Appendix-F

IRRIGATION AND DRAINAGE

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

FINAL REPORT
Volume-VI: Appendixes for Master Plan
Appendix-F
Irrigation and Drainage

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Chapter F-1 Present Condition of Irrigation and Drainage

F-1.1 Inventory Survey for the Existing Irrigation Systems

F-1.1.1 Objective and Scope

An inventory survey was conducted and completed by MOWRAM in Kampong Speu in March 2005. As the survey area is a part of the Target Area, the result could be utilized in the Study, although a supplemental inventory survey was required in PDOWRAM Kampong Speu. The major supplemental items are (i) O&M responsibility of irrigation facility, (ii) collection of irrigation service fee, (iii) flatness of paddy fields, (iv) water borne disease, (v) situation of soil erosion and wash way soils, and (vi) problems in operation and maintenance.

In addition, the Study Team carried out the inventory survey in Angk Snuol District and Kandal Stung District which were not included in the said survey,in the same manner.

The questionnaire used in Kampong Speu by MOWRAM was presented and explained to PDOWRAM Kandal Province by the Study Team. To identify the irrigation area, the Study Team requested village chief or inhabitant to show the boundary of irrigation area in the field. Main points of boundary indicated were identified by handheld GPS, and pricked on the topographic map with a scale of 1 to 50,000.

F-1.1.2 Definition of Irrigation System

The results of Inventory Survey are summarized in Table F1.1.1 and Figure F1.1.1. The following are major findings by the Inventory Survey and field inspection by the Study Team.

1) There are 85 irrigation systems in the Target Area
2) Out of 85, 67 irrigation systems have a small reservoir for each
3) Each irrigation system is an independent system by PDOWRAM as well as farmers even though some of them currently receive supplemental irrigation water from two Main Canals from the Roleang Chrey Regulator.

F-1.1.3 Classification of Inventorized Irrigation Systems

Based on the results of Inventory Survey by MOWRAM and the Study Team, irrigation systems were classified by means of water resource and irrigation method.

(1) Classification by water resource

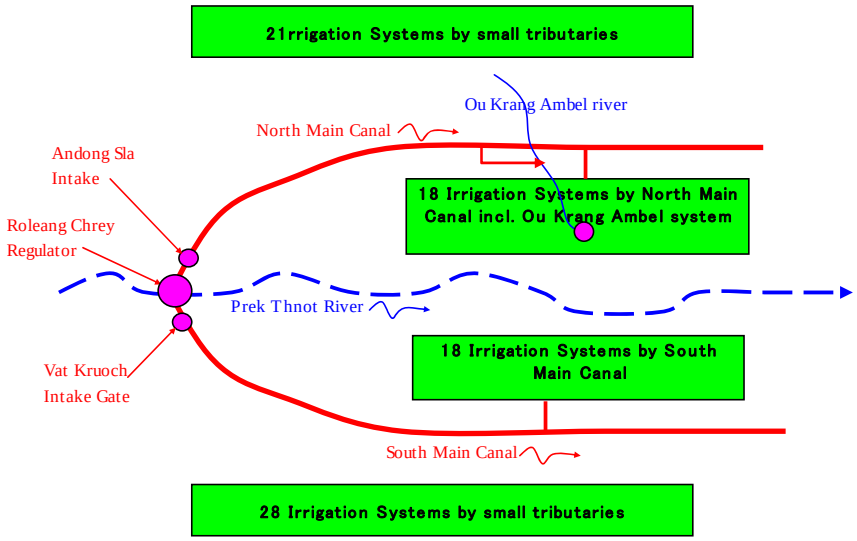
The irrigation systems in the Target Area were classified into 3 types by water source.

Irrigation Systems Classified by Geographic Condition and Water Source

Category	Type of water source	No. of systems	Inventory Area[1/]	No. of system with reservoir
1	Prek Thnot River	35	15,207	17
2	Ou Krang Ambel River	1	498	1
3	Small tributaries of Prek Thnot River	49	1,796	49
	Total in the Target Area	85	17,501	67

[1/]: Reported by farmers or PDOWRAM

Source: Study Team



(2) Classification by irrigation method

The irrigation systems in the Target Area are classified into 3 types by irrigation method applied currently.

Irrigation Systems Classified by Irrigation Method

Category	Type of irrigation method	No. of system (no.)	Inventory Area (ha)[1/]
1	Gravity	1	180
2	Gravity and small pump by farmers	80	15,325
3	Pump by PDOWRAM	4	1,996
	Total in the Target Area	85	17,501

[1/]: Reported by farmers or PDOWRAM

Source: Study Team

As can be seen in the above table, gravity and small pump by farmers are predominant in the Target Area. It means farmers have to pump up irrigation water from adjacent canals such as secondary, tertiary, or water course because water level in the canal is lower than paddy field. The reason is mainly due to that canal is mostly constructed in the low elevated area, and/or water level in canal is lower than the paddy field due to less number of check structures.

The only one gravity irrigation system exists in Kandal Province, but does not function presently because appurtenant pond is damaged.

F-1.1.4 Definition of Irrigation Area

(1) Inventory Survey

The area obtained by inventory survey is quite large as follows:

Inventory Area by Farmers and PDOWRAM (Unit: ha)

Name of District	Inventory Area Rainy season	Inventory Area Dry season
Chbar Mon	325	243
Samraong Tong	10,875	711
Kong Pisei	206	17
Angk Snuol	4,139	0
Kandal Stung	1,956	10
Total in the Target Area	17,501	981

Source: Study Team

The above figures were carefully studied by the present study as described hereunder.

(2) Meaning of Irrigation in Cambodia

Irrigation generally means artificial water supply to crop to cover a deficit between crop evapotranspiration and effective rainfall in order to secure healthy growth and yield of crop, and various water losses which inevitably occur between water sources to crop field. However, in the Target Area, as well as Cambodia, volume of water to be supplied to the crop can not be considered so much. People calls this “Supplemental Irrigation” when some amount of water is given to crop whatever it is sufficient or not.

(3) Present irrigation area assumed

Due to idea of “Supplemental Irrigation”, identification of irrigation area is also different from general understanding. During the Inventory Survey, developed area boundary indicated by farmers contained the area which is irrigated only a few days in one crop season or the area which is irrigated once in a few years.

The result of Inventory Survey was compared with available water in the Target Area as described in the following Chapter. Eventually, the present irrigation area is assumed to be about 6,000 ha in rainy season, which is about 30 % of development area obtained through the inventory survey.

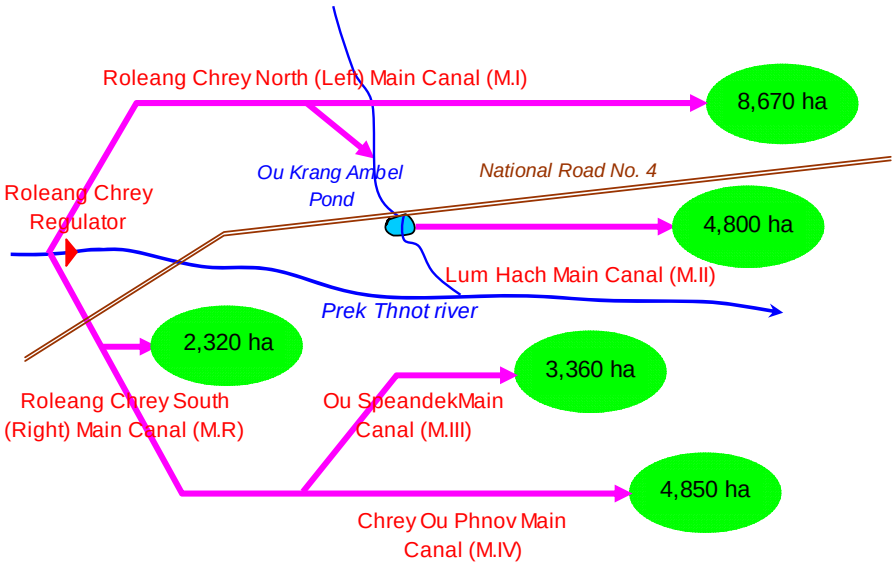
F-1.2 On-going or Proposed Irrigation Projects in and around Target Area

F-1.2.1 Western Phnom Penh Integrated Development Center Project

The project started in 2001 by government budget. The project aims to irrigate about 24,000 ha which extend over Kampong Speu Province, Kandal Province, Phonm Penh Metropolitan Area, and Takeo Province. Project’s main facilities are Roleang Chrey Regulator and Intakes, North and South Main Canals, and secondary canals.

Outline of the project is given as follows:

- Total project cost:	US$7,900,000 (about 7% has been invested up to 2005)
- Water source:	Prek Thnot River: Roleang Chrey Regulator and Intakes, Pump stations (4 new, 1 rehabilitation)
- Service area:	24,000 ha in Kampong Speu, Kandal, and Takev Provinces
- Main canals:	North Main Canal (M.I): 8,670 ha, Design capacity 15 m^3/sec, Lum Hack Canal (M.II): 4,800 ha, starts from Ou Krang Ambel Pond, South Main Canal (M.R): 2,320 ha, Design capacity 15 m^3/sec Ou Speandek canal (M.III): 3,360 ha, Chrey Ou Phnoy Canal (M.IV): 4,850 ha
- Secondary canals:	19 secondary canals : 62 km,
- Tertiary canals:	50 tertiary canals : 192 km
- Drainage canals:	26 drains : 95 km
- Major structures:	Spillways 2, Turnouts 40, Inlets 14, Bridges 24, Culvert 72, Maintenance roads 79 km,
- Formation of FWUC	Not specified



As shown in the above figure, the project service area is partially located in the Target Area. The irrigation water is supplied to the area through the Roleang Chrey Regulator and Main Canals which were constructed in 1970s but not effectively used until early 2000s. The major problems observed in this project, which have been obtained by the Inventory Survey and field inspection by the Study Team are as follows.

- The size of service area planned seems to be very large due to no rationale water balance study (estimate of irrigable area by comparing between available water resources and water demand)
- Water level is planned to be lower than paddy fields, and check structure is insufficient in number.
- Low quality of construction work

The problems and current situation of the project are analyzed in the following section in detail.

F-1.2.2 Kandal Stung Irrigation Rehabilitation Project

Kandal Stung Irrigation Rehabilitation Project is located in Kandal Stung District of Kandal Province. The project aims to develop irrigation area of 1,950 ha. The construction work was started in September 2006 by grant aid of Government of Japan and will continue up to August 2008.

A new diversion weir is under construction on the Prek Thnot River to take irrigation water. The project fully depends on the Prek Thnot River as its water source. The outline of the rehabilitation project is summarized as follows:

Project area:	1,950 ha
New diversion weir and intake:	Movable weir (W)50 m × (H)4.8 m, Flood gates (W)12.5 m × (H)4.8 m × (no.)3, Sluice way gate (W)5.0 m × (H)4.8 m×(no.)1, River maintenance flow gate (W)1.5 m × (H)1.5 m×(no.)1
Rehabilitation of 7th January Weir:	Re-heightening 0.55 m, L=212 m
Rehabilitation of Tuk Thla Regulator:	Raising 0.55 m, L=36.75 m
Rehabilitation of Deum Russ Regulator:	Raising 0.55 m, L=5.87 m
Demolishing Konpong Tuol Regulator:	Demolishing

Rehabilitation of Irrigation canals and related structures:	a) Main irrigation canal 1.03 – 2.73 m^3/sec, L=5.3 km, Canal slopes are lined by concrete blocks b) Intake 2.73 m^3/sec, Slide gate (W)1.8 m × (H) 2.1 m × (no.) 3 c) Turnouts 26 nos., Check 2 nos., Box culvert 8 nos., Maintenance flow gates 6 nos., End structure 1 no., O&M road 14.6 km

F-1.2.3 Tonle Bati Irrigation Project

Tonle Bati Irrigation Project is located in Takev Province. The irrigable area of the project is 4,200 ha which consists of (i) the area of 1,600 ha (the existing Tonle Bati area) and (ii) the area of 2,600 ha lying around the existing area. The project was studied in 2 cases namely with and without Prek Thnot Reservoir.[1] The study concluded that only 1,600 ha caould be irrigated by run-of-river of the Prek Thnot River by constructing connection canal. The total area of 4,200 ha can be irrigated after development of Prek Thnot Reservoir.

F-1.2.4 Dangkor Pump Irrigation Project

Irrigation water of the Dangkor Pump Irrigation Project was pumped up from left bank of by-pass channel of the Prek Thnot River at immediately upstream of Tuk Thla Regulator. The project irrigation area under the original plan was 300 ha, and irrigation facilities are mostly poor in quality, and do not presently function well. However, MOWRAM has a strong intention to rehabilitate the system.

F-1.3 Irrigation Systems Supplied from Prek Thnot River

F-1.3.1 Roleang Chrey Regulator, Andong Sla Intake Gate, and North Main Canal

Roleang Chrey Regulator is located in the Prek Thnot River in Roleang Chrey Village, Taing Kruoch Commune, Samraong Tong District in Kampong Speu Province.

The construction of Roleang Chrey Regulator, Andong Sla Intake, and North Main Canal (NMC) was planned in late 1960s and started early 1970s as a part of Prek Thnot Multi Purpose Project. Roleang Chrey Regulator was constructed to control water level in the Prek Thnot River. Andong Sla Intake was constructed at about 800 m downstream of NMCfrom the Regulator to control irrigation water taking from the river for the northern area of the Prek Thnot River. The construction of NMC was ceased completely because of war activities. After 1979, the construction was resumed by the government under assistance by donor countries. The most downstream part of NMC has been recently constructed by MOWRAM. A total length of NMC is about 32 km from the Roleang Chrey Regulator to the end point in Angk Snuol District in Kandal Province.

Irrigation Systems by the North Main Canal

No. of system[1/] (nos.)	Inventory Area[2/] (ha)	Wet season irrigate area [3/] (ha)	No. of system with reservoir
18	5,445	3,100	10

[1/]: Including Ou Krang Ambel System (498 ha)
[2/]: Reported by farmers or PDOWRAM
[3/]: Assumed by the Study Team

There are 18 irrigation systems branched off from the NMC at present including Ou Krang Ambel System (498 ha). The present supplemental irrigation area is assumed at about 3,100 ha. Most of them were developed by farmers in late 1970s.

