addition, the Project will be implemented in a participatory approach commencing on an early stage. Taking into consideration the above, it is proposed to establish a Project Office directly under the responsibility of the Undersecretary of State of MOWRAM. The proposed organization of the Project Office is given below:



(30) Environmental Examination (C-2.8)

The initial environmental examination of the Project concluded the following:

- As a whole, the Project Development Plan was judged to be acceptable from an environmental viewpoint, if proper mitigation measures presented previously are undertaken.
- Some of likely negative impacts on both the social and natural environments were pointed out, such as limitation of water availability during the construction period and deterioration of water quality during start of operation. Therefore, to avoid/mitigate anticipated negative impacts, proper management along with the proposed mitigation measures and management/monitoring plan should be implemented.
- Considering the strong sensitivity of the farmers to the subject, the land acquisition process should be conducted very cautiously. Thus, this shall be carried out under a proper management implementing the proposed mitigation measures and management plan.

(31) Cost Estimate (C-2.9)

The estimated total investment cost was US\$ 2,479,000, equivalent to Riel 10,064,740,000. The estimated replacement cost for the gates and its accessories was US\$ 187,000 equivalent to Riel 759,220,000. Said replacement will be carried out on the 25th year upon completion of the improvement work. Estimated annual O&M cost was US\$ 5,900, equivalent to Riel 23,954,000. In addition, the estimated annual cost of environmental monitoring works, which will continue for 20 years from completion of construction, was US\$ 648, equivalent to Riel 2,630,880.

(32) Project Evaluation (C-2.10)

Estimated EIRR for the Project was 11.1 %. B-C and B/C at 7% discount rate were also estimated as Riel 2,969 million and 1.5 respectively. Judging from these economic indicators, the Project was proven to be economically feasible. The Project will also bear the increase of rice, from 1,821 tons 3,107 tons, (about 70% increase).

A farm budget analysis was conducted for typical farms (Type A: farm families having a double cropped rice field, and Type B: having only a single cropped rice field) for the present “without-project” and future “with-project” conditions. Under the “with-project” condition, average gross income of the farming households would increase to 87% for Type A and 89% for Type B. The annual net increase in income would average Riel 469,000 for Type A and Riel 448,000 for Type B. The farmers’ ability to pay was defined as the ratio of the Irrigation Service Fee (ISF) to the annual net increase in income under with project condition. The average ISF was estimated at Riel 47,400/year/household for Type A and Riel 15,300/year/household for Type B. These values are less than 11% of the annual net increase in income of Type A, and less than 4% of Type B households. This will enable most of the farmers to pay ISF.

The Project will also significantly contribute to many socio-economic aspects such as i) improvement of farmers’ and other peoples’ incomes and employment opportunities, ii) self-sufficiency in upland crops and vegetables in the Project Area, iii) improvement of the regional economy, iv) capacity development of staff concerned, and v) ripple effects as a development model to be introduced into neighboring and other areas.

(33) Monitoring for Project Effects (C-2.11)

This is a model project to demonstrate proper water management and increase rice production through harmonizing the inputs from agriculture, irrigation and drainage, and institutional development. Upon completion of the project facilities, support services will have also been carried out to ensure the project effects. For this purpose, it is required to undertake monitoring activities for the Project, which shall be executed by the Project Office. The monitoring period is scheduled to be four years from the completion of project facilities. The proposed indicators for monitoring are as follows:

- Agriculture : Crop yield and cropping intensity
- Irrigation : Discharge measured at head of secondary canals
- Institution : Collection rate of irrigation service fees

(34) Conclusion and Recommendations (C-2.12)

Based on the feasibility study, the Project was justified as technically feasible and economically viable. From the institutional and organizational, social and natural environmental aspects, it was also found that the Project is generally sound. Execution of the Project could accomplish the principal objective of demonstration of proper water management and increase rice production under well harmonized development of agriculture, irrigation and drainage and institutions. Thus, it is concluded that the Project should be implemented in the manner planned in this Study.

In connection with the implementation of the Project, the recommendations include: i) Urgent implementation of the Project, ii) Need of timely establishment of the Project office,

iii) Need for budget arrangements for support services, and iv) Need for environmental monitoring.

VOLUME-IV PILOT PROJECTS

Part A: General Information

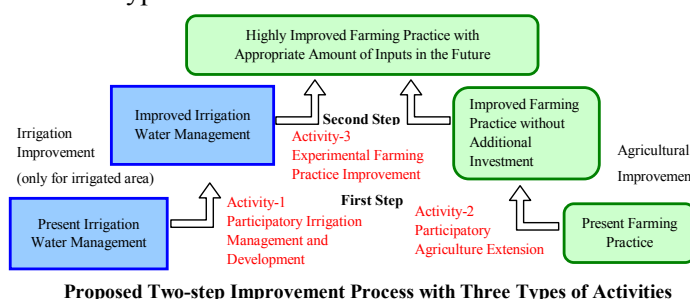
(1) Background (A-2)

In the M/P for Comprehensive Agricultural Development of the Prek Thnot River Basin, four pilot projects were proposed. Among the four, the following two priority pilot projects to be implemented in three zones were selected from viewpoints of its importance in M/P, urgency and farmers’ incentives.

- Irrigated Agriculture On-farm Technology Improvement pilot project (in Zones-1 and 3)
- Rainfed Agriculture Improvement pilot project (in Zone-4)

(2) Objective and Outline of the Pilot Projects (A-2.2.2, A-3.1)

The purpose of the pilot projects is to establish good models of improvement by confirming farmers’ response to the proposed improvement activities in the M/P and to contribute to its enhancement. A “good model of improvement” signifies that the model can demonstrate the effectiveness of the proposed improvement processes to meet the M/P target. The proposed two-step improvement process for the three types of activities is illustrated below. It is expected that farmers’ financial condition will improve through the first step improvement, without additional investment. They will then proceed to the second step, where highly improved farming practice is introduced, with appropriate amount of inputs in the future.



Proposed Two-step Improvement Process with Three Types of Activities

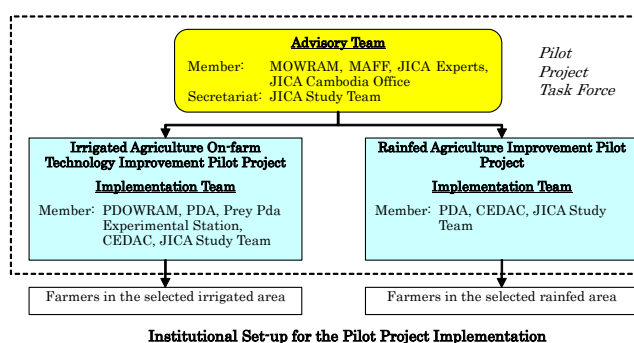
(3) Basic Strategies for Implementation (A-4.2)

The following five basic strategies for implementation were proposed.

Strategy-1	Learning from good farmer practices in Cambodia
Strategy-2	Project operation by a united farmer-government-NGO project team
Strategy-3	Government agencies collaborating in irrigated agriculture related activities
Strategy-4	Minimum material and equipment inputs from the farmers
Strategy-5	Introduction of farmer-to-farmer extension

(4) Institutional Set-up (A-5)

As shown in the right figure, the pilot project Task Force, which consisted of an advisory and two implementation teams, was formed for the pilot project implementation. Implementation teams formed were for Irrigated Agriculture On-farm Technology Project and Rainfed Agriculture Improvement pilot project.



Institutional Set-up for the Pilot Project Implementation

(5) Feedback Seminar (A-6)

A seminar which tackled the results of activities of the pilot projects was held on February 15, 2008 in Kampong Speu Province. Participants consisted of three MOWRAM officers, three PDOWRAM officers, seven PDA officers, two CEDAC staff and twenty farmers. After explanation of the background of the study, representatives of PDOWRAM, PDA and CEDAC discussed the activities of the pilot projects. Based on the results of group

discussions on envisaged problems related to lessons learned and future activities, almost all farmers agreed and emphasized the necessity of the pilot project activities to continue as proposed.

Part B: Pilot Projects (2006/2007)

Section-I: Irrigated Agriculture On-farm Technology Improvement Pilot Project (Zone-1)

Chapter BI-1: Framework of the Project

(1) Objective (*BI-1.1*) and Activities (*BI-1.2.1*)

The objective of the pilot project was to establish a good model of on-farm irrigated agricultural improvement in Zone-1. The three types of activities that were conducted are: i) Participatory Irrigation Management and Development, ii) Participatory Agricultural Extension, and iii) Experimental Farming Practice Improvement.

Chapter BI-2: Participatory Irrigation Management and Development Activities

(2) Objective (*BI-2.1*) and Area (*BI-2.3.1*)

The objective of participatory irrigation management and development activities is to achieve efficient use of irrigation water based on the irrigation service plan. The RT-2 tertiary canal area was selected as the activity area.