[1] *Master Plan Study on the Integrated Agricultural and Rural Development Project in the Suburb of Phnom Penh, Japan International Cooperation Agency, Nippon Koei Co., Ltd., February 1995*

Ou Krang Ambel System

The Ou Krang Ambel System is also located in the geographic area of NMC. It has a pond in the Ou Krang Ambel River for irrigation purpose. The Ou Krang Ambel River is the largest tributary of the Prek Thnot River flowing in the Target Area, and its catchment area is estimated at 453 km2 at the pond located along the National Road No.4 near Kampong Speu town. However, two ponds were further constructed for the irrigation development in the upstream of the Ou Krang Ambel River. Accordingly available water source of the Ou Krang Ambel System remarkably decreased. Ou Krang Ambel System therefore mainly receives water from NMC.

NMC and related structures

NMC has designed by deviating considerably from the original design in 1960s. At present, the following problems are reported by farmers and observed by the Study Team.

1) The water level in the canal is generally kept lower than paddy fields because of lack of check structures. So, water level in the secondary or tertiary canal is lower than paddy field. This forces farmers to use pump in many places, which leads to high operation cost.
2) The excavated sandy soil is roughly being deposited on the both side of the canal without compaction. The soil, therefore, severely eroded and flow into canal decreasing flow capacity.
3) Subordinate canals such as secondary and tertiary canals are not adequately constructed in number and in length. It makes difficult to distribute water properly from main canal to paddy fields. To solve this problem, farmers excavate canals and bury pipes in many places (so called Farmers Intake). They do not properly backfill the canal, which causes collapse of canal.
4) Culverts are not sufficiently provided in the canal in number causing people difficult to crossing canal for daily activities. To settle this problem, people block the canal by burying pipes, which results in decrease of flow capacity in the canal.

Secondary canals and related structures

5) The water level is lower than paddy fields so that pumping up of water is required.
6) In the secondary and tertiary canals, related structures such as turnouts, checks, culverts are not sufficiently constructed in number due to lack of budget. This obstructs proper water management such as timely irrigation and smooth water distribution.
7) The number and length of secondary canals are not sufficient for proper water distribution.

Reservoirs

8) All 9 reservoirs do not have gates on the intake structure. Out of 9, 3 systems function presently. Three systems embankment is partly damaged but function. The remaining three systems have been seriously damaged.

F-1.3.2 Vat Kruoch Intake Gate and South Main Canal

Vat Kruoch Intake Gate was constructed for 1.5 km south from the Roleang Chrey Regulaotr to divert water from the Regulator to southern area of the Prek Thnot River. Since then, the government has continued construction of the South Main Canal (SMC), and completed it by 2002. A total length of SMC is about 38.5 km from Roleang Chrey Regulator to the end point i.e. crossing point with National Road No.3 in Kong Pisei in Kampong Speu Province.

Irrigation Systems by the South Main Canal

No. of system (no.)	Inventory Area [1/] (ha)	Wet season irrigate area [2/] (ha)	No. of system with reservoir
18	10,260	2,100	9

[1/]: Reported by farmers or PDOWRAM

[2/]: Assumed by the Study Team

There are 18 irrigation systems branched off from the SMC at present. The present supplemental irrigation area is assumed to be about 2,100 ha. Most of them were constructed in late 1970s by farmers.

At present, the following problems are reported by farmers and observed by the Study Team.

SMC and related structures

1) The water level in SMC is generally kept lower than paddy fields because of lack of check structures. So, water level in the secondary or tertiary canal is also lower than paddy field. This forces farmers to use pump in many places.
2) The route of the SMC was selected along with contour line EL. 30.m. Accordingly, top of canal bank is always constant at about 30 m, but canal base was designed to have slope downward resulting in deep water depth. This makes high pumping head to take water from canal.
3) Subordinate canals such as secondary and tertiary canals are not sufficiently constructed in number and in length. It makes difficult to distribute water properly from main canal to paddy fields. To solve this problem, farmers excavated canal and bury pipes in many places (so called Farmers Intake). They do not properly backfill the excavated places, which causes collapse of canal.
4) Culverts are not sufficiently provided in the canal in number, which causes the difficulty for farmers to cross canal for their daily activities. To solve this, farmers block the canal by soil burying pipes, which results in decrease of flow capacity in the canal.

Secondary canals and related structures

5) The water level in the canal is lower than paddy fields, which requires pumping up by farmers.
6) In the secondary and tertiary canals, related structures such as turnouts, checks, culverts are not sufficiently constructed in number due to lack of budget. This obstructs proper water management, and needs high pumping cost and blocking of canal by soil for crossing.
7) The number and length of secondary canals are not sufficient for adequate irrigation.

Reservoirs

8) All 9 reservoirs do not have gates on the intake structure. Out of 9, 1 reservoir embankment is fairly good condition. Seven reservoir embankments are seriously damaged. One pond embankment is partly damaged but function.
9) Three types of pumps are installed by the government to take water from Prek Thnot River. Those are fixed types pumps, mobile type pumps, and floating type pumps. All systems are located in Kandal Stung District in Kandal Province, and geographically are provided in the SMC area. Due to shortage of operation cost, these pumps are operated for limited time only. The condition of pumps is fairly good.

F-1.4. Irrigation Systems Supplied by Water Harvesting in Tributaries

There are 49 irrigation systems in the outside of 2 Main Canals commanding area. All systems have reservoir. These catchment areas varies from less than 10 ha to more than 100 km^2 and average 2 km^2 although most frequent size is about 1.0 km^2. All tributaries do not have perennial flow. These reservoirs collect only rainfall in the catchment. Since the catchment is small, a reservoir is generally dry from January to May. In this Study, accordingly, such small reservoir should be categorized as water harvesting facility.

Irrigation Systems by Water Harvesting Facilities

No. of system (no.)	Inventory Area [1/] (ha)	Wet season irrigate area [2/] (ha)	No. of system with reservoir
49	1,796	800	49

[1/]: Reported by farmers or PDOWRAM
[2/]: Assumed by the Study Team

The total Irrigation Service Area is reported at 1,796 ha. Out of 49, 13 systems fairly function. Twenty one ponds embankment is partly damaged but function. Fifteen ponds embankment is seriously damaged and do not function well or not function at all.

F-1.5 Flood and Drainage Condition

Based on the Inventory Survey, about 60 irrigation systems or 2,270 ha are affected or damaged by flood every year or once in a few years, out of 85 irrigation systems or 17,501 ha (Table F1.1.1). Only 13 % of the inventory area suffers from flood or poor drainage. This means that food or drainage problem is not a main problem in the Target Area.

These are scattered in the western and central parts in the Target Area. The flood or drainage damage seems to occur in the depressed area in which insufficient drain is provided in every irrigation system concerned. The drainage improvement is required in such limited area.

F-1.6 Operation and Maintenance

F-1.6.1 Responsible Organization

According to the Inventory Survey and information given by PDOWRAM, operation and maintenance of irrigation facilities are carried out as follows.

Responsibility for Operation and Maintenance of Irrigation Facilities

Facility	Organization		
	PDOWRAM	Community	Individual farmer
Roleang Chrey Regulator and 2 Intakes	○	×	×
NMC and SMC	○	×	×
Pumps on the Prek Thnot River	○		
Secondary canals	○	×	×
Tertiary canals	×	○	
Reservoirs	×	○	
Small pump	×	×	○

FWUC has been established in 25 irrigation systems, but not yet registered to the Government.

F-1.6.2 Operation and Maintenance of Roleang Chrey Regulator and Intake Gates

Kampong Speu PDOWRAM is responsible for the operation and maintenance of Roleang Chrey Regulator and Andong Sla Intake Gate and Vat Kruoch Intake Gate, but it is practically executed by one aged person who has been working since 1970s.

There is no written operation manual of the Regulator and Intake Gates. The Regulator gate is frequently opened in rainy season when upstream water level reaches to the critical level of the upstream embankment, which is assumed at about EL. 36.0 m. However, due to mechanical problem of gate hoist system and large size of the gate, it is difficult to open the gate as required. To cope with this, the gate operator opened the gate more than required in a certain time and close after water level goes down. This causes remarkable fluctuation of water level in the downstream intake site such as Tuk Thla and Kampong Tuol located about 50 km downstream in Kandal Province. In dry season, when the river flow decreases remarkably, a gate is partially opened to release small amount to downstream. However, due to the same problem, it is difficult to release small amount constantly. Even at flood time, the smooth gate operation is difficult due to the same reasons mentioned above.

Intake Gates are operated customarily based on the request from farmers of NMC and SMC. When NMC needs water, intake of SMC is closed.

Although the gates are operated by skillful operator, such operation results in much loss of water source as well as high risk of damages of facilities. The gates have to be rehabilitated as soon as possible including communication system among gate operators, PDOWRAM offices and MOWRAM.

F-1.6.3 Operation and Maintenance of Main Canals

There is no written operation manual of main canal facilities. Opening of turnout gates in the main canal is practically executed by communities concerned.

In SMC, its inspection road was recently repaired. The conditions of hydraulic structures, however, are poor due to lack of maintenance. This results in much water loss and discourage of stakeholders to participate in water management activity.

F-1.6.4 Operation and Maintenance of Water Harvesting Reservoirs

A reservoir irrigation system is operated by communities concerned. The operation rule is determined by community. Embankment, reservoir, and appurtenant structures are in very poor condition in many pond systems. MOWRAM is allocating budget for rehabilitation of them, but its amount is so small. Many reservoirs are thus left ruined.

F-1.7 Water Management

(1) Irrigation Service Plan

There is no written Irrigation Service Plan recommended by the Government.

(2) Present Activity

At present, water management activity is left to community. The reasons are as follows:

a) There is no systematic approach to implement water management activity. The reasons are:
   - No O&M manual of facilities,
   - No guidelines or tools to rationally predict a base flow of the Prek Thnot River,
   - Lack of government budget for O&M,
   - Not enough human resources[2]

b) People in the Target Area do not have sufficient experience of planning and exercising water management plan, so that they do not enjoy effect of executing water management activity

[2] *Director of PDOWRAM is pressed with daily administration work, but he does not have enough technical staff to assist him.*

c) Main hydraulic structures in the Prek Thnot River and canal are deteriorated and hard to be controlled precisely in accordance with plan

d) FWUC is not yet well organized or activated

e) Water source in the Target Area fully depends on rainfall which fluctuates remarkably year by year (from 800 mm to 2,000 mm), and month by month

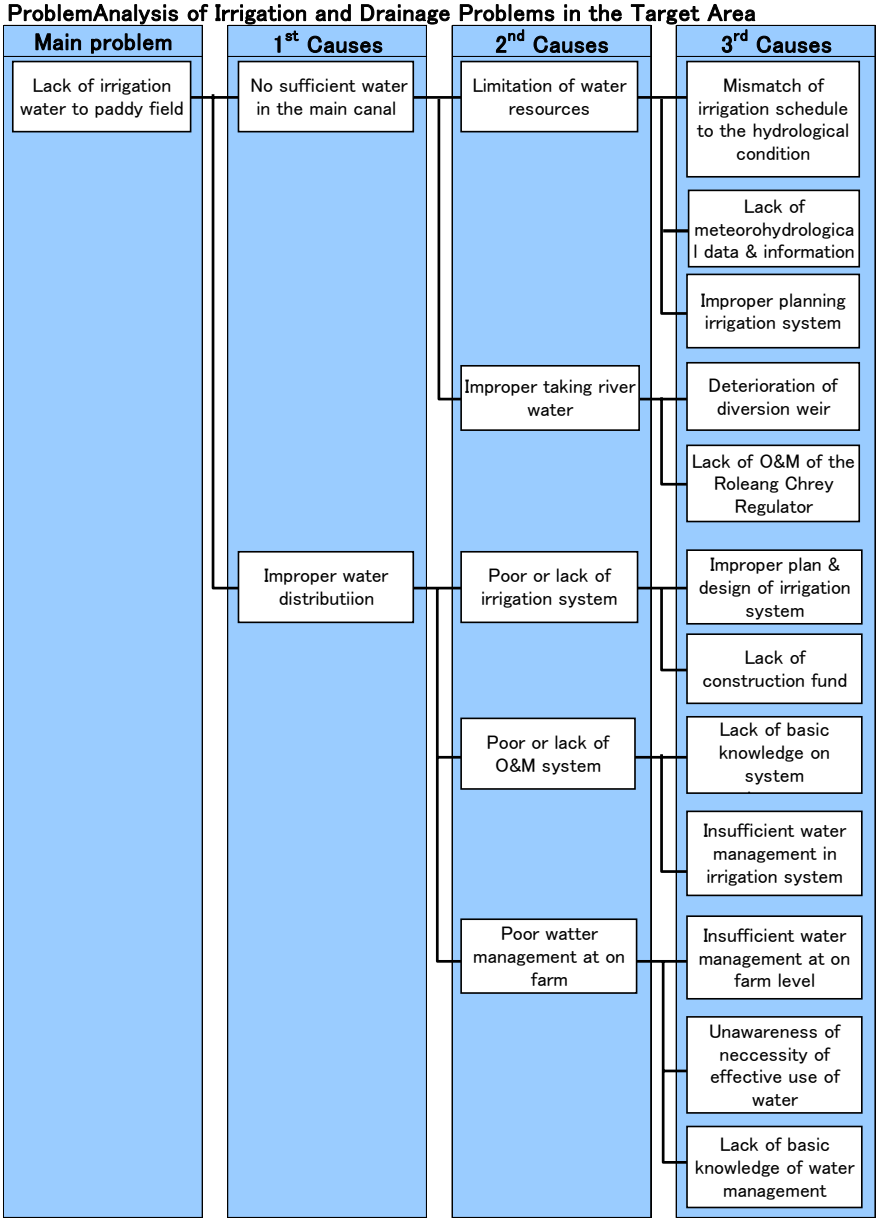
F-1.8 Current Problems

Current problems of irrigation and drainage in the Target Area are analyzed based on the field inspection and workshops with farmers and government staff.

Irrigation is an important measure to support healthy growth of crops and finally to assure harvest with high crop yield together with other farm inputs such as fertilizer. During the field inspection and workshops all farmers and government agency concerned recognized that lack of irrigation water is one of the most severe problems in the agriculture in the Target Area.

The lack of water to paddy field is derived from many causes. A problem analysis is made and a result is summarized as follows.

ProblemAnalysis of Irrigation and Drainage Problems in the Target Area



Based on the above analysis, the causes of lack of irrigation water to paddy field are summarized as follows:

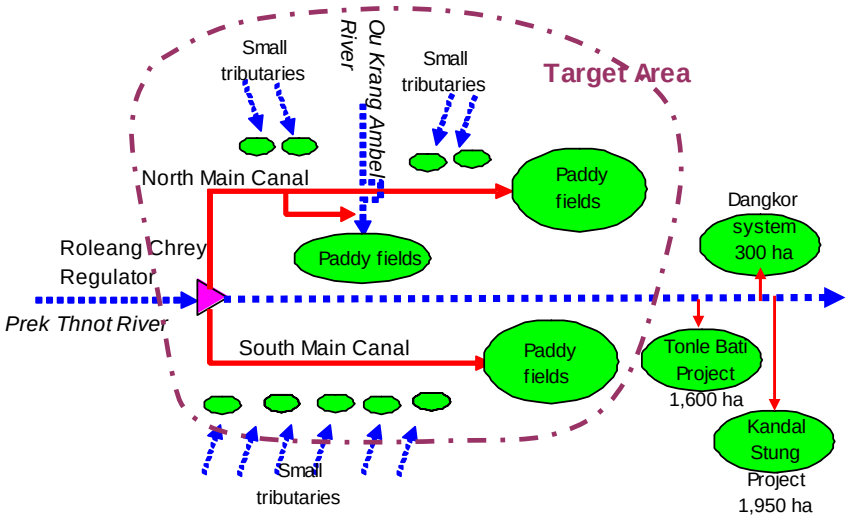
1) Limitation of water resources
2) Poor of lack of irrigation system
3) Unawareness of necessity of effective water use
4) Lack of basic knowledge on water management
5) Lack of basic knowledge on system maintenance
6) Insufficient water management in irrigation system
7) Insufficient water management at on-farm level
8) Improper plan and design of irrigation system
9) Insufficient hydro-meteorological information and data
10) Insufficient communication on flood
11) Deterioration of Roleang Chrey Regular
12) Flood damage

Chapter F-2 Water Resources and Demand Study

F-2.1 General

In this chapter, water availability for the agricultural development of the Target Area was studied without consideration of any new water resources development in the Prek Thnot River basin.

In the Target Area, there are three types of water sources: (i) the Prek Thnot River, (ii) the Ou Krang Ambel River as one of the largest tributary of the Prek Thnot River flowing in the Target Area, and (iii) other small tributaries. The existing facilities to use these water resources for agriculture are (i) Roleang Chrey Regulator and Intake Gates, (ii) North and South Main Canals constructed under the Western Phnom Penh Integrated Development Center Project and Ou Krang Ambel Pond, and (iii) 49 small ponds located on small tributaries as illustrated below:



On the other hand, the present major water users are (i) 85 irrigation systems in the Target Area including service area proposed by Western Phnom Penh Integrated Development Center Project, and (ii) On-going and proposed irrigation project downstream of the Target Area to take water from the Prek Thnot River.

Until now, many studies have been made for the water resources potential of the Prek Thnot River. As a result, these studies have indicated limitation of water resources development in the basin unless new water resource facility like a dam is constructed at upstream site. In this Study, therefore, a focus is placed on how to use the existing water resource effectively, and new extension of paddy field in the Target Area is not taken into consideration.

F-2.2 Water Sources in Target Area

F-2.2.1 River Discharge in Prek Thnot River at Roleang Chrey Regulator

The 5-day dependable discharge in the Prek Thnot River at Roleang Chrey Regulator was estimated as explained in Appendix A.

F-2.2.2 River Discharge in Ou Krang Ambel River

In the Target Area, the Ou Krang Ambel River is the largest tributary of the Prek Thnot River, and its catchment area is estimated at 453 km^2 at the Ou Krang Ambel Reservoirlocated along the National Road No.4. Two reservoirs were further constructed for the purpose of irrigation development in the upstream of the Ou Krang Ambel River. Accordingly, inflow to the Ou Krang Ambel Reservoir decreases remarkably. The inflow

to the Ou Krang Ambel Reservoir was estimated through reservoir simulation considering 2 irrigation systems. The main feature of two irrigation systems is as follows.

(1) O Sya Irrigation System
- Location: Upstream of the Ou Krang Ambel River
- Catchment area of reservoir: 144 km^2
- Effective storage of reservoir: 3,600,000 m^3
- Irrigation Service Area: 730 ha

(2) Chan Tanal Irrigation System
- Location: between O Sya Irrigation System and Ou Krang Ambel Irrigation System
- Catchment area of reservoir: 124 km^2 (between O Sya and Ou Krang Ambel)
- Effective storage of reservoir: 3,000,000 m^3
- Irrigation Service Area: 1,470 ha.

The reservoir operation was made for each reservoir using the following equation.

$$V_i=Q_i-(EV_i+PL_i+Qd_i)+V_{i-1}$$

Where, V_i *; Water in the reservoir at the time i*

Q_i *; Inflow to reservoir between time i-1 to i*

EV_i *; Evaporation loss from reservoir between time i-1 to i*

PL_i *; Percolation loss from reservoir between time i-1 to i*

Qd_i *; Irrigation water demand for irrigation to be supplied from reservoir between time i-1 to i*

V_{i-1} *; Water in the reservoir at the time i-1*

In the reservoir operation, the following are assumed:

(a) Inflow to the reservoir was estimated by a dependable discharge of the Ou Krang Ambel River at confluence with the Prek Thnot River (453 km^2) in proportion to catchment area of the reservoir

(b) Evapotranspiration from reservoir was determined by Penman-Montieth method (refer to Section 2.4) using meteorological data at Phnom Penh Air Port.

(c) Percolation from reservoir was assumed at 0.2 % of the storage volume referring to the Japanese Guideline, and considering soil characteristics in the reservoir and quality of soil compaction work.

(d) Irrigation water demand was estimated similar with that used for water balance study (refer to Section F2.4). Other water demands such as domestic use were not taken into account in the calculation considering that those were balanced by return flow of irrigation water.

As the result of reservoir operation, dependable inflow to the Ou Krang Ambel Reservoir was calculated as shown in Table F2.2.2

F-2.2.3 Small Tributaries

The discharge of tributaries can be figured out by the dependable discharge of the Prek Thnot River at Peam Khley in proportion to catchment and annual rainfall in the catchment area of each tributary. Catchment area at Peam Khley was calculated at 3,654 km^2. The annual rainfall in the Target Area was assumed at 900 mm per annum from isohyet map prepared by the Study Team. On the other hand, the most frequent catchement size of a water harvesting reservoir is less than 10 km^2, and very small comparing with that at Peam Khley. Runoff characteristic in the small cathcment and

large catchment is quite different. The large catchment area like the Prek Thnot River has a base flow mainly due to groundwater. A runoff from small tributary is only direct runoff caused by heavy rain. To cope with this problem, minimum mean monthly discharge was extracted from monthly mean discharge data of the Prek Thnot River at Peam Khley from 1901 to 2004 as shown in Appendix A. The moving average for every 3 months were calculated from the minimum mean monthly discharge, and deducted from dependable discharge at Peam Khley as a base flow.

Estimated Base Flow in Prek Thnot River at Peam Khley (m^3/sec)

Items	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Minimum mean monthly discharge	2.4	0.4	0.4	1.5	3.7	3.0	5.3	12.7	69.8	45.6	12.0	2.4
3 month moving average (Base flow)	5.6	1.7	0.8	0.6	1.4	2.1	3.0	5.3	22.0	32.0	31.8	15.0

Based on the above result, the discharge of small tributary is calculated as follows.

$Qr = Qp \times 900/1225/3654 \times 10 = 0.0020 \times Qp$

Where,

Qr: discharge of a tributary per 10 km^2
Qp: discharge at Peam Khley after deducting base flow (3,654 km^2)

Dependable 5-day discharge of tributary per 10 km^2 is summarized in Table F2.2.2.

F-2.3 Water Demands in Downstream Area of Target Area

F-2.3.1 On-going and Proposed Irrigation Projects in Downstream Area

(1) Kandaul Stung Irrigation Project

Kandal Stung Irrigation Project is located in Kandal Stung District of Kandal Province. The project will develop irrigation system commanding 1,950 ha in net.

Summary of Monthly Water Requirement of Kandal Stung Irrigation Project (m^3/sec)

Discharge	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Irrigation req.	0.8	0.7	0.0	0.1	0.8	1.3	2.33	1.0	0.3	0.6	1.3	1.5

Source: Basic Design Report of Kandal Stung Irrigation Project, 2005

(2) Dangkor Pump Irrigation System

Irrigation water of the Dangkor Pump Irrigation Project is pumped up from left bank of by-pass channel of the Prek Thnot River at immediately upstream of Tuk Thla Regulator. The project area under the original plan is 300 ha, most of which is not irrigated now. Irrigation water requirement to this project should also be considered in the Study.

Since no data on irrigation water requirement for the project is available, it is estimated by applying similar cropping pattern proposed in the Study, as summarized below.

Summary of Monthly Water Requirement of Dangkor Irrigation Project (m^3/sec)

Discharge	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Irrigation req.	0.0	0.0	0.0	0.2	0.05	0.05	0.16	0.3	0.18	0.21	0.23	0.03

Source: Study Team

(3) Tonle Bati Irrigation Project

The irrigation water requirement for the project was estimated as follows, and is to be taken into account in the Study. .[1]

[1] *Master Plan Study on the Integrated Agricultural and Rural Development Project in the Suburb of Phnom Penh, JICA, Nippon Koei Co., Ltd., February 1995*

Summary of Half-monthly Water Requirement of Tonle Bati Irrigation Project (m^3/sec)

Discharge	Jan.		Feb.		Mar		Apr.		May		June	
Irrigation req.	0.95	0.57	0.66	0.64	0	0	0.02	0.05	0.4	0.84	0.91	0.99
Discharge	**July**		**Aug.**		**Sep**		**Oct**		**Nov**		**Dec**	
Irrigation req.	1.66	1.42	1.14	0.68	0.34	0.50	0.82	0.64	0.75	0.82	0.98	1.21

F-2.3.2 River Maintenance Flow

The river maintenance flow to downstream from the Roleang Chrey Regulator was estimated at 0.6 m^3/sec throughout a year referring to the Guideline in Japan[2] and actual water utilization in the downstream from Tuk Thla Regulator[3].

F-2.3.3 Minimum Responsible Discharge to Downstream Area

The minimum responsible discharge from the Roleang Chrey Regulator to downstream is figured out by summing water requirement of 3 irrigation projects and river maintenance flow described above as shown in Table F2.3.1.

F-2.4 Irrigation Water Requirement in the Target Area

F-2.4.1 Water Right

At present, water law is under preparation, so that water rights are not officially recognized so far. For the agricultural activities, customary water wrights by accompanying to agriculture land mainly paddy fields are prevailing in the Target Area. This system may not be changed drastically unless the water law is enacted.

Some farmers have been selling their land to other private sector for industry development. This is observed at many scattered places along the national roads, which is called as Urban Sprawl in general. Urban Sprawl frequently occurs very rapidly beyond control of the Government. This Urban Sprawl phenomenon complicates the water management. The water law should be therefore enacted as soon as possible.

F-2.4.2 Introduction of Water Saving Irrigation Method

Net irrigation water requirements are estimated on condition that water saving irrigation method will be introduced for paddy cultivation.

Water is not stored in the paddy fields after land preparation and transplanting, but is supplied to keep only soil moisture content in the root depth at not less than 75% of full saturation throughout the total growing period. Water is stored in the paddy field only during a period of 30 days starting at head initiation till the end of flowering. In the calculation, this was converted to the decrease of percolation loss in every 5 days as presented in Table F2.4.1. In this irrigation practice, percolation losses can be remarkably reduced by about 20% to 25% of total net irrigation water requirements.

F-2.4.3 Calculation Procedure

The irrigation water requirement was estimated in accordance with the following procedures and conditions.

(1) To estimate the Crop Evapotranspiration (ETo), Penman-Montieth method with the available meteorological data at Phnom Penh Air Port located near the Target Area is used. The Penman-Montieth method is one of the recommendations in the Guideline for Crop Evapotranspiration, FAO Irrigation and Drainage Paper 56: The calculation was made every month from 1991 to 2005 except for data missing month. An annual daily mean Crop Evapotranspiration is calculated at 4.9 mm/day.

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[2] *In Japan the river maintenance flow is determined at between the average drought discharge and the minimum drought discharge in 10 years.*

[3] *Basic Design Report of Kandal Stung Irrigation Rehabilitation Project, 2005*

Crop Evapotranspiration by FAO Penman-Montieth Method (mm/day)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
4.6	5.3	6.0	6.1	5.5	5.2	4.6	4.9	4.3	4.0	4.4	4.4

(2) To determine the Crop Coefficients of paddy and other crops, reference is made to the above Guideline, and the consumptive use of water of each crop is obtained by multiplying the Crop Evapotranspiration and Crop Coefficients. Based on the cropping calendar proposed, a mean 5-day irrigation water requirements were calculated.

(3) Water requirement of land preparation was determined based on water layer replacement in the paddy field.

(4) To obtain a field water requirement by summation of consumptive use of water, percolation, land preparation, and water layer replacement; the percolation rate was determined at 8 mm/day based on the field measurement at 9 locations by the Study Team. In this regards, water saving irrigation was proposed in the Study as described in the previous Section F2.4.2.