(3) Situation before Starting the Pilot Project (*BI-2.3*)

There were turnout structures with gates at the head of RT-2 tertiary canal, but there were no on-farm facilities in the command area. The area was managed by Ou Veang FWUC. The FWUC was not functioning well due to low awareness on the importance of irrigation management, lack of basic information, insufficient capacity of leaders, etc.

(4) Activities Conducted for Improvement (*BI-2.5*)

Leaders of Ou Veang FWUC visited the more advanced Ou Treang FWUC during the study tour. The leaders analyzed their situation and prepared their improvement plan together with PDOWRAM. The improvement plan consisted of 11 practices. Among these, the following eight were carried out, while three were completed in 2006/07.

Practices Conducted	Results
(a) Preliminary Land Holding Map Preparation Practice	A land holding map for RT-2 canal command area (about 63 ha) was prepared using GPS and GIS software, together with the FWUC leaders in a rapid and low cost manner (completed).
(b) Water Use Map Preparation Practice	The current situation of water use was surveyed and plotted on the map. It was found that the most upstream village was not paying their irrigation service fee properly and there were many part-time farm households (completed).
(c) Water Loss Identification and Reduction Practice	Discharge in canals was measured by PDOWRAM and it was found there was water loss at the incomplete spillway structure. Gates were provided on the spillway to prevent water loss.
(d) FWUC Sub-group Establishment Practice	FWUC sub-groups in the related five villages were formed and leaders were elected.
(e) Proper Irrigation Water Use Education Practice	The importance of the FWUC activities was explained in village meetings and also FWUC magazines were published in order to disseminate FWUC activities by the pilot project implementation team.
(f) FWUC Administration Improvement Practice	A series of training sessions was provided to the FWUC leaders by PDOWRAM.
(g) Irrigation Service Plan	Percolation rate in the area was measured by PDOWRAM to

Preparation Practice	prepare a water distribution plan.
(h) On-farm Irrigation Facilities Construction Practice	After obtaining consensus with the FWUC, 6 division structures with checks, 2 off-takes, and 1 cross drain structure were constructed (completed).

Chapter BI-3: Participatory Agriculture Extension Activities

(5) Objective (BI-3.1) and Area (BI-3.3.1)

The objective of the participatory agricultural extension activities was to disseminate information regarding low cost and low inputs SRI. This also aims to achieve satisfactory results in irrigated and rainfed areas in Cambodia. The low inputs System of Rice Intensification (SRI) should satisfy at least three items, out of the following 12 items. Rumleang Village located downstream of the RT-2 canal was selected as the area for the activity.

12 Principles of LowInputs SRI

- 1) Level the paddy field and provide drainage
- 2) Select purified and dense seeds for sowing
- 3) Raise nursery beds or use dry nursery beds
- 4) Select big seedlings and transplant them immediately
- 5) Transplant young seedlings (seedlings younger than 15 days)
- 6) Transplant one plant per hill
- 7) Transplant seedlings at a shallow depth and keep the roots horizontal
- 8) Transplant seedlings in a line
- 9) Transplant seedlings 25-40 cm apart
- 10) Weed at least 2-4 times a season
- 11) Keep the water depth in the paddy field shallow
- 12) Apply natural fertilizer as much as possible

(6) Situation before start of the Pilot Project (BI-3.3)

SRI had not been introduced in Rumeleang Village, where no self-reliant farmers' group exists.

(7) Activities Conducted for Improvement (BI-3.5)

(a) Farmer-to-farmer Low Inputs SRI Extension

During the initial guidance, farmers were motivated to introduce low inputs SRI according to the recommended manner, which was i) to divide paddy plots into two in order to compare SRI against traditional farming, ii) to allocate a micro-scale area for SRI, and iii) to start low inputs SRI without additional agricultural inputs such as fertilizer and seeds. In addition, more frequent use of compost instead of chemical fertilizer was suggested.

As a result, four farmers volunteered as experimental farmers, to join the monitoring activity. The following SRI extension works were completed:

- Study tour to Kampong Cham province to learn about SRI
- Village training
- Inter-village training to share the experiences of the experimental farmers in three Zones (Zone-1, 3, and 4)
- Farmers' field day to demonstrate SRI to villagers

(b) Farmer-to-farmer Ecological Chicken Raising Extension

Considering farmers' interest, ecological chicken raising was selected as an activity in the dry season. The following training on chicken raising was then presented:

- Study tour to Kampong Cham province to learn about chicken raising
- Village training

(c) Farmers' Group Strengthening

Since an active farmers' group is essential for the farmer-to-farmer extension, the said group was established, and strengthened in the following manner.

- Study tour (participants discussed also the farmers' group in the study tours for SRI and chicken raising)
- Village training

Chapter BI-4: Experimental Farming Practice Improvement Activities

(8) Objective (BI-4.1)

The objective of experimental farming practice improvement activities was to verify that the target yields proposed in the M/P were achievable through application of SRI based on improved farming practices. It also aims to determine further improvement on practices, when required.

(9) Situation before Starting of the Pilot Project Activities (BI-4.3)

The agricultural conditions before starting the pilot project are as follows:

Nursery	Seeds of own products were used, while seed replacement with good quality was seldom done
Transplanting	Random planting was applied.
Fertilization	Manure (1.7 ton/ha) and DAP(58 kg) & Urea (70 kg/ha)
Paddy yield	Early rainy season: 2.4 ton/ha, Rainy season: 2.3 ton/ha

(10) Verification Test (BI-4.8)

Yield of six verification test plots were compared with the target yield of the M/P:

Yield Comparison with the Master Plan Target

Category of Variety	Variety	Plot No.	Target Yield of Master Plan (t/ha)	Average Yield in Year 2006 (t/ha)	Difference (t/ha)
Medium Variety	Riang Chey	Plot 1	3.0	3.9	+0.9
	Riang Chey	Plot 2	3.0	4.8	+1.8
	Riang Chey	Plot 3	3.0	3.9	+0.9
	Niang Meng	Plot 4	3.0	3.2	+0.2
	Average		3.0	4.0	+1.0
Early Variety	Sen Pidao	Plot 5	3.0	4.0 ^{1/}	+1.0
	Sen Pidao	Plot 6	3.0	4.0 ^{1/}	+1.0
	Average		3.0	4.0	+1.0

^{1/}: Assesment by a demonstrator; production is rough estimate

As a result, yield of verification plots was higher as compared to M/P's target this year.

(11) Small Scale Adaptability Test (BI-4.9)

(a) Adaptability Tests on Medium Variety (BI-4.7.3)

Adaptability tests on medium variety consisted of i) variety trial, ii) on-farm water management, iii) seeding rate & planting method. The results of these tests are as follows:

Results of Simple Trial for Medium Variety in Zone 1

Trial/Variety	Treatment	Crop Cut Yield ^{1/}	Whole Plot Yield
Variety Trial	Phka Rumchang	3.6 t/ha	-
	Phka Rumduol	3.9 t/ha	3.8 t/ha
	Riang Chey	5.9 t/ha	3.9 t/ha
On-farm Water Management (Riang Chey)	Continuous intermittent	4.7 t/ha	3.7 t/ha
	Intermittent in vegetative stage	5.9 t/ha	4.4 t/ha
	Continuous flooding	5.1 t/ha	3.2 t/ha
Seeding Rate & Planting Method (Riang Chey)	40 g/m ² & 2-3 plants/hill	5.5 t/ha	5.4 t/ha
	60 g/m ² & 2-3 plants/hill	5.8 t/ha	5.7 t/ha

^{1/}: Samples taken at point showing normal growth

(b) Adaptability Test on Early Variety (*BI-4.9.4*)

Adaptability tests on early variety consisted of i) variety trial, ii) on-farm water management, iii) seeding rate & planting method. The results of these tests are as follows:

Results of Simple Trial for Early Variety in Zone 1

Trial/Variety	Treatment	Crop Cut Yield ^{1/}	Whole Plot Yield
Variety Trial	IR 66	5.4 t/ha	5.9 t/ha
	Sen Pidao	5.9 t/ha	4.5 t/ha
	IR Kesar	5.2 t/ha	4.5 t/ha
On-farm Water Management (Sen Pidao)	Continuous intermittent	5.2 t/ha	4.1 t/ha
	Intermittent in vegetative stage	6.1 t/ha	4.4 t/ha
	Continuous flooding	5.6 t/ha	4.9t/ha
Seeding Rate & Planting Method (Sen Pidao)	40 g/m ² & 1 plant/hill	6.1 t/ha	5.1 t/ha
	40 g/m ² & 2-3 plants/hill	5.7 t/ha	4.6 t/ha

^{1/}: Samples taken at point showing normal growth

(12) Farmers' Acceptability Survey (*BI-4.10*)

The farmers' acceptability survey was carried out with the objective of preliminary assessment of the adoptability of improved farming practices, introduced in the verification plots by farmers. The acceptability survey was carried out on the improved rice farming practices through simple interview survey with the demonstrators. All the eight demonstrators assessed the adopted improved farming practices with a rating of either "good" or "proper".