(5) A net field water requirement was calculated by deducting effective rainfall from the field water requirement. A sample calculation is presented in Table F2.4.2. The proposed cropping calendar was generally staggered for about one month or more. Accordingly, the cropping calendar was divided into several blocks by 5-day, and the calculation of water requirement was made for every block. This will be, in future, useful for water management for different blocks of which cultivation date starts differently.

(6) A diversion water requirement was estimated by taking into account seepage loss, loss from canal and related structures, and operational loss between intake and field. The overall irrigation efficiency was determined at 66 % of the water at intake.

(7) A unit diversion water requirement of the proposed cropping calendar was calculated by multiplying a unit cropping area, i.e. one hectare, to the above (6). The cropping area was divided into several blocks equally as described in paragraph (5) above. A sample calculation is shown in Table F2.4.3.

(8) Supplemental explanation on proposed irrigation efficiency and effective rainfall

1) Proposed Irrigation Efficiency

In general, it is assumed that a quarter to one third of the total quantity of water diverted will be lost before it reaches the rice plant due to operational waste, evaporation and seepage. Losses by evaporation and seepage are generally small in comparison with operational waste.

A technical reference presents a range of irrigation losses as follows:

a) 15 to 22.5 % in the tertiary unit, between tertiary turnout and the fields

b) 7.5 to 12.5 % in the secondary canal

c) 7.5 to 12.5 % in the primary canal

During field survey, the Study Team frequently saw some water was wasted and flow out to downward field. The reasons of this are deemed that:

- Number of water control facility is very limited in the main canal and secondary canal, so that farmer can not properly control water in the canal, and
- Farmers seem not paying attention to water saving for other farmers.

From above, farmers appear to have a potential to execute water saving activity provided that sufficient facility and training are provided. Irrigation efficiency for the Study is set up as follows:

i) For paddy irrigation

a) In the tertiary unit, low water loss can be achieved by farmers, so low water loss rate of 15 % is applied, efficiency=100-15 %=85 %

b) In the secondary canal, it will take some time to train farmers and to disseminate water technology, so high water loss rate of 15 % similarly with that at current condition is conservatively applied, efficiency =100-12 %=88 %

c) In the main canal, as explained in b) above, the same efficiency×100-12 %=88 %

d) Overall efficiency can be figured out by multiplying the above efficiency conjunctively. Overall irrigation efficiency = 85 × 88 × 88 % = 65.8 % = 66 %

ii) For upland crop irrigation

A surface irrigation method was proposed such as furrow irrigation for upland crops other than rice. There is an inevitable water loss in the upland crop irrigation such as seepage in the furrow and operational loss in the field. Such loss or reversely called as Field Application Efficiency was assumed at 80 % (=100-20 %) of water reached to the entrance of the field. The others efficiencies from intake to tertiary canal are set at same as for paddy irrigation above.

The overall irrigation efficiency for upland crop is figured out at 53 % as follows: Overall irrigation efficiency for upland crop =80 × 85 × 88 × 88 % = 52.6 = 53 %

2) Determination of effective rainfall to crops

i) For paddy field

Effective rainfall to paddy field was determined in accordance with the following condition and procedure.

a) Calculate effective rainfall daily using daily rainfall record at Kampong Speu between 2001and 2005 based on the following condition.
   - A daily rainfall less than 5 mm/day is neglected
   - If a daily rainfall exceeds more than 5 and less than 80 mm/day, 80 % of the daily rainfall is considered to be effective
   - If a daily rainfall exceeds 80 mm/day, the effective rainfall is considered to be 64 mm/day

b) Calculate monthly effective rainfall by summation of the daily effective rainfall above

c) Determine relationship between monthly effective rainfall to monthly rainfall by correlation and regression analysis, and obtained the following equation

$Y=0.75X-0.4 \quad (r^2=0.97)$

Where; Y is monthly effective rainfall (mm)

X is monthly rainfall (mm)

r^2 is correlation coefficient

d) Calculate dependable monthly rainfall at Kampong Speu using monthly rainfall data between 1901 and 2004

e) Using the above equation and dependable monthly rainfall, monthly dependable effective rainfall was determined in the paddy field. The 5-day effective rainfall was determined by equally distributing the monthly effective rainfall to 5-day each. The results are shown in Table F2.4.4.

ii) For upland crop field

The monthly effective rainfall for upland crop field was determined by applying the monthly dependable rainfall to standard made by USDA as shown in Table F2.4.4. The 5-day effective rainfall was determined by equally distributing the monthly effective rainfall to 5-day each.

F-2.4.4 Diversion Water Requirement

The peak unit diversion water requirement of the proposed cropping calendar is figured out at 1.60 lit/sec/ha for Medium Rice.

The diversion water requirement is calculated by multiplying the unit diversion water requirement and proposed cropping area. A total diversion water requirement at intake site is obtained by sum up all diversion water requirements at every 5-day. A sample calculation is shown in Table F2.4.3.

F-2.5 Water Balance Study

F-2.5.1 Procedure

The river discharge and water demand were compared in the following manner.

(a) The 5-day diversion water requirement calculated in the above Section F2.4 was compared with 80% dependable 5-day mean discharge.

(b) If water deficit is observed more than two 5-days, irrigation area is reduced until one 5-day deficit

(c) The cropping calendar which gives the largest irrigable area was searched by try and error by moving cropping calendar earlier time in collaboration with the other staff of the Study Team.

After executing the above try and error, the most suitable cropping calendar is shown in Table F2.5.1. In the table total irrigable area is conservatively 500 ha for Early Rice-1 (April to July) and Early Rice-2 (August to November), and 5,900 ha for Medium Rice by Prek Thnot River and Ou Krang Ambel River with 80 % dependability (4 in 5 years). About 600 ha irrigation is guaranteed by small tributaries as a whole.

F-2.5.2 Probable Irrigation Areas

(1) Probable irrigation area by Prek Thnot River and Ou Krang Ambel River

Based on the procedures mentioned above, probable irrigation area was calculated based on the different water sources and different dependability to examine the impact of these factors on probable maximum irrigation area.

Probable Irrigation Area by Prek Thnot River by Roleang Chrey Regulator

Dependability	Early rice-1 (ha)	Early rice-2 (ha)	Medium rice (ha)
80% (4 in 5 years)	400	400	5,500
50% (3 in 6 years)	3,500	3,500	13,000
33%(1 in 3 years)	3,600	3,600	18,000

Early rice-1: Cultivated from middle April to early August
Early rice-2: Cultivated from early August to early December
Medium rice: Cultivated from early July to early December

The probable irrigation area by the Ou' Krang Ambel River was calculated as shown below. In the calculation, additional water supply from the North Main Canal is not taken into account.

Probable Irrigation Area by Ou Krang Ambel River

Dependability	Early rice-1 (ha)	Early rice-2 (ha)	Medium rice (ha)
80% (4 in 5 years)	115	115	430
50% (3 in 6 years)	250	250	700
33%(1 in 3 years)	265	265	1,065

Based on the above examination, the irrigation area by Prek Thnot River is to be 17,450 ha for Medium rice and Early rice-2 with 50 % dependability, and is less than 20,000 ha. The total irrigable area by two rivers reaches at 22,930 ha with 33 % dependability. This means the entire area of the project can be guaranteed nearly 33% (one in 3 years). To heighten the dependability, one option is to decrease the beneficiary area up to 5,900 ha (Early rice + Medium rice), the other option is a need of new water resource development in the upstream.

(2) Probable irrigation area by Water Harvesting

Similarly, the probable irrigation area by water harvesting is estimated as tabulated below:

Probable Irrigation Area by Water Harvesting (Pond)

Dependability	Early rice-1 (ha)	Early rice-2 (ha)	Medium rice (ha)
80% (4 in 5 years)	-	-	600
50% (3 in 6 years)	-	-	1,200
33%(1 in 3 years)	-	-	1,600

F-2.5.3 Estimate of Present Irrigation Area

As for the present irrigation area, no data is available. Therefore, it was assumed based on the currently dominant cropping pattern, irrigation water requirement. As the result of calculation, the present irrigation area is estimated to be 6,000 ha with 80% dependable discharge from July to December. Only 500 ha are completely irrigated in dry season from May to August.

F-2.6 Zoning of Target Area

F-2.6.1 Need of Zoning

The Target Area exhibits diversity in terms of water availability and land use. In view of this situation, it is inadvisable to simply apply a uniform development approach plan to such large area. Instead, zoning of the Target Area is recommendable as an appropriate approach, especially for crop sub-sector, which is a main income source for farmers in the Target Area. The Master Plan for comprehensive agricultural development should be thus formulated by applying the zone based approach.

F-2.6.2 Methodology

(1) Adoption of Different Dependability of Water Resources to the Target Area

As shown in the previous section, water resources in the Target Area are not enough at present. However, NMC and SMC were already constructed under the Western Phnom Penh Integrated Development Center Project. It is hard to immediately start new water resources development project due to lack of hydrological data and information, social problems, needs of resettlement and so on. Taking into consideration such conditions surrounding the Target Area, it is proposed to classify the beneficiary area into two dependability, namely with 80% dependability (4 in 5 years), and with 50% dependability (3 in 6 years).

At present and in general, the upstream area of main irrigation canal can enjoy more opportunity of water. It seems so difficult to change this situation. On the other hand, the downstream area could not be supplied from the main canal at present. Therefore, the upstream area is classified into 80% dependable area, and the downstream area by 50% dependable area.

The Target Area is divided into two areas by NMC and SMC. It is proposed to divide each beneficiary area of one main canal for the implementation.

Thus, the irrigation areas of two main canals are divided into two areas taking into account topography, location of paddy fields, existing canal layout, and operation activity. The irrigation area by water harvesting is also classified in a similar way.

The result of classification is shown as follows:

Irrigation Area by Different Dependability (Unit; ha)

Name of canal	80% dependability	50% dependability	Design discharge applying 50% dependability (m^3/sec)
South Main Canal	3,450	10,200	16.3
North Main Canal	2,210	3,600	10.4[1/]
Ou Krang Ambel	-	2,900	4.6
Sub-total	5,660	16,700	26.7
Small tributaries	600	1,200	1.9[2/]
Total	6260	17,900	28.6

1/ *Including 4.6 m^3/sec to Ou Krang Ambel System since the system is mainly supplied by North Main Canal.*

2/ *A summation of 49 irrigation systems*

(2) Overlaying of the above areas to land use map to delineate the rain-fed area

The present land use was assessed by the Study Team based on the information obtained during the Study. The assessed irrigation area was overlaid on the land use map, and then rain-fed area is delineated.

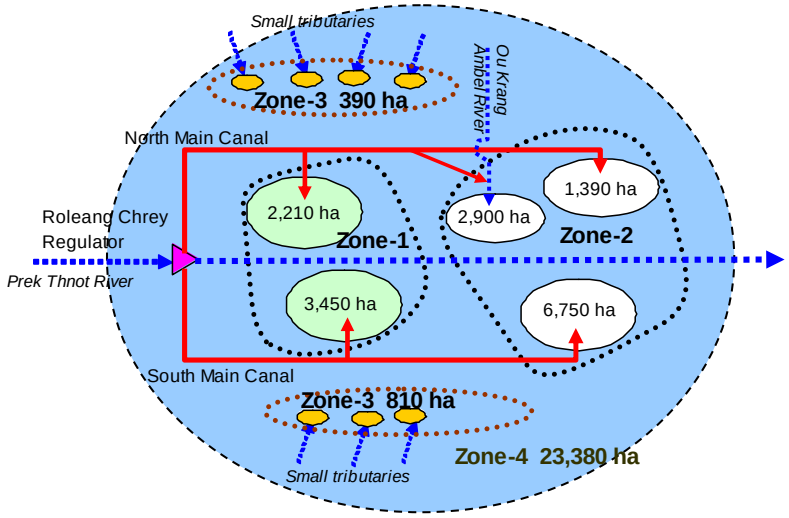
The zoning map prepared by the above procedure is presented in Figure F2.6.1.

F-2.6.3 Classified Zones

As the results of zoning, the Target Area is divided into the following four zones:

Zone	Definition	Net irrigable area (ha)
Zone-1	Irrigated by Prek Thnot River with 80 % dependability	5,660
Zone-2	Irrigated by Prek Thnot and Ou Krang Ambel Rivers with 50 % dependability	11,040
Zone-3	Irrigated by Water Harvesting Pond with 50 % dependability	1,200
Zone-4	Rain-fed area=23,380 ha	-
	Total of Zone-1 to Zone-4 = 41,280 ha	Total irrigable area=17,900

The geographical distribution of the zones is illustrated as follows:



Chapter F-3 Basic Concept of Irrigation and Drainage Improvement

F-3.1 Zone-1 Development

F-3.1.1 Development Objective

Development objective to Zone-1 in irrigation and drainage is to expand the irrigable area with 80 % dependability in water supply.

F-3.1.2 Irrigation Development Strategies

(1) Maximum Use of Existing Facilities

In Zone-1, main canal and secondary canal covering the Zone-1 area, were mostly constructed under the Western Phnom Penh Integrated Development Center Project, so that these existing facilities should be used as much as possible, to save construction cost.

(2) Application of Water Saving Irrigation Method

The existing water resources for the Target Area are limited. To expand the irrigation area under such situation, it is essential to apply the water saving irrigation method. In this Study, the moisture content of soil covering the root is taken into account when estimating the irrigation water requirement, to reduce the percolation loss.

(3) Minimum Rehabilitation/Improvement Works

The existing canals are excavated canals with comparatively large section as compared with the required discharge. These canals should be rehabilitated and/or improved in the minimum cost. As for the additional structures, the number should be minimized through the hydraulic calculation and site inspection.

(4) Use of Suitable Borrowed Materials for Canal Embankment

Some parts of existing canals were constructed using the unsuitable soil like dispersible soil, so that severe soil erosion occurred. Such portions should be rehabilitated using the suitable borrowed materials although the suitable excavated soils should be used for rehabilitation and/or improvement. In addition, sod-facing should be provided for embankment portion to prevent soil erosion.