Section-II: Irrigated Agriculture On-farm Technology Improvement Pilot Project (Zone-3)**Chapter BII-1: Framework of the Project**(13) Objective (*BII-1.1*) and Activities (*BII-1.2.1*)

The objective of the pilot project was to establish a good model of on-farm irrigated agriculture improvement in Zone-3 (irrigated area by water harvesting irrigation systems). The activities experimentally executed in Zone-3 included three types, namely (i) Participatory Irrigation Management and Development, (ii) Participatory Agricultural Extension and (iii) Experimental Farming Practice Improvement.

Chapter BII-2: Participatory Irrigation Management and Development Activities(14) Objective (*BII-2.1*) and Activity Area (*BII-2.3.1*)

The objective of the pilot project was to promote efficient use of reservoir water for irrigation in a sustainable and replicable way. The Prey Robong water harvesting irrigation system (about 40 ha) located in Banla S'et village was selected as the activity area.

(15) Situation before Starting the Pilot Project (*BII-2.3*)

Since the water harvesting irrigation system did not produce adequate supply, the system could only irrigate during the end of the rainy season. The system was managed by Trapeang Prey Robong irrigation management group. The group was not functioning well since farmers were not very attentive to the unreliable water harvesting irrigation system.

(16) Activities Conducted for Improvement (*BII-2.5*)

Due to severe drought, the irrigation canals of the Prey Robong water harvesting irrigation system was not utilized in 2006/07. Therefore, only two practices were conducted as part of the Participatory Irrigation Management and Development activities.

(a) Preliminary Land Holding Map Preparation Practice

The preparation of a preliminary landholding map could not be fulfilled since the farmers did not render satisfactory cooperation, mainly due to unreliable water harvesting irrigation system caused by unstable water source.

(b) Water Use Map Preparation Practice

The boundary of the reservoir impounding area and the routes of the irrigation canals were surveyed through simple means, and plotted on a map. This was intended as preparation for improvement of water management.

Chapter BII-3: Participatory Agriculture Extension Activities

(17) Objective (*BII-3.1*) and Area (*BII-3.3.1*)

The objective of participatory agricultural extension activities was to disseminate information regarding low cost and low input SRI. Mohaleaph village was selected as the area for the activity.

(18) Situation before Starting the Pilot Project (*BII-3.3*)

In Mohaleaph village, since there was no farmers' group existing, SRI had not been introduced.

(19) Activities Conducted for Improvement (*BI-3.5*)

(a) Farmer-to-farmer Low Input SRI Extension

During the initial guidance, farmers were motivated to introduce low input SRI similar to that recommended for Zone-1. As a result, four farmers volunteered as experimental farmers to join the monitoring activity. The same method of SRI extension works as offered in Zone-1 was also presented during this activity.

(b) Farmer-to-farmer Ecological Chicken Raising Extension

Considering farmers' interest, ecological chicken raising was selected as the activity during the dry season. This was taught during the study tour and village training.

(c) Farmers' Group Strengthening

Since an active farmers' group is essential for farmer-to-farmer extension, a farmers' group was established, and strengthened through the study tour and village training.

Chapter BII-4: Experimental Farming Practice Improvement Activities

(20) Objective (*BII-4.1*)

The objective of experimental farming practice improvement activities was to verify that the target yields proposed in the M/P are achievable, through application of SRI, based on improved farming practice. It also aims to determine further improvement on practices, when required.

(21) Situation before Starting the Pilot Project Activities (*BII-4.3*)

The agricultural conditions prior to commencement of the pilot project are as follows:

Nursery	Seeds of own products were used, while seed replacement with good quality was seldom done
Transplanting	Random planting was applied.
Fertilization	Manure (0.9 ton/ha) and DAP58 & Urea (doses depending)
Paddy yield	0.9~1.3 ton/ha (average 2003~2006)

(22) Verification Test (BII-4.8, BII-4.8.5)

Yields of five verification plots are presented in comparison with the target yield of the master plan as follows.

Yield Comparison with the Master Plan Target (ton/ha)

Category of Variety	Variety	Plot No.	Target Yield of Master Plan (t/ha)	Average Yield in Year 2006/07 (t/ha)	Difference (t/ha)
Medium Variety	Riang Chey	Plot 1	2.8	3.2	+0.4
	Chung Kong Mon	Plot 2	2.8	2.5	-0.3
	Srov Krohorm	Plot 3	2.8	3.2	+0.4
	Riang Chey	Plot 4	2.8	0.7	-2.1
	Rian Chey	Plot 5	2.8	1.6	-1.2
Average			2.8	2.2	+0.2

Target yield: Master Plan target yield

As shown in the table, the average crop yields of all the verification plots were mostly lower (except for two) than M/P's target .

(23) Small Scale Adaptability Test (BII-4.9, BII-4.9.4)

Adaptability tests on medium variety consisted of i) variety trial, ii) planting density, iii) seeding rate & planting method. The results of these tests are as follows:

Results of Simple Trial for Medium Variety in Zone 3

Trial/Variety	Treatment	Crop Cut Yield ^{1/}	Whole Plot Yield
Variety Trial	Phka Rumchang	3.9 t/ha	2.9 t/ha
	Phka Rumduol	2.4 t/ha	2.3 t/ha
	Sen Pidao	4.0 t/ha	-
	Chung Kong Mong	4.3 t/ha	3.4 t/ha
	Chma Prom	4.1 t/ha	3.4 t/ha
Planting Density (Riang Chey)	20 x 20 cm	2.9 t/ha	-
	25 x 25 cm	3.7 t/ha	-
	30 x 30 cm	4.0 t/ha	-
Seeding Rate & Planting Method (Riang Chey)	40 g/m ² & 2-3 plants/hill	3.7 t/ha	-
	60 g/m ² & 2-3 plants/hill	4.9 t/ha	-

^{1/}: Samples taken at point showing normal growth

(24) Farmers' Acceptability Survey (BII-4.10, BII-4.10.3)

Most demonstrators in the area assessed the main proposed farming practices with a rating of either "good" or "proper". All the demonstrators accepted the regular transplanting method, one of the most important practices of which the adoptability was to be verified.

Section-III: Rainfed Agriculture Improvement Pilot Project (Zone-4)**Chapter BIII-1: Framework of the Project**

(25) Objective (BIII-1.1)

The objective of the "Rainfed Agriculture Improvement pilot project" is to establish a good model of rainfed agriculture improvement in Zone-4 (rainfed agriculture area).

(26) Activities (BIII-1.1)

The model reveals the two-step development process with two activities, as its Activity-1. Participatory Irrigation Management and Development activity is not applied in Zone-4. These activities are (i) Participatory Agricultural Extension and (ii) Experimental Farming Practice Improvement.

Chapter BIII-2: Participatory Agriculture Extension Activities

(27) Objective (BIII-2.1) and Activity Area (BIII-2.3.1)

The objective of participatory agricultural extension activities was to disseminate low cost and low input SRI. Dam Daek Village was selected as the area for the activity.

(28) Situation before Starting the Pilot Project (BIII-2.3)

In Dam Daek village, SRI had not been introduced since there was no existing farmers' group.

(29) Activities Conducted for Improvement (BIII-2.5)

(a) Farmer-to-farmer Low Inputs SRI Extension

During the initial guidance, the farmers were motivated to introduce low inputs SRI using the same methods as recommended in Zone-1. As a result, three farmers volunteered as experimental farmers to join the monitoring activities. The same kind of SRI extension works as presented in Zone-1 were also offered in the activity.

(b) Farmer-to-farmer Ecological Chicken Raising Extension

Considering farmers' interest, ecological chicken raising was selected as an activity in the dry season. Ecological chicken raising was taught during the study tour and village training.

(c) Farmers' Group Strengthening

Since an active farmers' group is essential for farmer-to-farmer extension, a group was established and strengthened through the study tour and village training.

Chapter BIII-3: Experimental Farming Practice Improvement Activities

(30) Objective (BIII-3.1)

The objective of experimental farming practice improvement activities was to verify that the target yields proposed in the M/P are achievable through application of SRI-based improved farming practices. This also aims to further improve practices, when required.

(31) Situation before Starting the Pilot Project Activities (BIII-3.3)

The agricultural conditions prior to commencement of the pilot project are as follows:

Nursery	Seeds of own products were used while seed replacement with good quality was seldom done.
Transplanting	Random planting was applied.
Fertilization	Manure (3.2 ton/ha) and DAP, Urea, 16-16-8 (doses depending)
Paddy yield	1.8~2.1 ton/ha (average 2003~2005)

(32) Verification Test (BIII-3.8, BIII-3.8.5)

Yield of five verification test plots were compared with the target yield of the master plan as follows.