(5) Application of Gravity Method

The water level in the most canals is lower than the ground level of paddy field, so that irrigation water could not be supplied to paddy field by gravity. The portable pump irrigation system limits the irrigation area and requires higher operation cost. In this Study, the application of gravity irrigation system is planed by heightening water level in canal with provision of additional check structures.

(6) Appropriate Density of Minor Canals

In order to supply irrigation water to each field from canals smoothly and effectively, the density of subordinate canals is to be heightened such as secondary canals, tertiary canals and watercourse. Sub-secondary canals are planned to deliver water smoothly to tertiary canals in many places. The density of tertiary canals and water courses should be heightened up to, say 30m/ha for each.

F-3.1.3 Drainage Development Strategies

(1) Development concept

The development concept for drainage improvement is worked out as follows:

(a) Main crop in the Target Area is paddy, and drainage from paddy field is a main target of the drainage development plan.

(b) Small streams are to be utilized for drains as much as possible to minimize construction cost.

(c) An intensive drainage improvement is planned in the limited area, i.e. 14 irrigation systems commanding 620 ha as described in the previous section. An extensive drainage improvement is planned for the remaining areas of Zone-1.

(2) Allowable flooding depth, allowable inundation period

Paddy which is proposed as a main crop proposed in the Target Area, suffers a serious loss if it is submerged at booting stage by flood. The booting stage will start at about 6 days before flowering (heading) which occurs 30 days before harvesting (refer to Table F2.4.1). The height of paddy stem is generally more than 30 cm at the booting stage. The allowable maximum flooding depth and allowable inundation period in the paddy field is planed to be 300 mm and 3 days respectively by making reference with the study by Ministry of Agriculture, Forestry and Fishery of Japan.

(3) Design rainfall and drainage water requirement

A maximum daily rainfall and 3 continuous day rainfall are extracted from daily rainfall record at Kampong Speu from 2001 to 2005 as follows:

Annual maximum 1 day rainfall (mm) at Kampong Speu

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
2001				80.9			
2002				111.5			
2003	76.0						
2004					94.9		
2005[*1]			73.4				

[*1] Between May and August

Annual maximum continuous 3 days rainfall (mm) at Kampong Speu

Year	May	June	July	Aug.	Sept.	Oct.	Nov.
2001					130.2		
2002				112.9			
2003	115.0						
2004						114.5	
2005[*1]			80.1				

[*1] Between May and August

A probable rainfall with a 1/5 to 1/10 year return period is applied for planning of drainage system in the paddy field. As shown above, the record length is only 5 years, and difficult to carry out probable analysis by such small number of record. So, the maximum 3 continuous day rainfall is applied in the Study. The unit drainage water requirement is figured out by the following equation.

$$q=0.130\times10,000/(3\times86400) \times 1000 =5$$

where, q is the drainage water requirement (lit./sec/ha)

(4) Drainage canals

Drainage system is composed of field drains, tertiary, secondary, and main drains. Field drains is planned to be excavated by FWUC together with construction of quaternary irrigation canal. A density of tertiary and secondary drains is to be similar with tertiary and secondary irrigation canals. A field drain is planned to be excavated at lowest edge of the field unit which is irrigated by a field irrigation canal. A tertiary drain is planned to be excavated at lowest edge of each tertiary unit. Most of the small tributaries in the Target Area will serve as the secondary drains. However, the tributaries are to be

excavated to smoothly flow the drainage water.

Due to the topography in the Target Area, all small tributaries flow into the Prek Thnot river. The Prek Thnot River is to be a main drain in the Target Area.

The excavated material for drains will be used for embankment of irrigation canal provided that its soil characteristics are suitable as embankment materials.

F-3.1.4 Rehabilitation and Improvement Plan of North Main Canal System

(a) Command area: Upstream area 2,210 ha with 80% dependability

(b) Total length: 29.3 km in Zone-1

(c) Design discharge: 10.4 to 5.8 m^3/sec including water for Zone-2

(d) Number of structures on the Main Canal: Turnouts 16, Check 8, Cross drain 2, Bridge/culvert 9

(e) Secondary canals: New canals 5.2 km, existing canals to be rehabilitated 4.9 km

(f) Water harvesting reservoir: 7 systems

A proposed canal layout in the Zone-1 and Zone-2 areas is presented in Figure 3.1.1.

F-3.1.5 Rehabilitation and improvement Plan of South Main Canal System

(a) Command area: Upstream area 3,450 ha with 80% dependability

(b) Total length: 27.3 km in Zone-1

(c) Design discharge: 16.3 m^3/sec including water for Zone-2

(d) Number of structures on the Main Canal: Turnouts 16, Check 5, Cross drain 5, Bridge/culvert 13

(e) Secondary canals: New canals 22.3 km, Existing canals to be rehabilitated 15.6 km

(f) Water harvesting reservoir: 4 systems

F-3.1.6 Rehabilitation and Improvement Plan of Water Harvesting System

Based on the field inspection the present condition of the reservoirs in the Target Area is classified into the following three types.

(a) Reservoir with embankment in good condition

(b) Reservoir with embankment eroded and deformed partly,

(c) Reservoir with embankment eroded and deformed seriously.

The embankment of reservoirs classified as (b) and (c) are planned to be rehabilitated. All existing intake structures of reservoirs regardless of classification above, except that have been rehabilitated recently, are planned to be reconstructed or improved also.

The existing intake structure is planned to be reconstructed or be improved with proper dimensions of structure equipped with slide gates.

Almost all reservoirs do not have a spillway because the existing intake structure functions as intake and spillway because of no provision of gate. Since the gate is provided for intake to make water management properly, a spillway shall be provided for each reservoir.

F-3.1.7 FWUC Formation and Strengthening

(1) Development Objective

Objective of FWUC formation and strengthening is to realize the proper water management and O&M of minor canals such as secondary canal, tertiary canal and watercourse.

(2) Development Strategies

Zone-1 is located at upstream side of the existing NMC and SMC, and is blessed with the irrigation water as compared with other Zones. Number of existing FWUC is larger than that of Zones-2. However, activities of them such as water management and O & M at minor canal level, do not reach the satisfactory level. To attain the objective mentioned above, the following strategies should be applied:

(a) Precise Structure and Responsibilities

Presently, canal system is not completed, so that responsibilities of FWUC are not clear although the Policy for Sustainability of Operation and Maintenance Irrigation System, June 2000" is available. After completion of proper irrigation system, the following structure and responsibilities are proposed:

Proposed Structure and Responsibilities

In-charge	Canal Level	Responsibilities
Government	Main Canal	Maintenance of Main Canal and control of gates to Secondary Canal
FWUC	Secondary Canal	Maintenance of Secondary Canal and control of gates to Tertiary Canal
FWUG	Tertiary Canal	Maintenance of Tertiary Canal and control of division boxes/field outlets to Watercourse
WUG	Watercourse	Maintenance of Watercourse and control of water distribution to each field

(b) Formation of FWUC, FWUG and WUG considering Tragic History

Formation of FWUC, FWUG and WUG should be carefully carried out keeping the tragic history in mind. The results of various surveys have clarified that Commune Chief, Village Chief and VDC members are playing an important role for smooth formation of any farmer organization. Commune Chief, Village Chief and VDC members who are representatives selected from village people, is one of reasons. Formation/strengthening of FWUC, FWUG and WUG should therefore involve them from the beginning.

(c) Clear Share of Roles of FWUC, FWUG and WUG

The proposed roles of FWUC, FWUG and WUG are as follows:

Name of Organization	Membership	Activities
FWUC	• Farmers representatives from various levels of irrigation system	• Adhering to the decisions made by the steering committee of FWUC
Steering committee of FWUC	• Chiefs of FWUGs • Secretary • Accountant	• Solving water conflict as a federation of FWUGs
FWUG	• FWUG members	• Attending general meetings • Maintenance of tertiary canals
Steering committee of FWUG	• Leaders of WUGs • Secretary • Accountant	• Discussing O&M of tertiary canals • Convening FWUG members for general meetings • Collection of irrigation service fee from WUG members under FWUG
WUG	• Land owners/ tenants whose land is located in the irrigated area • A group leader (selected by secret ballot among all members)	• Discussing and determining the turns of irrigation water use • Dredging up mud and the other obstacles in tertiary canals

(d) Timely Participation of Beneficial Farmers

Participation of beneficial farmers should be made from the design stage to implant their awareness to the project. Canal layout should be determined under the mutual understanding of the government and beneficial farmers through workshop including Commune Chief, Village Chief and VDC members.

(e) Participation of Beneficial Farmers at Construction Stage

WUG should construct the water courses under the technical support of PDOWRAM. This activity should also be made under the mutual understanding through workshop including Commune Chief, Village Chief and VDC members.

(f) Collection of Irrigation Service Fee

Irrigation service fee should be collected by WUG. In cooperation with FWUC The collected irrigation service fee should be deposited to bank. The withdrawal of deposit should need the joint signature of Chief of FWUG and accountant.

F-3.1.8 Water Management and O&M

(1) Development Objective

Water management for Zone-1 area aims at water saving irrigation due to limited water resource. O&M for canal system aims to keep the good conditions of canals and related structure under well cooperation between the government and FWUCs.

(2) Development Strategies

(a) Need of Close Communication between the Government and FWUCs

Water management and O&M should be timely executed keeping the irrigation calendar in mind. This means that allocated responsibilities should be properly accomplished by the government and FWUCs. Close communication between the both should be required accordingly.

(b) Water Management for Main Canal

Taking into consideration the flow capacity of existing main canal and the cost saving, the continuous water supply is applied for the main canal.

(c) Water Management for Secondary, Tertiary and Watercourse

FWUC, FWUG and WUG should execute the water management along secondary canal, tertiary canal and watercourse, respectively. With same reasons, continuous water supply is applied for secondary canal, but rotational water supply is applied for tertiary canal and watercourse in consideration of the results of pilot projects mentioned in Volume IV. Prior to commencement of water distribution, water distribution plan is prepared at the FWUC steering committee meeting and approved at the general meeting.

(d) O&M

Responsibilities of O&M and emergency repairs of canals and related structures should be conducted in the following stepwise manner:

Share of O&M Cost

Year after completion	Government	Beneficial Farmers
One	80%	20%
Second	60%	40%
Third	40%	60%
Fourth	20%	80%
After Fifth	0%	100%

(3) Basic Concept of Water Management Practices

(a) Main system

(i) River Water Diversion Plan from Prek Thnot River

PDOWRAM is proposed to make a river water diversion plan at the Roleang Chrey Regulator and Intakes at the beginning of irrigation season taking into consideration the river discharge and rainfall in the catchment area.

In this regard, it is recommendable to study a relationship between rainfall and river discharge such as cumulative rainfall from the beginning of rainy season vs. cumulative river discharge. Should some relationship be developed, it can help to make a water diversion plan of next 5-day.

(ii) Rotational irrigation in each Main Canal;

It is recommendable to adopt continuous water supply for main canal in consideration of length and existing flow capacity of main canal and cost saving.

(iii) Water delivery to Zone-2 area

PDOWRAM is responsible to control water delivery to Zone-2 area from Zone-1. To be concrete, the following 3 cases of water availability can be considered conjunctively Zone-1 and Zone-2.

Case	**Zone-1**		**Zone-2**
Case-1	Guaranteed	and	Guaranteed
Case-2	Guaranteed	and	Not Guaranteed
Case-3	Not Guaranteed	and	Not Guaranteed

Irrigation water supply is controlled to guarantee water supply 8 in 10 years (80 % dependability) and 5 in 10 years (50 % dependability) to Zone-1 and Zone-2 respectively. The control will be practically made by the operation time of check gate which is constructed on the end point of Zone-1 in the main canal.

(iv) Operation of check gates and intake gates by PDOWRAM

After setting up the above concept, PDOWRAM is also responsible to open and close gates of check and intake gates on the main canals. To execute this, an operation manual of check gates and intake gates are to be prepared by PDOWRAM.

(b) Secondary canals

O&M of a secondary canal is under responsibility of FWUCs. The steering committee of FWUC shall make a water distribution plan of the secondary canal under the consultation with PDOWRAM and other agencies.

(c) Tertiary canals

FWUC shall prepare a O&M Work Plan and Irrigation Service Plan on the tertiary canal. FWUC is responsible to collect Irrigation Service Fee (ISF) from members, to keep ledger, to use the fund for maintenance of secondary and tertiary canals, and reservoir if any. Division boxes on tertiary canals will be operated in a rotational concept to realize even and timely water distribution.

(d) Watercourse

WUG is responsible for O&M of watercourse.

(e) Water harvesting reservoir

O&M of existing reservoir and water supply canal is customarily carried out by community except for important construction work such as intake structure or repair of

dike. This system is proposed to be continued. The water supply is made to the reservoir based on operation plan of the main canal.

F-3.2 Zone-2 Development

F-3.2.1 Development Objective

Development objective to Zone-2 in irrigation and drainage is to expand the irrigable area with 50 % dependability in water supply.

F-3.2.2 Irrigation Development Strategies

The strategies to be applied to Zone-2 is similar with those in Zone-1 as described in Clause F3.1.2 However, irrigation water supply condition is more severe than Zone-1, because irrigation water could not be guaranteed with three in six years although it is better than the current situation. Application of rotational water supply within Zone-2 is one of alternatives for non-guaranteed year from viewpoint of effective water use.

F-3.2.3 Drainage Development Strategies

The drainage improvement plan in Zone-2 is similar with that in Zone-1. However, the objective area for intensive drainage improvement is limited to 5 irrigation systems which command irrigation area of 780 ha. An extensive improvement is planned in the remaining areas in Zone-2.

F-3.2.4 Rehabilitation and Improvement of North Main Canal System

(a) Command area: 1,390 ha with 50% dependability

(b) Total length: 3.6 km in Zone-2

(c) Design discharge: 2.3 m3/sec

(d) Number of structures on the Main Canal: Turnout 1, Check 1

(e) Secondary canals: New canals 10.9 km, Existing canals to be rehabilitated 8.6 km

F-3.2.5 Rehabilitation and Improvement of Ou Krang Ambel System

(a) Command area: 2,900 ha with 50% dependability

(b) Total length of main canal (Ta Hor Canal): 21 km

(c) Design discharge: 4.6 m^3/sec

(d) Structures on the main canal: Turnouts 5, Check 5, Bridge/culvert 1

(e) Secondary canals: New canals 8.3 km, Existing canals to be rehabilitated 11.7 km

(f) Water harvesting facility (pond): 2 systems

F-3.2.6 Rehabilitation and Improvement of South Main Canal System

(a) Command area: Downstream area 6,750 ha with 50% dependability

(b) Total length: 6.2 km in Zone-2

(c) Design discharge: 6.6 m^3/sec

(d) Number of structures on the Main Canal: Turnouts 4, Check 1, Cross drain 2

(e) Secondary canals: New canals 60.5 km, Existing canals to be rehabilitated 5.8 km

(f) Water harvesting facility pond: 5 systems

F-3.2.7 Rehabilitation and Improvement Plan of Water Harvesting System

The rehabilitation and improvement of water harvesting ponds shall be executed in accordance with the concepts as described in Sub-section F3.1.6.

F-3.2.8 FWUC Formation and Strengthening

(1) Development Objective

Objective of FWUC formation and strengthening is to realize the proper water management and O&M of minor canals such as secondary canal, tertiary canal and water course.

(2) Development Strategies

Zone-2 is also irrigated agriculture area. Formation and strengthening of FWUC should be carried out in the same manner with Zone-1 as described in Sub-section F3.1.7. However, Zone-2 will face the limited water for irrigation, namely 50% dependable water supply. In this meaning, careful attention should be paid on the efficient use of irrigation water. Strict rotational irrigation should be applied at on-farm level under technical support of PDOWRAM. To minimize the loss of canals, proper O&M is one of important duties for FWUC.

F-3.2.9 Water Management and O&M

(1) Development Objective

The development of objective for Zone-2 is similar to that for Zone-1 as described in Sub-section F3.1.8.

(2) Development Strategies

The development strategies for Zone-2 are similar to those for Zone-1. However, as mentioned in “irrigation and drainage development”, rotational irrigation method within the Zone-2 area should be considered for non-guaranteed year. In order to fulfill the rotational irrigation successfully, FWUC is required to keep the more communication with PDOWRAM.

(3) Basic Concept of Water Management Practices

In principle, water management practices in Zone-2 are similar to those in Zone-1 as described in Sub-section F3.1.8. However, water availability in Zone-2 is limited with 50 %, and the area is located in downstream from Zone-1.

F-3.3 Zone-3 Development

F-3.3.1 Development Objective

Development objective for Zone-3 is to use the stored water in small reservoir effectively.

F-3.3.2 Irrigation Development Strategies

(1) Minimized Investment Cost

Development strategies for Zone-3 are similar to those for Zone-2. Rehabilitation and improvement of water harvesting ponds is also similar to those described in Sub-section F3.1.6. However, the benefits accrued from this system is so limited, investment cost should be minimized. Farmers’ participation is one of alternatives.

(2) Active Application of Farmers Participation

This system is mostly small-scaled, say less than 50 ha. This means that the required irrigation and drainage works would be in small size. These required works might be

possible to be completed by farmers themselves if proper technical support is given by PDOWRAM.

F-3.3.3 Drainage Development Strategies

The drainage improvement plan in Zone-3 is similar with that in Zone-2. However, the objective area for intensive drainage improvement is limited to 41 irrigation systems which are scattered and command irrigation area of 870 ha in total. An extensive improvement is planned in the remaining area in Zone-3.

F-3.3.4 FWUC Formation and Strengthening

(1) Development Objective

Objective of FWUC formation and strengthening is to realize the proper water management and O&M of reservoir and small supply canal covering mostly less than 50 ha in net.

(2) Development Strategies

Zone-3 is irrigated area by water harvesting. Irrigation system consists of reservoir and small supply canal. Formation and strengthening of FWUC should be carried out in the same manner with Zone-1. However, irrigation system in Zone-3 is small-scaled and could be mostly controlled by sole commune. In this meaning, FWUC formation and strengthening might be easier than Zones-1 and-2. Zone-3 has limited available water, so that irrigation water would be guaranteed in the rainy season only. Hence, technical support by PDOWRAM should focus on more effective water use considering the physiological characteristic of paddy and proper O&M for reservoir and canal.

F-3.3.5 Water Management and O&M

(1) Development Objective

The development of objective for Zone-3 is similar to that for Zone-2 with 50 % dependability in water supply.

(2) Development Strategies

The development strategies for Zone-3 are quiet different from those for Zone-2. Zone-3 has so limited available water, so that irrigation water would be guaranteed in the rainy season only. In some cases, water is not enough even in the rainy season due to recent unstable weather condition. Hence, technical support by PDOWRAM should focus on more effective water use considering the physiological characteristic of paddy. According to the physiological characteristic of paddy, the following periods require water indispensably:

- About 10 days after transplanting for rooting
- About 10 days at panicle initiation stage around 65 days before harvesting
- About 10 days at flowering/heading stage around 30 days before harvesting

Taking into consideration the storage condition in the reservoir and the physiological characteristic of paddy mentioned above, water supply from the reservoir should be done based on physiological characteristic of paddy.

As for O&M for reservoir and canal, FWUC shall be responsible for execution of it. However, since FWUC will be newly established, it has no capacity to execute the O&M activities. PDOWRAM shall provide it with frequent technical support.

Inland fishery cultivation in parallel to the irrigation development is one of recommendable plans to strengthening FWUC financially.

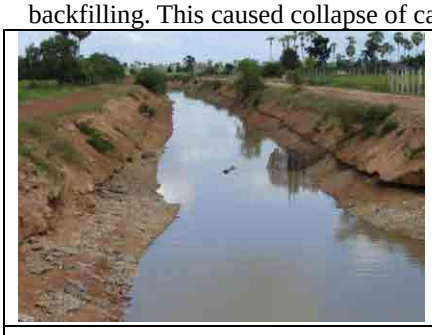
Chapter F-4 Formulation of Irrigation and Drainage Rehabilitation and Improvement Projects

F-4.1 General

Based on the basic concept of and approach to the irrigation and drainage rehabilitation and improvement, a lot of development projects/studies are worked out aiming at improvement of agricultural productivity centering rice in the Target Area. This chapter presents the various proposed development projects/plans expressed by means of project proposal, implementation schedule. In particular, an attention in the implementation plan of them is paid upon the harmonization of implementation time of respective projects/plans because these are in reciprocal relation on bearing their effects.

F-4.2 Zone-1 Projects

F-4.2.1 Irrigated Agriculture Improvement Model Project

(1) Title of Project	Irrigated Agricultural Improvement Model Project
(2) Location	District: Chbar Mon, Samraong Tong, Province: Kampong Speu
(3) Objective of Project	The project aims at demonstration of proper water management and increase of rice production in the model area by well harmonization of agriculture, irrigation and drainage and institution development.
(4) Site Description	The South Main Canal (SMC) has been recently constructed by MOWRAM. However, the canal has not been well maintained due to lack of government budget. Further, related structures of secondary and tertiary canals such as turnouts, regulators, culverts are not constructed sufficiently. Water of the SMC is not efficiently delivered to paddy fields because of the above constraints. This poor condition of irrigation facilities must be one of the important reasons of low agricultural productivity in the area. **South Main Canal and related structures** - SMC of about 26 km has been recently constructed. However, its design considerably deviates from ordinal one. The present canal is designed to keep water level lower than adjacent paddy fields. A few water level regulators were constructed, but water level in the secondary or tertiary canal is still lower than paddy fields. To struggle against this difficulty, many farmers are taking water from the main canal by using portable pumps. - Permanent turnouts which divert water from the main canal to secondary and tertiary canals are rarely constructed. It makes farmers difficult in taking water. To solve this problem, some farmers broke canal embankments and buried pipes without proper backfilling. This caused collapse of canal embankments.   *The South Main Canal seriously eroded* | *A check structure severely deteriorated* **Secondary canals and related structures** - Number and length of secondary canals are insufficient. - Gravity irrigation is unable to be practiced since design water level of the canal is lower than adjacent paddy fields. - Existing turnouts and regulators are deteriorated. - Numbers of turnouts and regulators are insufficient. - Design criteria of secondary and tertiary canal are unclear. This unclear criteria cause poor water management, since some canals commands too large area. **Tertiary canal systems**

- Improper layout of tertiary systems cause poor water management.

A check structure recently constructed

An existing tertiary canal

(5) Agricultural Development Plan

The agriculture development plan indicated in comparison with the present condition is as follows;

Agriculture Development Plan (Paddy Production)

	With Project			Present	Increment
	Early Rainy	Rainy Season	Annual	Annual	
Cropped Area	285ha	570ha	855ha	860ha	-5ha
Yield	3.3t/ha	3.0~3.3t/ha	3.0~3.3t/ha	1.5~2.4t/ha	-
Production	941t	1,796t	2,737t	1,892t	845t

Refer to Appendix D

At a full development stage, an incremental production of paddy of some 850 t/year from the present level is aimed at.

(6) Irrigation Development Plan

Water management of the irrigation system will be made by government agencies for major facilities and by FWUCs for on-farm facilities. As the first step, a model of on-farm level water management is planned to be established in "Irrigated Agriculture On-farm Technology Improvement Pilot Project". For the second step, total irrigation system management from the main canal to on-farm facilities needs to be established by this model project. Implementation of the model project also can demonstrate actual benefit from the irrigation system.

Taking strong relation with above-mentioned pilot project into account, the model project need to be conducted in surrounding area of the pilot project, which is upstream part of the SMC system. It is also necessary that the model project area has proper scale to practice and demonstrate proper water management. The proper size of the model area would be the area operated by several turnouts and a few check structures. Taking these criteria into account, the model project area was finally decided to be the most upstream command area of SMC distributed in Chbar Mon and Samraong Tong districts. Length of the SMC and paddy area in the model project area is 7 km and 570 ha respectively. A complete irrigation will be achieved in the entire project area at least four years out of five (80% dependability) in the rainy season.

To introduce river water from the Prek Thnot River to the paddy fields, all canals are proposed to be improved to be able to maintain proper water level for gravity irrigation. Related structures such as check structures, turnouts are planned to be provided at diversion point on the main canal. To avoid the canals obstructing public transportation, culvert or bridges are planned to be provided. Among 32 km of total length of the SMC, most upstream 7km is proposed to be rehabilitated by the project. Design discharge of the SMC is 16.3 m^3/sec.

Participatory approach will be applied in the planning of tertiary canal system and construction of quaternary canals. Tertiary and quaternary canals layout will be determined through workshop by farmers in the planning stage. Quaternary canals will be constructed by farmers under guidance of the government. Formation and strengthening of FWUCs will also be implemented in parallel.

(7) Project Component

(i) Construction works

- Rehabilitation of the SMC from Vat Kruoch Intake Gate up to 7 km including construction of related structures
- Rehabilitation of existing secondary canals (6.1 km), construction of new secondary canals (1.0 km), and rehabilitation of tertiary canal systems for 570 ha, including

	related structures and drainage canals - Rehabilitation of 4 water harvesting facilities (ponds) including intake structure and irrigation canal system (ii) Procurement of O&M (operation and maintenance) equipment (iii) Formation and strengthening of FWUCs/FWUGs (iv) Agricultural support services - Field Programs, Farmer/Farmer Group Training Programs (including training of village extension agents), Mass Guidance & Workshop, staff empowerment (v) Engineering Services - Survey, design, preparation of tender documents, and construction supervision - To prepare operation rule and operation manual of facilities - To reinforce organization for O&M of the project facilities.
(8) Required Cost	Total: US$1,679,000 (*refer to Appendix H*)
(9) Executing Agency	MOWRAM and MAFF
(10) Implementation	*As shown below*

	Activities	Expected Results	2009				20010				2011				2012				2013				In-charge	Equipment	Remarks
			1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12			
(1)	Survey, Design, Preparation of Tender Documents including Drawings	Design reports & drawings, tender docs.																							
	- Topo survey of main and secodnary canals																								
	- Design of main and secodnary canals																						Consultant	As required	
	- Topo survey of tertiary area																								
	- Design of tertiary canal																						Consultant	As required	
(2)	Tender and Contract award	Contract																							
	- Main, secondary & tertiary canals																						MOWRAM	As required	
																							MOWRAM	As required	
(3)	Construction work of irrigation facilities	Facilities																							
	- Main, secondary & tertiary canals																						Contractor	As required	
																							Contractor	As required	
	- Quaternary canals																						Farmers/PDOWRAM		
(4)	Preparation of O&M manual	O&M manual																					Consultant/ Contractor	As required	
(5)	Formation of FWUC	FWUC, FWUG and WUG																					PDOWRAM/ NGO	As required	
(6)	Workshop for tertiary canal system layout	Tertiary canal layout																					PDOWRAM/ NGO	As required	
(7)	Training FWUC for water management	Dissemination of water saving system																					PDOWRAM/ NGO	As required	
(8)	Implementation of agriculture support program	Dissemination of improved rice production system																					MAFF/PDA/ NGO	As required	

Rainy season

**: estimated assuming that Roleang Chrey Regulatot and Intakes have been completed prior to commencement of this project.*

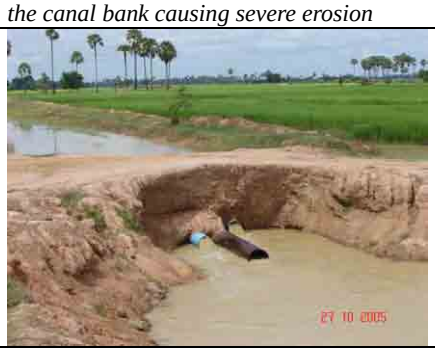
F-4.2.2 Upper North Main Canal Irrigated Agriculture Improvement Project

(1) Title of Project	Upper North Main Canal Irrigated Agriculture Improvement Project
(2) Location	District: Chbar Mon, Samraong Tong, Province: Kampong Speu
(3) Objective of Project	The project aims to increase rice production in the upper north area (2,210ha) by improvement of irrigation system and strengthening of agricultural support services and FWUCs.
(4) Site Description	The construction of North Main Canal (NMC) was planned in late 1960s and started early 1970s as a part of Prek Thnot Multi Purpose Project. The construction started from Roleang Chrey Regulator. The construction was ceased completely because war activities. After 1979, the construction was resumed by the Government of Cambodia under assistance by donor countries. Its designs, however, deviate considerably from the original design. The most downstream part of NMC has been recently constructed by MOWRAM. However, all canals have not been well maintained until now. Further, secondary and tertiary canals, related structures such as turnouts, regulators, culverts are not sufficiently constructed due to lack of budget. Water in the NMC is not efficiently delivered to paddy fields at present because of the reasons above. This appears one of the important reasons of low agricultural productivity in the area. Farmers excavate canal embankment and bury small pipe intakes in the embankment without compacting soils. This frequently causes collapse of the NMC. **North Main Canal and related structures** - The North Maim Canal of about 25.2 km has been recently constructed. However, its design considerably deviates from original design. The present canal is designed to keep water level lower than adjacent paddy fields. No water level regulator is constructed, so, water level in the secondary or tertiary canal is also lower than paddy field. A pump irrigation is practiced in many places. - The excavated sandy soil is being deposited on both side of the canal without compaction due to lack of construction budget. The soil, therefore, severely eroded and flow into canal decreasing flow capacity. - Permanent turnouts which divert water from main canal to secondary and tertiary canals are rarely constructed. It makes difficult farmers take water from main canal. To solve this problem, farmers excavated canal and bury pipes. They do not properly backfill the canal causing collapse of canal.