Yield Comparison with the Master Plan Target

Category of Variety	Variety	Plot No.	Target Yield of Master Plan (t/ha)	Average Yield in Year 2006 (t/ha)	Difference (t/ha)
Medium Variety	Chma Prom	Plot 1	2.0	4.4	+2.4
	Riang Chey	Plot 2	2.0	3.7	- 1.7
	Chma Prom	Plot 3	2.0	3.9	+1.9
	Chma Prom	Plot 4	2.0	3.3	- 1.3
	Riang Chey	Plot 5	2.0	3.2	- 1.2
	Average		2.0	3.7	- 1.7

As a result, yield of verification plots is higher than M/P's target in 2006/07.

(33) Small Scale Adaptability Test (*BIII-3.9, BIII-3.9.4*)

Adaptability tests on medium variety consisted of i) variety trial (transplanting), and ii) variety trial (direct sowing). The results of these tests are as follows:

Results of Simple Trial for Medium Variety in Zone 4

Trial/Variety	Treatment	Crop Cut Yield ^{1/}	Whole Plot Yield
Variety Trial: Transplanting	Phka Rumchang	4.1 t/ha	-
	Phka Rumduol	4.9 t/ha	-
	Sen Pidao	3.0 t/ha	2.4 t/ha
	Chung Kong Mong	3.3 t/ha	-
	Chma Prom	3.0 t/ha	2.9 t/ha
	Riang Chey	2.5 t/ha	2.2 t/ha
Variety Trial: Direct Sowing	Phka Rumchang	3.4 t/ha	-
	Phka Rumduol	3.4 t/ha	-
	Sen Pidao	2.8 t/ha	-
	Chung Kong Mong	2.5 t/ha	-
	Chma Prom	1.9 t/ha	1.7 t/ha
	Riang Chey	1.7 t/ha	2.1 t/ha
Nursery Trail	10 treatments	3.7 t/ha	-

^{1/}: Samples taken at point showing normal growth

(34) Farmers' Acceptability Survey (*BIII-3.10, BIII-3.10.3*)

In the area, rice productions in all the verification plots were satisfactory and most of the proposed practices were supported by the demonstrators. In all the plots, paddy yield increased compared with that of last year. The reasons for the positive results were improved farming practices, favorable rainfall and top dressing timing.

Section-IV: Technology Transfer, Sharing of Experiences and Lessons Learned

(35) Through the pilot project activities, various types of technology were transferred to PDOWRAM and PDA staff mainly by on-the-job training. These experiences were shared with the pilot project task force members during joint monthly meetings.

(36) Lessons Learned (*BIV-2.2*)

The following lessons learned were realized from the pilot project activities conducted in 2006/07.

1) Participatory Irrigation Management and Development

Strategy-1: Learning from good farmers' practices in Cambodia

- Necessity of Development of Water Resource Scarce Areas
- Importance of a Quick Plan-Do-See Cycle in Project Operation
- Necessity of Empowering Farmers by Confirming Their Behavioral Change
- Necessity of Incentives for FWUC Committee Members
- Identified Keys for Proper Irrigation Service Fee Collection

Strategy-2: Project operation by united farmers-government-NGO project team

- Related Institutions to be involved in the Project Activities
- Necessity of Implementing Formal Processes in FWUC Activities

Strategy-3: Government agencies collaborating in irrigated agriculture-related activities

- Finding Proper timing of Integrating FWUC Strengthening and Agricultural Extension Activities
- Effectiveness of Utilizing the Existing Social Capital of Local Communities
- High Capability of Provincial Government Staffs in Communicating with Local

Inhabitants

- Necessity of Applying Different Approaches to Empowering FWUC or Irrigation Management Groups in Different Zones

Strategy-5: Introduction of farmer-to-farmer extension

- Effectiveness of Group Discussions in Meetings and Training sessions

Others

- Importance of Providing Non Formal Education to Farmers
- Empowerment of Farmers and Local Government Staff, Taking Their Abilities into Account
- Proper Use of Scientifically Obtained Data and Collected Data in a Participatory manner
- Necessity of Paying Careful Attention to Sustainable Development
- Necessity of Proper Understanding of the Necessary Conditions and Requirements for an Active FWUC
- Necessity of Understanding the Nature of an FWUC and Providing a Proper amount of Time for Strengthening
- Necessity of Improving Administration of an FWUC Prior to Implementing Water Management
- Difficulties in Establishing Trans-village Networks for FWUC Activities
- Effectiveness of Utilizing Various Village Events in FWUC Activities
- Importance of Preparing a Preliminary Landholding Map in FWUC Strengthening
- Necessity of Developing a Rapid and Low Cost Preliminary Landholding Map Preparation Method
- Necessity of Establishing a Simple Method for Updating a Preliminary Landholding Map
- Effectiveness of Introducing FWUC-Initiated Training System
- Importance of Publicity Information to the People on the Activities of FWUC
- Necessity of Providing Technical Information to PDOWRAM

2) Participatory Agricultural Extension

Strategy-2: Project Operation by United Farmer-Government-NGO Project Team

- Importance of Presenting Various Types of Farming Practices in Agricultural Extension

Strategy-5: Introduction of Farmer-to-Farmer Extension

- Identified Key Points for Effective Participatory Agricultural Extension
- Importance of Sharing Experiences through Lateral Farmers' Networks
- Importance of Farmers' Groups in Agricultural Extension and Further Development

Others

- Importance of Farmers' Self-reliance in Improving Farming Practices
- Assessment of Ease or Difficulties in low input SRI Principles by Farmers
- Possibility of Applying Similar Extension Processes in All Zones
- Necessity of Guiding Farmers toward Flexible Application of New Farming Practices
- Necessity of Continuing Activities in the Dry Season
- Importance of Testing SRI without Applying New Seeds
- Strong Demand of Farmers for Savings Activities
- Expected Effect of Savings Activities on Sustainable and Self-reliant Farmers' Groups
- Proposed Process of Establishing Farmers Cooperatives in the Future

3) Experimental Farming Practice Improvement

Strategy-4: Minimum material and equipment input from farmers

- Easy Improvement by Farmers on Identified Farming Skills
- Need of Improvement on Farming Practices which were Identified as Difficult to Execute

Others

- Necessity of Careful Consideration of Farmers' Financial Condition
- Importance of Improving Farming Practices to avoid Uneven Growth in the Plots
- Necessity of Introducing Simple Comparison Tests that can be executed by the Farmers
- Necessity of Empowering PDA Extension Staff by implementing Learning through Doing
- Necessity of Establishing Practical Extension Systems

Part C: Pilot Projects (2007/2008)***Section-I: Irrigated Agriculture On-farm Technology Improvement Pilot Project (Zone-1)******Chapter BI-1: Framework of the Project***(1) Project Area (*CI-1.2*)

Three activities mentioned in (1) of Chapter BI-1, Section I, Part B: pilot projects (2006/2007), were conducted in the following areas:

Administration of Selected Areas/Plots for Three Activities in Zone-1

Province	District	Commune	Village	Activity-1	Activity-2	Activity-3
Kampong Speu	Samraong Tong	Kahaeng	Bos Ta Ney	○		○
			Kahaeng	○	○	
			Ou Veang	○		
	Chbar Mon	Kandaol Dom	Srae Thnal	○	○	
			Pongro	○		
			Kandaol Dom		○	
			Rumleang		○	
			Trapeang Preah		○	

Chapter CI-2: Participatory Irrigation Management and Development Activities(2) Activities Conducted for Improvement (*CI-2.5, CI-2.5.1*)

In 2006/07, the Ou Veang FWUC water management improvement was discussed among FWUC members and PDOWRAM staff, under facilitation of the JICA study team, and based on the results of study tour to the advanced FWUC. Consequently, the improvement plan consisting of 11 practices was elaborated. Out of the 11 practices, three were completed from 2006 to 2007. The remaining eight practices were conducted and completed from 2007 to 2008, which are explained below:

(3) Water Loss Identification and Reduction Practice (*CI-2.5.3*)

Three activities were carried out for the purpose of minimizing water loss: improvement of incomplete spillway, removal of illegal pipes and repair of mouse holes. Before executing these works, water loss in RT-2 was measured to be about 60%. After execution of the works, it was reduced to about 16 %.

(4) FWUC Sub-Groups Establishment Practice (*CI-2.5.4*)

FWUC sub-groups were organized based on the canal layout, intended to support the FWUC activities. Leaders of each WUG were elected through voting. The leader of FWUG was finally selected among the leaders of WUG.

(5) FWUC Administration Improvement Practice (*CI-2.5.5*)

PDOWRAM and NGO provided training sessions to FWUC committee members and leaders

of FWUC and WUGs to improve their administration capability. Consequently, collection rate of ISF reached 86%, which is a very sharp increase considering the previous 10%.