Pump irrigation from main canal due to low water level in the canal

The excavated sandy soils are deposited on the canal bank causing severe erosion

Canal bank collapsed due to water seepage along pipes illegally buried by farmers



Culvert constructed by people blocks main canal

<table>
<tr><td></td><td>No turnout to the secondary canal, water level in the canal is lower than paddy field resulting unable gravity irrigation.
Secondary canals and related structures
- The number and length of secondary canals are insufficient for adequate irrigation.
- The water level is designed lower than adjacent paddy field.
- Turnouts and regulators are insufficient for proper water management.
- At present, definition and classification of secondary canal and tertiary canal is not clear and not precise, so some existing secondary canal commands very large area in which proper water management activities are not able to be implemented.
Tertiary canal systems
- A size and number of tertiary system is lack causing inadequate water management.
Reservoirs
- The existing 11 reservoirs were mostly constructed late 1970s in the project area, to collect rainfall (water harvesting). These have been used for irrigation of paddy fields. They are deteriorated due to lack of maintenance work.</td></tr>
<tr><td>(5) Agricultural Development Plan</td><td>The agriculture development plan indicated in comparison with the present condition is as follows;

Agriculture Development Plan (Paddy Production)
<table>
<tr><td></td><td colspan="3">With Project</td><td>Present</td><td></td></tr>
<tr><td></td><td>Early Rainy</td><td>Rainy Season</td><td>Annual</td><td>Annual</td><td>Increment</td></tr>
<tr><td>Cropped Area</td><td>215ha</td><td>2,210ha</td><td>2,425ha</td><td>2,445ha</td><td>-20ha</td></tr>
<tr><td>Yield</td><td>3.3t/ha</td><td>3.0 ~ 3.3t/ha</td><td>3.0 ~ 3.3t/ha</td><td>1.5 ~ 2.4t/ha</td><td>-</td></tr>
<tr><td>Production</td><td>710t</td><td>6,695t</td><td>7,405t</td><td>4,797t</td><td>2,608t</td></tr>
</table>
Refer to Appendix D
At a full development stage, an incremental production of paddy of 2,600 t/year from the present level is aimed at.</td></tr>
<tr><td>(6) Irrigation Development Plan</td><td>The project is planned to develop irrigated agriculture in 2,210 ha of paddy fields. The project area is scattered along North Main Canal in Chbar Mon and Samraong Tong Districts in Kampong Speu province.
A complete irrigation will be achieved in the entire project area at least 4 years out of five (80% dependability) from the view point of water resources in the rainy season. Water is diverted from the Prek Thnot River at Roleang Chrey Regulaotr flows in the North Main Canal, and will be finally distributed to paddy field through secondary and tertiary canals. To achieve this all canals are proposed to be rehabilitated and improved to maintain proper water level for gravity irrigation. Related structures such as check structures, turnouts are planned at diversion point on the main canal. To avoid the canals being obstacle of public transportation, culvert or bridges are also planned on the canal. The design discharge of North Main Canal varies from 10.4 m3/sec to 5.8 m3/sec at end point. All stretch of the North Main Canal (32 km) is proposed to be rehabilitated by the project, so that water availability in the downstream area will be also improved.
Existing ponds are also to be rehabilitated to recover original designed storage capacity. Those ponds are planned to receive irrigation water from North Main Canal, and function as a regulating pond to store inflow and regulate outflow to the downstream paddy field.
The project proposes to apply participatory approach in the planning tertiary canal system and construction of quaternary canals. Tertiary and quaternary canals layout will be determined through workshop by farmers in the planning stage. Quaternary canals will be constructed by farmers under guidance of the government. Formation and strengthen of FWUC shall be implemented before detailed design work.</td></tr>
<tr><td>(7) Project Component</td><td>(i) Construction works
- Rehabilitation of North Main Canal from Andong Sla Intake Gate up to end of the canal (32 km) including construction of related structures
- Rehabilitation of existing secondary canals (4.9 km), construction of new secondary canals (5.2 km), and rehabilitation of tertiary canal systems for 2,210 ha, including related structures such as turnouts, checks, culverts and drainage canals
- Rehabilitation of 11 water harvesting facilities (ponds) including intake structure and</td></tr>
</table>

	irrigation canal system (ii) Procurement of O&M (operation and maintenance) equipment (iii) Formation and strengthening of FWUC/FWUGs/WUGs (iv) Agricultural support services - Field Programs, Farmer/Farmer Group Training Programs (including training of village extension agents), Mass Guidance & Workshop, staff empowerment (v) Engineering Services - Survey, design, preparation of tender documents, and construction supervision - To prepare operation rule and operation manual of facilities - To reinforce organization for O&M of the project facility.
(8) Required Cost	Total US$11,332,000 (*refer to Appendix H*)
(9) Executing Agency	MOWRAM and MAFF
(10) Implementation	*As shown below*

	Activities	Expected Results	2011				2012				2013				2014				2015	In-charge	Equipment	Remarks
			1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12				
(1)	Survey, Design, Preparation of Tender Documents including Drawings	Design reports & drawings, tender docs.																				
	- Topo survey of main and secodnary canals																					
	- Design of main and secodnary canals																			Consultant	As required	
	- Topo survey of tertiary area																					
	- Design of tertiary canal																			Consultant	As required	
(2)	Tender and Contract award	Contract																				
	- Main and secondary canals																			MOWRAM	As required	
	- Tertiary canals																			MOWRAM	As required	
(3)	Construction work of irrigation facilities	Facilities																				
	- Main and secondary canals																			Contractor	As required	
	- Tertiary canals																			Contractor	As required	
	- Quaternary canals																			Farmers/PDOWRAM		
(4)	Preparation of O&M manual	O&M manual																		Consultant/ Contractor	As required	
(5)	Formation of FWUC	FWUC, FWUG and																		PDOWRAM/ NGO	As required	
(6)	Workshop for tertiary canal system layout	Tertiary canal layout																		PDOWRAM/ NGO	As required	
(7)	Training FWUC for water management	Dissemination of water saving system																		PDOWRAM/ NGO	As required	
(8)	Implementation of agriculture support programs	Dissemination of improved rice production system																		MAFF/PDA/ NGO	As required	

Rainy season

**: estimated assuming that Roleang Chrey Regulatot and Intakes have been completed prior to commencement of this project*

F-4.2.3 Upper South Main Canal Irrigated Agriculture Improvement Project

(1) Title of Project	Upper South Main Canal Irrigated Agricultural Improvement Project
(2) Location	District: Chbar Mon, Samraong Tong, Province: Kampong Speu
(3) Objective of Project	The project aims to increase rice production in the upper south area (2,880ha) by improvement of irrigation system and strengthening of agricultural support services and FWUCs
(4) Site Description	The South Main Canal (SMC) has been recently constructed by MOWRAM. However, all canals have not been well maintained until now due to lack of government budget. Further, secondary and tertiary canals, related structures such as turnouts, regulators, culverts are not sufficiently constructed. Water in the SMC is not efficiently delivered to paddy fields at present because of the reasons above. This appears one of the important reasons of low agricultural productivity in the area. Farmers excavate canal embankment and bury small pipe intakes in the embankment without compacting soils. This frequently causes collapse of the SMC. **South Main Canal and related structures** - The South Maim Canal of about 26 km has been recently constructed. However, its design considerably deviates from ordinal irrigation canal design. The present canal is designed to keep water level lower than adjacent paddy fields. A few water level regulator were constructed, however, water level in the secondary or tertiary canal is still lower than paddy field. A pump irrigation is practiced in many places.

Water level in the canal is lower than paddy field

Breach of bank of South Main Canal due to seepage

- Permanent turnouts which divert water from main canal to secondary and tertiary canals are rarely constructed. It makes difficult farmers take water from main canal. To solve this problem, farmers excavated canal and bury pipes. They do not properly backfill the canal causing collapse of canal.

Water level in the subsidiary canal is lower than paddy field resulting unable gravity irrigation.

Secondary canals and related structures

- The number and length of secondary canals are not sufficient for adequate irrigation.
- The water level is designed lower than adjacent paddy field.
- Existing turnouts and regulators are deteriorated, and insufficient for proper water management.
- At present, definition and classification of secondary canal and tertiary canal is not clear and not precise, so some existing secondary canal commands very large area in which proper water management activities are not able to be implemented.

Tertiary canal systems

- A size and number of tertiary system is lack causing inadequate water management.

Ponds

- The existing 4 ponds were mostly constructed late 1970s in the project area, to collect rainfall (water harvesting). These have been used for irrigation of paddy fields. They are deteriorated due to lack of maintenance work.

A pond for water harvesting, dike was severely washed away

A intake structure at water harvesting pond is very deteriorated

(5) Agricultural Development Plan

The agriculture development plan indicated in comparison with the present condition is as follows;

Agriculture Development Plan (Paddy Production)

	With Project			Present	Increment
	Early Rainy	Rainy Season	Annual	Annual	
Cropped Area		2,880ha	2,880ha	2,905	-25ha
Yield		3.0t/ha	3.0t/ha	1.5 ~ 2.1t/ha	-
Production		8,640t	8,640t	5,471t	3,169t

Refer to Appendix D

At a full development stage, an incremental production of paddy of some 3,200 t/year from the present level is aimed at.

(6) Irrigation Development Plan

The project is planned to develop irrigated agriculture in 2,880 ha of paddy fields. The project area is scattered along South Main Canal in Chbar Mon and Samraong Tong Districts in Kampong Speu province.

A complete irrigation will be achieved in the entire project area at least 4 years out of five (80% dependability) from the view point of water resources in the rainy season.

Water is diverted from the Prek Thnot River at Roleang Chrey Regulaotr flows in the South Main Canal, and will be finally distributed to paddy field through secondary and tertiary canals. To achieve this all canals are proposed to be rehabilitated and improved to maintain proper water level for gravity irrigation. Related structures such as check structures, turnouts are planned at diversion point on the main canal. To avoid the canals being obstacle of public transportation, culvert or bridges are also planned on the canal.

The design discharge of South Main Canal varies from 16.3 m3/sec to 6.6 m3/sec at end point. Out of 32km, 25 km is proposed to be rehabilitated by the project, so that water availability in the upstream and middle stream area will be also improved.

Existing ponds are also to be rehabilitated to recover original designed storage capacity. Those ponds are planned to receive irrigation water from South Main Canal, and function as a regulating pond to store inflow and regulate outflow to the downstream paddy field.

The project proposes to apply participatory approach in the planning tertiary canal system and construction of quaternary canals. Tertiary and quaternary canals layout will be determined through workshop by farmers in the planning stage. Quaternary canals will be constructed by farmers under assist and advice by the government. Formation and strengthen of FWUC shall be implemented in parallel with project implementation.