(6) Proper Irrigation Water Use Education Practice (CI-2.5.6)

In order to inform all FWUC members regarding the suggested improvement of their present situations, the Ou Veang FWUC magazines were published as a means of public information. In the magazine, the following slogans were repeatedly mentioned, to raise their awareness on the FWUC activities. As a result, FWUC members actively participated in cleaning the RT-2 canal, and 97 % of the members paid their ISF dues.

Slogans for FWUC

- *Let's use canal water effectively and evenly.*
- *Let's maintain the project facilities well.*
- *Let's avoid unauthorized water abstraction.*
- *Let's pay irrigation service fee for proper FWUC activities.*
- *Let's observe regulation of FWUC.*

(7) Irrigation Service Plan Preparation Practice (CI-2.5.7)

Irrigation service plan was prepared by FWUC, although extensive support was provided by PDOWRAM and the JICA study team. Based on this irrigation service plan, FWUC conducted rotational irrigation and cleaning of RT-2.

(8) Watercourse Construction/Rehabilitation Practice (CI-2.5.8)

Construction/rehabilitation of watercourses was carried out by FWUC members, under the supervision of PDOWRAM. The constructed/rehabilitated watercourses measure a total length of 2,475 m., which was about 70 % of the planned accomplishment. FWUC expressed commitment that the remaining watercourses will be constructed before commencement of the next cultivation.

(9) Water Management Training Practice (CI-2.5.9)

Presently, the downstream area could not be supplied with enough water. In order to improve the situation, rotational irrigation method was implemented. In this connection, PDOWRAM and the JICA study team trained the gate operator based on the water supply schedule and the water demand per paddy.

(10) FWUC Meeting Building Construction Practice (CI-2.5.10)

The Ou Veang FWUC has no allotted site to perform related administrative works such as accounting, preparation of irrigation service plan, and regular meeting venues. Thus, a meeting building was constructed by PDOWRAM under the financial support of JICA.

Chapter CI-3: Participatory Agriculture Extension Activities

(11) Activities Conducted for Improvement (CI-3.5)

(a) Farmer-to-farmer Low Inputs SRI Extension Practice (CI-3.5.2)

The following SRI extension works were completed during this session.

- Study tour to Kampong Chhnang province to learn about SRI. Fifteen farmers joined the tour from Zone-1.
- Village training to farmers' group
- Inter-village training to share experiences of the experimental farmers in three Zones (Zone-1, 3, and 4)
- Supporting and monitoring of experimental farmers on solution for problems encountered, selection of good rice seed, and collection of data
- Village general meeting to obtain feedbacks on the results of activities

As a result of these activities, the number of farmers applying SRI by January 2008 reached

82, which is significantly more than the target of 50 farmers.

(b) Farmer-to-farmer Ecological Chicken Raising Extension Practice (CI-3.5.3)

The following activities related to training on chicken raising were conducted.

- Study tour to Andong Rorveang Vilage and Stok Kavas Village, Bor Re Bor and Rolear Baear District, Kampong Chhnang province to learn about chicken raising
- Village training
- Inter-village workshop
- Village General Meeting to obtain feedbacks on the results of the activities

Due to the above activities, 11 farmers have adopted the ecological chicken raising by January 2008.

(c) Farmers' Group Strengthening Practice (CI-3.5.4)

Farmers' group was established and strengthened through the following activities:

- Study tour (participants discussed also the farmers' group in the study tours for SRI and chicken raising)
- Village training
- Inter-village workshop
- Village General Meeting to obtain feedbacks on the results of the activities

As a result of these activities, 16 farmers' groups were organized as savings group. Their total amount earned and deposited by January 2008, was Riel 19,965,400.

Chapter CI-4: Experimental Farming Practice Improvement Activities

(12) Verification Test (CI-4.4, CI-4.5, CI-4.5.5)

The verification tests were executed for 5 plots. Yields of five plots are as follows:

Yield Comparison with the Master Plan Target (ton/ha)

Category of Variety	Variety	Plot No.	Target Yield	Verification Yield	Difference
Medium Variety	Riang Chey	Plot 1	3.0	3.7	+0.7
	Riang Chey	Plot 4	3.0	3.1	+0.1
	Riang Chey	Plot 5	3.0	3.6	+0.6
	Average		3.0	3.5	+0.5
Early Variety	Sen Pidao	Plot 2	3.3	3.4	+0.1
	Sen Pidao	Plot 3	3.3	4.0	+0.7
	Average		3.3	3.7	+0.4
Overall Average			3.2	3.6	+0.4
Farmers Field ^{1/}	Riang Chey	2 plots	-	2.8	-

Target yield: Master Plan target yield for rainy season

^{1/}: Crop cut survey(2x2m) results of fields showing average growth around the verification plots

As shown in the table, all the verification plots attained yield levels higher than the target of M/P.

(13) Small Scale Adaptability Test (CI-4.3.2, CI-4.6, CI-4.6.4)

(a) Adaptability Tests on Medium Variety (CI-4.6, CI-4.6.4)

Adaptability tests on medium variety consisted of i) planting method, ii) on-farm water management, and iii) fertilization trial. The results of these tests are as follows:

Results of Tests for Medium Variety in Zone 1

Trial/Variety	Treatment	Crop Cut Yield	Whole Plot Yield
Planting Method (Riang Chey)	1 plant/hill	4.4 t/ha	3.7 t/ha
	2 plants/hill	5.4 t/ha	3.8 t/ha
	3 plants/hill	3.9 t/ha	4.0 t/ha
	4 plants/hill	4.3 t/ha	3.8 t/ha
	5 plants/hill	4.8 t/ha	3.9 t/ha
Planting Method (Sen Pidao)	1 plant/hill	3.1 t/ha	-
	2 plants/hill	2.7 t/ha	-
	3 plants/hill	2.5 t/ha	-
	4 plants/hill	2.4 t/ha	-
	5 plants/hill	2.4 t/ha	-
On-farm Water Management ^{1/} (Riang Chey)	Continuous intermittent	5.1 t/ha	4.3 t/ha
	Intermittent in vegetative phase	4.3 t/ha	4.0 t/ha
	Continuous flooding	4.9 t/ha	3.9 t/ha
Fertilization Trial ^{1/} (Riang Chey)	Manure 10 ton/ha only	4.6 t/ha	4.2 t/ha
	Manure 5 ton/ha only	4.2 t/ha	3.8 t/ha
	Manure 2.5 ton/ha + fertilizer	4.5 t/ha	4.3 t/ha
	Fertilizer only	4.6 t/ha	4.3 t/ha

*Crop cut survey: 1 sample/ treatment; random sampling of 1m² (16 hills) at normal growth spot
^{1/}: Average of triplicate treatments*

(b) Adaptability Test on Early Variety (CI-4.6, CI-4.6.4)

In the adaptability tests done on early variety, the planting method was conducted. The results of these tests are as follows:

Results of Test for Early Variety in Prey Pdao Station ^{1/}

Trial/Variety	Treatment	Whole Plot Yield	
		Range	Average
Planting Method (IR 66)	Regular planting	4.7 ~ 4.8 t/ha	4.7 t/ha
	Random planting	4.1 ~ 4.8 t/ha	4.5 t/ha
	Seedling broadcasting	4.1 ~ 4.4 t/ha	4.3 t/ha
	Direct sowing (under puddled condition)	4.1 ~ 4.9 t/ha	4.5 t/ha

^{1/} Average of triplicate treatments

The results indicated that there were no significant differences among treatments. However, the possibility of adopting seedling broadcasting and direct sowing, under puddle condition, was identified.

(14) Farmers' Acceptability Survey (CI-4.7, CI-4.7.3)

As a result, all eight demonstrators assessed the improved farming practices adopted, with a rating of either "good" or "proper". The farmer groups members interview indicate that practices such as reduced number of seedlings/hill, planting of younger seedling and reduced seeding rate are acceptable. Thus, such practices will be disseminated quickly with demonstration and timely provision of guidance.

Section-II: Irrigated Agriculture On-farm Technology Improvement Pilot Project (Zone-3)

Chapter CII-1: Framework of the Project

(15) Area (CII-1.2, CII-1.2.1)

Three activities namely, Participatory Irrigation Management and Development, Participatory Agriculture Extension and Experimental Farming Practice Improvement, were conducted at the following areas.

Activity	Area
(a) Participatory Irrigation Management and Development	Prey Robon Water Harvesting Irrigation System in Bala S'et Village, Orey Kijeay Water Harvesting Irrigation System in Mohaleap Village, Ta Kao Water Harvesting Irrigation System in Mohalumpeang Ti Muoy and Mohalumpeang Ti Pir Villages
(b) Participatory Agriculture Extension	Mohaleap Village
(c) Experimental Farming Practice Improvement	Bala S'et Village

Chapter CII-2: Participatory Irrigation Management and Development Activities

(16) Activities Conducted for Improvement (CII-2.5)

Taking into consideration the agricultural conditions and by referring to improvement activities in Zone-1, the following practices were carried out:

- Preliminary Landholding Map Preparation Practice
- Water Use Map Preparation Practice
- FWUC Establishment Practice
- Reservoir Capacity Clarification Practice
- Irrigation Service Plan Preparation Practice
- Water Management Training Practice

(17) Preliminary Landholding Map Preparation Practice (CII-2.5.2.1)

To identify owner-farmers and their farm plot size, a preliminary landholding map was prepared for the three systems, using handheld GPS and GIS. The area and number of owner-farmers identified are as follows:

Water Harvesting Irrigation System	Total Area	Nos. of Farmers
Prey Robong	44.58 ha	73
Prey Kijeay	39.41 ha	73
Ta Kao	59.73 ha	187

(18) Water Use Map Preparation Practice (CII-2.5.2.2)

To confirm the canal layout and water supply method, a water use map was prepared for each of the three systems. The features for each system clarified from the map are as follows.

(19) FWUC Establishment Practice (CII-2.5.2.3)

The irrigation management group only exists for each system to manage discharge of water from the reservoir. The FWUC is therefore needed to execute the proper O&M of the irrigation system. The executed activities for establishing FWUC were (i) election of committee members, and (ii) preparation of regulations.

(20) Reservoir Capacity Clarification Practice (CII-2.5.2.4)

PDOWRAM under direction of the JICA study team, performed a simple topographic survey for the respective reservoirs, using the handheld GPS, leveling instrument, poles and measuring tape. Survey results reveal that the effective storage volume for Prey Robong, Prey Kijeay, and Ta Kao were about 53,000 m³, 40,000 m³ and 170,000 m³, respectively. From these results, it was confirmed that the respective reservoirs have insufficient storage capacities.

(21) Irrigation Service Plan Preparation Practice (CII-2.5.2.5)

The FWUC should have prepared the irrigation service plan under support of PDOWRAM. However, since the FWUC was newly established, it had no capability to prepare the plan. Instead, PDOWRAM initiated preparation, in consultation with the JICA study team.

(22) Water Management Training Practice (CII-2.5.2.6)

Based on the irrigation service plan, the FWUC should release water from the reservoir to the adjacent canal. PDOWRAM explained to FWUC that gate should be operated based on observed water level in the reservoir, as indicated in the staff gauge.

Chapter CII-3: Participatory Agriculture Extension Activities

(23) Activities Conducted for Improvement (CII-3.5)

(a) Farmer-to-farmer Low Inputs SRI Extension Practice (CII-3.5.3)

The initial guidance was conducted for SRI extensions in the same manner as the Zone-1. Fifty two farmers attended the meeting. As a result, two volunteered as experimental farmers to join the monitoring activity. The following SRI extension works were completed.

- Study tour to Andong Rorveang Vilage and Stok Kavas Village, Bor Re Bor and Rolear Baear District, Kampong Chhnang province to learn about SRI. One farmer attended the tour from Zone-3.
- Village training to farmers' group
- Inter-village training to share the experiences of the experimental farmers in three Zones (Zone-1, 3, and 4)
- Supporting and monitoring of experimental farmers on solutions to problems encountered, selection of good rice seed and collection of data
- Village general meeting to obtain feedbacks on the results of activities

As a result of these activities, the number of farmers applying SRI by January 2008 reached up to 41, equivalent to about 80% of the target of 50 farmers.

(b) Farmer-to-farmer Ecological Chicken Raising Extension Practice (CII-3.5.4)

The following activities related to training on chicken raising were conducted:

- Study tour to Andong Rorveang Vilage and Stok Kavas Village, Bor Re Bor and Rolear Baear District, Kampong Chhnang province to learn about chicken raising
- Village training
- Inter-village workshop
- Village General Meeting to obtain feedbacks on the results of the activities

After these activities were keenly carried out for the farmers, some expressed interest in ecological chicken raising. However, as of January 2008, none of the farmers have pursued the activity.

(c) Farmers' Group Strengthening Practice (CII-3.5.5)

The activities of farmers' group were conducted in the following manner:

- Study tour (participants discussed also the farmers' group during study tours for SRI and chicken raising)
- Village training
- Inter-village workshop
- Village General Meeting to obtain feedbacks on the results of the activities

As a result of these activities, three farmers' groups were organized as savings group. Their total amount earned and deposited by January 2008 was Riel 1,826,900.

Chapter CII-4: Experimental Farming Practice Improvement Activities

(24) Verification Test (CII-4.3.1, CII-4.5, CII-4.5.6)

Yields of 4 verification plots are presented in comparison with the target yield of the M/P as follows.

Yield Comparison with the Master Plan Target (ton/ha)

Category of Variety	Variety	Plot No.	Target Yield	Verification Yield	Difference
Medium Variety	Riang Chey	Plot 1	2.8	2.8	-
	Riang Chey	Plot 2	2.8	3.0	+0.2
	Riang Chey	Plot 3	2.8	3.1	+0.3
	Chung Kong Mon	Plot 4	2.8	3.1	+0.3
Average			2.8	3.0	+0.2
Farmers Field ^{1/}	Chung Kong Mon	2 plots	-	2.1	-

Target yield: Master Plan target yield

^{1/}: Crop cut survey(2x2m) results of fields showing average growth around the verification plots

As shown in the table, all the verification plots attained yield levels as either slightly higher than or equal to the target of M/P.

(25) Small Scale Adaptability Test (CII-4.3.2, CII-4.6, CII-4.6.4)

Adaptability tests on medium variety consisted of i) variety trial, ii) planting density, iii) planting method trial, iv) direct sowing trial, v) dry seedbed. The results of these tests are as follows:

Results of Trial for Medium Variety in Zone-3

Trial/Variety	Treatment/ Variety	Crop Cut Yield
Variety Trial	Phka Rumchak	3.4 t/ha
	Phka Rumduol	4.1 t/ha
	Sen Pidao	4.5 t/ha
	Riang Chey	4.6 t/ha
	Chung Kong Mon	4.0 t/ha
	Nieng Om	4.7 t/ha
Planting Density (Riang Chey)	20 x 20 cm	3.5 t/ha
	25 x 25 cm	3.6 t/ha
	30 x 30 cm	3.2 t/ha
Planting Method (Riang Chey)	1 plant/hill	3.9 t/ha
	2 plants/hill	3.2 t/ha
	3 plants/hill	3.7 t/ha
	4 plants/hill	3.7 t/ha
	5 plants/hill	3.6 t/ha
Direct Sowing	Phka Rumduol	3.9 t/ha

Crop cut survey: One sample per treatment; random sampling of 1m² (16 hills)

(26) Farmers' Acceptability Survey (CII-4.3.3, CII-4.7, CII-4.7.3)

All the four demonstrators assessed the improved farming practices adopted with a rating of either "good" or "proper". Interviews with the farmer group members revealed high enthusiasm on improving rice productivity through the adoption of improved farming practices. This was because the area is usually subjected to drought and the villagers' livelihood is commonly poor. It also indicated that practices such as reduced number of seedlings/hill, planting of younger seedling and reduced seeding rate were acceptable to the farmers. These could be disseminated promptly through execution of timely demonstration and guidance.

Section-III: Rainfed Agriculture Improvement Pilot Project (Zone-4)

Chapter CIII-2: Participatory Agriculture Extension Activities

(27) Activities Conducted for Improvement (CIII-2.5)

(a) Farmer-to-farmer Low Input SRI Extension Practice (CIII-2.5.2)

Eleven volunteered as experimental farmers to join the monitoring activity. The following

SRI extension works were completed.

- Study tour to Kampong Chhnang province to learn about SRI. One farmer attended the tour from Zone-3.
- Village training to farmers' group
- Inter-village training to share the experiences of the experimental farmers in three Zones (Zone-1, 3, and 4)
- Supporting and monitoring of experimental farmers on solutions to problems encountered, selection of good rice seed and collection of data
- Village general meeting to obtain feedbacks on the results of activities

As a result from these activities, the number of farmers applying SRI by January 2008 reached 46, which is equivalent to about 90% target of 50 farmers.

(b) Farmer-to-farmer Ecological Chicken Raising Extension Practice (CIII-2.5.3)

The following activities related to training on chicken raising were conducted:

- Study tour to Andong Rorveang Village and Stok Kavas Village, Bor Re Bor and Rolear Baear District, Kampong Chhnang province to learn about chicken raising
- Village training
- Inter-village workshop
- Village General Meeting to obtain feedbacks on the results of the activities

Due to the above activities, nine farmers started ecological chicken raising by January 2008.

(c) Farmers' Group Strengthening (CIII-2.5.4)

The activities of farmers' group were conducted in the following manner.

- Study tour (participants discussed also the farmers' group during study tours for SRI and chicken raising)
- Village training
- Inter-village workshop
- Village General Meeting to obtain feedbacks on the results of the activities

As a result, five farmers' groups were organized as savings group. Their total amount earned and deposited by January 2008 was Riel 2,011,800.

Chapter CIII-3: Experimental Farming Practice Improvement Activities

(28) Verification Test (CIII-3.3.1, CIII-3.4, CIII-3.5, CIII-3.5.5)

Crop yields obtained at three verification plots are presented, in comparison with the target yield of the M/P as given in the following table.

Yield Comparison with the Master Plan Target (ton/ha)

Category of Variety	Variety	Plot No.	Target Yield	Verification Yield	Difference
Medium Variety	Riang Chey	Plot 1	2.0	3.3	+1.3
	Chma Prom	Plot 2	2.0	3.2	+1.2
	Chma Prom	Plot 3	2.0	2.9	+0.9
Average			2.0	3.1	+1.1
Farmers Field ^{1/}	Chung Kong Mon	3 plots	-	2.3	-

^{1/}: Crop cut survey(2x2m) results of fields showing average growth around the verification plots

As shown in the table, all the verification plots attained yield levels higher than the target of M/P.

(29) Small Scale Adaptability Test (CIII-3.3.2, CIII-3.6, CIII-3.6.4)

Adaptability tests on medium variety consisted of (i) variety trial, (ii) planting density, (iii) planting method and iv) direct sowing:

Results of Trial for Medium Variety in Zone-4

Trial/Variety	Treatment/ Variety	Crop Cut Yield	Whole Plot Yield
Variety Trial	Phka Rumduol	4.2 t/ha	-
	Riang Chey	3.6 t/ha	3.6 t/ha
	Chma Prom	3.6 t/ha	-
	Nieng Om	5.3 t/ha	-
Planting Density (Riang Chey)	20 x 20 cm	3.1 t/ha	3.2 t/ha
	25 x 25 cm	4.1 t/ha	3.1 t/ha
	30 x 30 cm	2.6 t/ha	3.4 t/ha
Planting Method (Riang Chey)	1 plant/hill	4.3 t/ha	2.9 t/ha
	2 plants/hill	3.9 t/ha	3.0 t/ha
	3 plants/hill	3.4 t/ha	3.6 t/ha
	4 plants/hill	3.2 t/ha	2.8 t/ha
	5 plants/hill	4.0 t/ha	4.2 t/ha
Direct Sowing	Riang Chey	-	2.0 t/ha

Crop cut survey: 1 sample per treatment; random sampling of 1m² (16 hills)

(30) Farmers' Acceptability Survey (*CIII-3.3.3, CIII-3.7, CIII-3.7.3*)

All the demonstrators assessed the improved farming practices adopted, except for the seeding rate and fertilization, with a rating of either "good" or "proper". They assessed positively the simple line planting newly introduced in the season. The farmer group members' interviews revealed high enthusiasm on improving rice productivity through the adoption of improved farming practices in the project area. In Zone-4 as well as Zone-1 and Zone-3, it also indicated that practices such as reduced number of seedlings/hill, planting of younger seedling and reduced seeding rate were acceptable to the farmers and could be disseminated promptly through provision of demonstration and guidance.

Section-IV: Technology Transfer, Sharing of Experiences and Lessons Learned

(31) Technology Transfer to PDOWRAM Staff (*CIV-1.2*)

Throughout the pilot project period during the second season, the following technologies were transferred to PDOWRAM staff by the JICA study team.

- Use of handheld GPS and GIS for map preparation
- Application of rotational irrigation method
- Preparation of H-Q curve for intake gate at RT-2
- Determination of size of watercourses
- Simple survey for preparation of H-V curve for reservoir
- Formation of WUG and Sub-FWUG
- Empowerment of WUG leaders
- Methodology for collection of ISF

(32) Technology Transfer to PDA Staff (*CIV-1.3*)

Throughout the pilot project period during the second season, the following technologies were transferred to PDA staff by the JICA study team.

- Improved farming practices: learning through doing from seed bed preparation to transplanting & fertilization
- Water management at on-farm level
- Upland crop cultivation at onset of rainy season
- Seed selection with salt water
- Seeding rate and sowing
- Variety trial
- Harvesting and yield surveys
- Farmers' acceptability survey

(33) Lessons Learned (CIV-2.2)

The following lessons learned were realized from the pilot project activities.

1) Participatory Irrigation Management and Development

Strategy-1: Learning from good farmers' practices in Cambodia

- Application of Experienced Procedure for ISF Collection in Other Project

Strategy-2: Project Operation by United Farmer-Government-NGO Project Team

- Formation of United Farmer-Government-NGO Project Team to Collect ISF

Strategy-3: Government Agencies Collaboration in Integrated Agriculture Related Activities

- Need of Collaboration of PDOWRAM and PDA for Dissemination of Proper Water Management
- Need of Joint Meeting for Creating Coordination between PDOWRAM and PDA

Others

- Inadequate Basic Knowledge and Experience of PDOWRAM Staff in Irrigation
- High Motivation of PDOWRAM Staff on Knowledge Growth
- High Expectation of Downstream Farmers on Proper Water Management
- Need of Formation of WUGs on Canal Basis
- Need of Slipping Out of Bad Circularity in FWUC Activity
- Application of Collection of ISF at the Village Level
- Effect of Involvement of Local Authority
- Need of Simple Measuring Device
- Need of Discussion focusing on What Farmers Can do by themselves
- Need of further strengthening the coordination among leaders of WUGs and FWUC
- Heightening of awareness of FWUC
- Recognition of importance of PDOWRAM's role for supporting FWUC

2) Participatory Agricultural Extension

Strategy-1: Learning from good farmers' practices in Cambodia

- Participation of Government Staff in Study Tour Visiting to Successful Project
- Difficulty in Dissemination of Proposed Manner against Insect and Mouse Injuries

Strategy-2: Project Operation by United Farmer-Government-NGO Project Team

- Expectation of Follow-up Works by Government and NGO

Strategy-4: Minimum Material and Equipment Input from Farmers

- Effect of Minimum Inputs of Material and Equipment from Farmers

Strategy-5: Introduction of Farmer-to-Farmer Extension

- High Impact by Presentation of Experienced Farmers

Others

- High Impression by Paddy Cultivation in SRI System and Traditional System at the Same Plot
- Effect of Timely Monitoring and Support to Cooperative Farmers

3) Experimental Farming Practice Improvement

Strategy-3: Government Agencies Collaboration in Integrated Agriculture related Activities

- Need of Collaborative field activities of PDA and PDORAM

Strategy-5: Introduction of Farmer-to-Farmer Extension

- Difficulty in farmer-to-farmer extension

Others

- Improved Practices Easily Accepted
- Dissemination of Improved Farming Practices in Zone-3
- Farmers Knowledge on Organic Fertilizer
- Effect of Provision of Seed on Seed Replacement
- Farmer Operated Trial
- Limited Practical Skills of PDA Staff
- Weak Field Extension Activities

Part D: Evaluation of Pilot Projects

(1) Purpose of Evaluation (D-1)

During the crucial period of the pilot projects, more comprehensive evaluation should be undertaken to determine if the intended objectives of each pilot project are achievable. The results of the evaluation are utilized as information sources for judging whether the pilot projects are sustainable and/or replicable.

(2) Framework of Evaluation (D-2)

Evaluation was carried out by referring to the objectively verifiable indicators stipulated in PDM. The required data was collected through (i) literature review, (ii) interview with the JICA study team, (iii) participatory evaluation workshop and (iv) questionnaire survey. .

(3) Evaluation Results (D-5)

Evaluation was conducted based on five criteria, namely, Relevance, Effectiveness, Efficiency, Impact and Sustainability. The evaluation results for each pilot project are as follows:

Criteria	Irrigated Agriculture On-farm Technology Improvement Pilot Project		Rainfed Agriculture Improvement Pilot Project
	Zone-1	Zone-3	Zone-4
1) Relevance	Very high	Very high	Relatively High
2) Effectiveness	High	Relatively High	High
3) Efficiency	High	High	High
4) Impact	Positive	Positive/Slight Negative	Positive
5) Sustainability	High	Relatively High	High
6) Conclusion	The sustainability and replicability of the project were verified	The sustainability and replicability of the project were nearly verified	The sustainability and replicability of the project were verified
7) Recommendation	- Allocate enough budget to PDA and PDOWRAM - Authorize collection procedure of ISF	- Allocate enough budget to PDA and PDOWRAM - Authorize measurement method of farm plot	- Understand method, expected results and benefits of low input SRI

(4) Recommendations (D-6)

(a) Need of Strengthening of Budget Arrangement for Provincial Offices

The farmers' subsequent activity aiming at higher agricultural productivity still needs the support of provincial offices (PDOWRAM and PDA). The high crop yields obtained at the pilot projects could be continuously ensured by appropriate guidance of similar water management and farming practices, initiated by the provincial offices at the pilot projects. However, the provincial offices have insufficient budgets to provide such appropriate

guidance to farmers. It is thus recommended that in view of the decentralization policy, the Government should keenly consider the matter, to realize and effectively maintain the higher agricultural production, using the valuable experiences of water management and farming practices by farmers. These can be carried out through the support of provincial offices.

(b) Need of Monitoring and Further Strengthening of FWUC Capability by Kampong Spue PDOWRAM

Through the Participatory Irrigation Management and Development activities at the pilot project, the Ou Veang FWUC could collect ISF with a high collection rate of 86%. This means that farmers who paid ISF dues, highly expect proper activities of Ou Veang FWUC. If the Ou Veang FWUC could not supply the irrigation water evenly and timely through proper maintenance of irrigation facilities, farmers would discontinue paying ISF. In this regard, the next season appears significant to the Ou Veang FWUC as well as to Kampong Spue PDOWRAM. Furthermore, transparency in accounting is so crucial for collection of ISF. With these viewpoints, it is recommended that the Kampong Spue PDOWRAM should properly monitor the Ou Veang FWUC activities and further strengthen its capability as required.

VOLUME-V HYDROLOGICAL STUDY AND ENVIRONMENTAL MANAGEMENT BASIC CAPACITY STRENGTHENING

Part A: General Information

(1) Hydrological Study (*A-1.3.2*)

The Target Area suffers from the floods almost every year. The floods threaten crop cultivation, as well as the villages. In particular, the floods largely influence crop production. In the M/P, therefore, a project and a study regarding hydrological aspects were proposed as subject-wise Improvement: the Hydrological Observation Strengthening Project and the Flood Forecasting and Warning Study. For the Hydrological Observation Strengthening Project, ten rainfall gauging stations and five water level recorders were set anew in the Prek Thnot River Basin in 2005. The observation was then conducted for two years (2005 and 2006) on a contractual basis. As of date, the Flood Forecasting and Warning Study was executed, which include the works, namely, (i) Study on Characteristic of Prek Thnot River, (ii) Study on runoff model, (iii) Preparation of Operation Rule of Major Gate Facilities on the Prek Thnot River, (iv) Preparation of Probable Inundation Map, (v) Preparation of Flood Hazard Map and (vi) Study on Flood Forecasting and Warning System.

(2) Environmental Management Basic Capacity Strengthening (*A-1.3.3*)

Environment is also an essential issue related to agricultural development. Thus, the M/P proposed an Environmental Management Basic Capacity Development Project and an Environmental Management Applied Capacity Development Project. During this period, a part of the Environmental Management Basic Capacity Development Project was executed, as follows:

- Recommendation of study items for surrounding areas for the development of new water sources, and other related important issues.
- Methods of environmental management and monitoring for the beneficial area after completion of water source development.

Part B: Hydrological Study

(1) Study on Characteristic of the Prek Thnot River (*B-1.1 to B-1.10*)

The characteristic of the Prek Thnot River was studied based on the results of topographic survey, discharge observation and site inspection. The aim is to obtain basic information and data necessary for preparation of a probable inundation map, flood hazard map, gate operation procedure, flood forecasting and warning system, and runoff model. The confirmed features of the Prek Thnot River are as follows:

- 1) Longitudinal slope

- River mouth to Chainage 35,000	1/5,100
- Chainage 35,000 to Chainage 65,000	1/4,170
- Chainage 65,000 to Roleang Chrey Regulator	1/2,720
- Roleang Chrey Regulator to Peam Khley bridge	1/2,720
- 2) Roughness coefficient (low water channel) 0.035
- 3) Discharge carrying capacity

- Kandal Steung Weir to Railway	800 – 1,000 m ³ /s
- Railway to C64	300 – 800 m ³ /s
- C64 to Roleang Chrey Regulator	800 – 1,200 m ³ /s
- Roleang Chrey Regulator to Peam Khley bridge	1,000 – 1,600 m ³ /s

(2) Study on Runoff Model (*B-2.1 to B-2.5*)

A runoff model of the Prek Thnot River was studied using the storage function method. The constant coefficients necessary for the model were determined based on the actual rainfall data and river discharge, observed in August and September 2006. Since the actual observed data are so limited, the established runoff model was regarded only as provisional. This should consequently be enhanced based on further data updates.

(3) Preparation of Operation Rule of Major Gate Facilities (*B-3.1 to B-3.5*)

There are three major gate facilities on Prek Thnot River. These are the Roleang Chrey Regulator, Teuk Thla Weir and Kandul Steung Weir. To sufficiently cope with the flood discharge of Prek Thnot River, proper operation of these facilities, including its communication system are regarded as vital. Presently, gate operation of these facilities is conducted stepwise, starting from its center, then outwards, by observing the upstream water level. There were no serious problems found in this operation. However, gate opening should be as synchronized as possible to avoid causing irregular flow condition at the downstream side. In addition, gate operation of the Teuk Thla Weir should be prioritized too, since the Kandul Steung Weir gates are already operated properly.

The flood travel time from the Roleang Chrey Regulator to Kandul Steung Weir is about 13 hours. If the communication system among gate operators of these three sites is adequate, operation of gates would be efficient. Therefore, it is important to ensure and maintain timely communication among the gate operators.

(4) Preparation of Probable Inundation Map (*B-4.1 to B-4.5*)

The probable inundation map was prepared based on non-uniform equation and results of longitudinal and cross sectional survey for the Prek Thnot River. This is intended to verify general information on flood conditions of the river. The prepared map indicates that even the 2-year probable flood would cause inundation to the riparian areas. This however does not appear significant. The map also reveals that the peak of flood for the downstream area would be mitigated through the existing open levees in the middle reach.

(5) Preparation of Flood Hazard Map (*B-5.1 to B-5.6*)

The flood hazard map was prepared for the selected model area, which presents more comprehensive information related to the flood, such as that which occurs in Kampong Speu City. The information and data required for the preparation of flood hazard map were obtained using a 2-dimensional flooding calculation (FLO-2D) software. Based on the available data and the results of site inspection, the flood hazard map for the model area was generated, showing tentative locations of evacuation centers and evacuation routes. This map however is subjected to further enhancement since its finalization would require thorough discussions with the provincial office and many other stakeholders.

(6) Study on Flood Forecasting and Warning (*B-6.2 to B-6.4*)

The study on flood forecasting and warning for the model area indicated two systems as follows:

1) Flood forecasting with water level

The flood water level observed at Peam Khley is considered since it reveals ideal flood travel time, which is two hours from Peam Khley to Roleang Chrey Regulator, and 13 hours from Roleang Chrey Regulator to Kandul Steung Weir. This indicates that there is enough time to issue warning to inhabitants prior to flood occurrence.

2) Flood forecasting with rainfall

There is one rainfall observation station located at Kirirom. According to the study, 48 hours accumulative rainfall at Kirirom relates well with the water level at Peam Khley 24 hours later. If this correlation is considered rather than flood forecasting using water level

information alone, further time would be realized. However, additional equipment and facilities such as telemeter system would be required for data transmission to the flood center.

Part C: Environmental Management Basic Capacity Strengthening

(1) Environmental Consideration for Water Resources Development (C-I.2)

The Prek Thnot River basin has various problems such as periodic flooding, shortage of water for agriculture during the dry season, and increase of water demand due to rapid industrialization and population growth. These signify the need for planning of water resources development in the near future. The water resources development largely influences the natural and social environment. MOWRAM and MAFF, as executing agencies, should consider and design based on environmental considerations. In relation to this, the following matters are clarified and suggested:

- Public participation/consultation and information disclosure, including implementation of stakeholder analysis, planning and budget allocation; consideration of participation method and its level; and invitation to environmental NGOs
- Consideration of mitigation measures
- Land acquisition/involuntary resettlement including formulation of land acquisition/resettlement plan, in cooperation with inter-ministerial resettlement committee and other agencies; time schedule and budgeting for resettlement; and consideration on implementation of follow-up program and monitoring

(2) Environmental Management and Monitoring Plan for Water Resources Development (C-I.3)

After implementation of the water resources development project, environmental management and monitoring (EMM) should be performed properly and periodically. The EMM activities proposed are as follows:

- Prepare checklist for EMM planning
- Give attention to water quality monitoring, management of agricultural activities, monitoring of people's lives and watershed management

(3) Recommendation of Capacity Development (C-I.4)

MOWRAM

- Establish a responsible unit for environmental and social impact management.
- Ensure knowledge and skills to consider, supervise and monitor EIA study.

MAFF

- Strengthen the existing EIA Office by clarifying the mission and job responsibility; prepare annual and mid-term action plans; develop cooperation with other technical departments
- Strengthen capability on preparation of TOR for the EIA study; supervise execution of the EIA study; and review of EIA report.