(7) Project Component

(i) Construction works

- Rehabilitation of South Main Canal from 7 km up to 25 km including construction of related structures
- Rehabilitation of existing secondary canals (9.5 km), construction of new secondary canals (21.3 km), and rehabilitation of tertiary canal systems for 2,880 ha, including related structures such as turnouts, checks, culvers and drainage canals,
- Rehabilitation of 4 water harvesting facilities (ponds) including intake structure and irrigation canal system

(ii) Procurement of O&M (operation and maintenance) equipment

(iii) Formation and strengthening of FWUC/FWUG

(iv) Agricultural support services

	- Field Programs, Farmer/Farmer Group Training Programs (including training of village extension agents), Mass Guidance & Workshop, staff empowerment (v) Engineering Services - Survey, design, preparation of tender documents, and construction supervision - To prepare operation rule and operation manual of facilities - To reinforce organization for operation and maintenance of the project facility.
(8) Required Cost	Total: US$9,871,000 (*refer to Appendix H*)
(9) Executing Agency	MOWRAM and MAFF
(10) Implementation	*As shown below*

	Activities	Expected Results	2011				2012				2013				2014				2015	In-charge	Equipment	Remarks
			1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12				
(1)	Survey, Design, Preparation of Tender Documents including Drawings	Design reports & drawings, tender docs.																				
	- Topo survey of main and secodnary canals		■																			
	- Design of main and secodnary canals			■	■	■														Consultant	As required	
	- Topo survey of tertiary area						■	■														
	- Design of tertiary canal							■	■	■										Consultant	As required	
(2)	Tender and Contract award	Contract																				
	- Main and secondary canals				■	■														MOWRAM	As required	
	- Tertiary canals								■	■										MOWRAM	As required	
(3)	Construction work of irrigation facilities	Facilities																				
	- Main and secondary canals						■	■	■	■	■	■	■	■						Contractor	As required	
	- Tertiary canals									■	■	■	■	■	■	■	■	■		Contractor	As required	
	- Quaternary canals									■	■	■	■	■	■	■	■	■		Farmers/PDOWRAM		
(4)	Preparation of O&M manual	O&M manual								■	■									Consultant/ Contractor	As required	
(5)	Formation of FWUC	FWUC, FWUG and		■	■															PDOWRAM /NGO	As required	
(6)	Workshop for tertiary canal system layout	Tertiary canal layout			■	■	■													PDOWRAM /NGO	As required	
(7)	Training FWUC for water management	Dissemination of water saving system										■	■	■	■	■	■	■	■	PDOWRAM /NGO	As required	
(8)	Implementation of agriculture support programs	Dissemination of improved rice production										■	■	■	■	■	■	■	■	MAFF/PDA/ NGO	As required	

Rainy season

**: estimated assuming that Roleang Chrey Regulatot and Intakes have been completed prior to commencement of this project.*

F-4.3 Zone-2 Projects

F-4.3.1 Lower North Main Canal Irrigated Agriculture Improvement Project

<table>
<tr><td>(1) Title of Project</td><td>Lower North Main Canal Irrigated Agriculture Improvement Project</td></tr>
<tr><td>(2) Location</td><td>District: Angk Snuol, Province: Kandal</td></tr>
<tr><td>(3) Objective of Project</td><td>The project aims to increase rice production in the lower north area (1,390ha) by improvement of irrigation system and strengthening of agricultural support services and FWUCs.</td></tr>
<tr><td>(4) Site Description</td><td>The most downstream part of NMC has been recently constructed by MOWRAM. However, secondary and tertiary canals, related structures are not sufficiently constructed due to lack of budget. Water in the NMC is not efficiently delivered to paddy fields at present because of the reasons above. This appears one of the important reasons of low agricultural productivity in the area. Farmers excavate canal embankment and bury small pipe intakes in the embankment without compacting soils. This frequently causes collapse of the NMC.
Secondary canals and related structures
- The number and length of secondary canals are insufficient.
- The water level is designed lower than adjacent paddy field.
- At present, definition and classification of secondary canal and tertiary canal is not clear and not precise, so some existing secondary canal commands very large area in which proper water management activities are not able to be implemented.
- Permanent turnouts which divert water from secondary canal to tertiary canals are rarely constructed. It makes difficult farmers take water from canal.
- Culverts are not sufficiently provided in the canal causing people difficult to crossing canal for daily activities. To solve this people block the canal by soil burying pipes resulting decrease of flow capacity in the canal.
 
No turnout to the tertiary canal, water level in the canal is lower than paddy field resulting unable gravity irrigation.
 
Water level in the canal is too low to irrigate by gravity
Tertiary canal systems
- Sizes and numbers of tertiary systems are insufficient.</td></tr>
<tr><td>(5) Agricultural Development Plan</td><td>The agriculture development plan indicated in comparison with the present condition is as follows;
Agriculture Development Plan (Paddy Production)
<table>
<tr><td></td><td colspan="3">With Project</td><td>Present</td><td></td></tr>
<tr><td></td><td>Early Rainy</td><td>Rainy Season</td><td>Annual</td><td>Annual</td><td>Increment</td></tr>
<tr><td>Cropped Area</td><td>200ha</td><td>1,390ha</td><td>1,590ha</td><td>1,400</td><td>190ha</td></tr>
<tr><td>Yield</td><td>3.3t/ha</td><td>2.8t/ha</td><td>2.8 ~ 3.3t/ha</td><td>1.5 ~ 2.1t/ha</td><td>-</td></tr>
<tr><td>Production</td><td>660t</td><td>3,892t</td><td>4,552t</td><td>2,430t</td><td>2,122t</td></tr>
</table>
Refer to Appendix D
At a full development stage, an incremental production of paddy of 2,100 t/year from the present level is aimed at.</td></tr>
<tr><td>(6) Irrigation Development Plan</td><td>The project is planned to develop irrigated agriculture in 1,390 ha of paddy fields. The project area is scattered downstream of North Main Canal in Angk Snuol District in Kandal Province. A supplemental irrigation will be achieved in the entire project area at least 3 years out of six (50% dependability) from the view point of water resources in the rainy season.
Water is diverted from the Prek Thnot River at Roleang Chrey Regulaotr flows in the North Main Canal, and will be finally distributed to paddy field through secondary and tertiary canals. To achieve this all canals are proposed to be rehabilitated and improved to</td></tr>
</table>

	maintain proper water level for gravity irrigation. Related structures such as check structures, turnouts are planned at diversion point on the main canal. To avoid the canals being obstacle of public transportation, culvert or bridges are also planned on the canal. Design discharge of 5.8 m3/sec will be conveyed to the project area at peak period. All secondary and tertiary canals is proposed to be rehabilitated by the project, so that water availability in the downstream area will be also improved. The project proposes to apply participatory approach in planning tertiary canal system and construction of quaternary canals. Tertiary and quaternary canals layout will be determined through workshop by farmers. Quaternary canals will be constructed by farmers under assist and advice by the government. Formation and strengthen of FWUC shall be implemented before detailed design work.
(7) Project Component	(i) Construction works - Rehabilitation of existing secondary canals (8.6 km), construction of new secondary canals (10.9 km), and rehabilitation of tertiary canal systems for 1,390 ha, including related structures such as turnouts, checks, culvers and drainage canals (ii) Procurement of O&M (operation and maintenance) equipment (iii) Formation and strengthening of FWUC/FWUG (iv) Agricultural support services - Field Programs, Farmer/Farmer Group Training Programs (including training of village extension agents), Mass Guidance & Workshop, staff empowerment (v) Engineering Services - Survey, design, preparation of tender documents, and construction supervision - To prepare operation rule and operation manual of facilities - To reinforce organization for O&M of the project facility.
(8) Required Cost	Total US$3,190,000 *(refer to Appendix H)*
(9) Executing Agency	MOWRAM and MAFF
(10) implementation	

	Activities	Expected Results	2011				2012				2013				2014				In-charge	Equipment	Remarks
			1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12			
(1)	Survey, Design, Preparation of Tender Documents including Drawings	Design reports & drawings, tender docs.																			
	- Topo survey of secodnary canals		■																		
	- Design of secodnary canals			■	■														Consultant	As required	
	- Topo survey of tertiary area					■	■														
	- Design of tertiary canal						■	■	■										Consultant	As required	
(2)	Tender and Contract award	Contract																			
	- Secondary canals				■														MOWRAM	As required	
	- Tertiary canals								■										MOWRAM	As required	
(3)	Construction work of irrigation facilities	Facilities																			
	- Secondary canals						■	■											Contractor	As required	
	- Tertiary canals										■	■							Contractor	As required	
	- Quaternary canals										■	■							Farmers/PDWRAM		
(4)	Preparation of O&M manual	O&M manual									■	■		■					Consultant/ Contractor	As required	
(5)	Formation of FWUA	FWUA and WUG	■	■															PDWRAM/ NGO	As required	
(6)	Workshop for tertiary canal system layout	Tertiary canal layout		■	■	■													PDWRAM/ NGO	As required	
(7)	Training FWUA for water management	Dissemination of water saving system										■	■	■	■	■	■	■	PDWRAM/ NGO	As required	
(8)	Implementation of agriculture support programs	Dissemination of improved rice production										■	■	■	■	■	■	■	MAFF/PDA /NGO	As required	

Rainy season

**: estimated assuming that Roleang Chrey Regulatot and Intakes,Upper South Main Canal Improvement Project and Ou Kurang Irrigated Improvement Projec have been completed prior to commencement of this project.*

F-4.3.2 Lower South Main Canal Irrigated Agriculture Improvement Project

(1) Title of Project	Upper South Main Canal Irrigated Agricultural Improvement Project
(2) Location	District: Kong Pisei, Kandal Stung, Province: Kampong Speu, Kandal
(3) Objective of Project	The project aims to increase rice production in the lower south area (6,750ha) by improvement of irrigation system and strengthening of agricultural support services and FWUCs
(4) Site Description	The South Main Canal (SMC) has been recently constructed by MOWRAM. However, all canals have not been well maintained until now due to lack of government budget. Further, secondary and tertiary canals, related structures such as turnouts, regulators, culverts are not sufficiently constructed. Water in the SMC is not efficiently delivered to paddy fields at present because of the reasons above. This appears one of the important reasons of low agricultural productivity in the area. Farmers excavate canal embankment and bury small pipe intakes in the embankment without compacting soils. This frequently causes collapse of the SMC.

South Main Canal and related structures

- The South Maim Canal of about 26 km has been recently constructed. However, its design considerably deviates from ordinal irrigation canal design. The present canal is designed to keep water level lower than adjacent paddy fields. A few water level regulator were constructed, however, water level in the secondary or tertiary canal is still lower than paddy field. A pump irrigation is practiced in many places.

Secondary from South MC, water level is low because the canal was a river before

End structure of South MC

- Permanent turnouts which divert water from main canal to secondary and tertiary canals are rarely constructed. It makes difficult farmers take water from main canal. To solve this problem, farmers excavated canal and bury pipes. They do not properly backfill the canal causing collapse of canal.

Water level in the subsidiary canal is lower than paddy field resulting unable gravity irrigation.

Secondary canals and related structures

- The number and length of secondary canals are not sufficient for adequate irrigation.
- The water level is designed lower than adjacent paddy field.
- Existing turnouts and regulators are deteriorated, and insufficient for proper water management.
- At present, definition and classification of secondary canal and tertiary canal is not clear and not precise, so some existing secondary canal commands very large area in which proper water management activities are not able to be implemented.

Tertiary canal systems

- A size and number of tertiary system is lack causing inadequate water management.

Reservoirs

- The existing 5 reservoirs were mostly constructed late 1970s in the project area, to collect rainfall (water harvesting). These have been used for irrigation of paddy fields. They are deteriorated due to adverse soil characteristics and lack of maintenance work.

Erosion at dispersive soil embankment

Embankment was collapsed due to seepage along pipe buried

(5) Agricultural Development Plan

The agriculture development plan indicated in comparison with the present condition is as follows;

Agriculture Development Plan (Paddy Production)

	With Project			Present	
	Early Rainy	Rainy Season	Annual	Annual	Increment
Cropped Area	1,000ha	6,750ha	7,750ha	6,880ha	870ha
Yield	3.3t/ha	2.8t/ha	2.8 ~ 3.3t/ha	1.5t/ha	-
Production	3,300t	18,900t	22,200t	10,320t	11,880t

Refer to Appendix D

At a full development stage, an incremental production of paddy of 11,900 t/year from the present level is aimed at.

(6) Irrigation Development Plan

The project is planned to develop irrigated agriculture in 6,750 ha of paddy fields. The project area is scattered along South Main Canal in Kong Pisei District and Kandal Stung District in Kampong Speu province and Kandal Province respectively.

A complete irrigation will be achieved in the entire project area at least 3 years out of six (50% dependability) from the view point of water resources in the rainy season.

Water is diverted from the Prek Thnot River at Roleang Chrey Regulaotr flows in the South Main Canal, and will be finally distributed to paddy field through secondary and tertiary canals. To achieve this all canals are proposed to be rehabilitated and improved to maintain proper water level for gravity irrigation. Related structures such as check structures, turnouts are planned at diversion point on the main canal. To avoid the canals being obstacle of public transportation, culvert or bridges are also planned on the canal.

The design discharge of South Main Canal varies from 16.3 m3/sec to 6.6 m3/sec at end point. Out of 31km, 6 km in downstream part is proposed to be rehabilitated by the project, so that water availability in the upstream and middle stream area will be also improved.

Existing reservoirs are also to be rehabilitated to recover original designed storage capacity. Those reservoirss are planned to receive irrigation water from South Main Canal, and function as a regulating reservoir to store inflow and regulate outflow to the downstream paddy field.

The project proposes to apply participatory approach in the planning tertiary canal system and construction of quaternary canals. Tertiary and quaternary canals layout will be determined through workshop by farmers in the planning stage. Quaternary canals will be constructed by farmers under assist and advice by the government. Formation and strengthen of FWUC shall be implemented in parallel with project implementation.

(7) Project Component

(i) EIA Study *(Refer to Appendix I)*

(ii) Construction works

- Rehabilitation of South Main Canal from 25 km to 31 km including construction of related structures
- Rehabilitation of existing secondary canals (5.8 km), construction of new secondary canals (60.5 km), and rehabilitation of tertiary canal systems for 6,750 ha, including related structures such as turnouts, checks, culvers and drainage canals,
- Rehabilitation of 5 water harvesting facilities (reservoirss) including intake structure and irrigation canal system

(iii) Procurement of O&M equipment

(iv) Formation and strengthening of FWUC/FWUG

	(v) Agricultural Support Services - Field Programs, Farmer/Farmer Group Training Programs (including training of village extension agents), Mass Guidance & Workshop, staff empowerment (vi) Engineering Services - Survey, design, preparation of tender documents, and construction supervision - To prepare operation rule and operation manual of facilities - To reinforce organization for operation and maintenance of the project facility.
(8) Required Cost	Total: US$15,183,000 *(refer to Appendix H)*
(9) Executing Agency	MOWRAM and MAFF
(10) Implementation	As shown below

	Activities	Expected Results	2011				2012				2013				2014				2015				In-charge	Equipment	Remarks
			1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12			
(1)	Survey, Design, Preparation of Tender Documents including Drawings	Design reports & drawings, tender docs.																							
	- Topo survey of main and secodnary canals																								
	- Design of main and secodnary canals																						Consultant	As required	
	- Topo survey of tertiary area																								
	- Design of tertiary canal																						Consultant	As required	
	- Environmental Impact Assessment Study	EIA report																					Consultant	As required	
(2)	Tender and Contract award	Contract																							
	- Main and secondary canals																						MOWRAM	As required	
	- Tertiary canals																						MOWRAM	As required	
(3)	Construction work of irrigation facilities	Facilities																							
	- Main and secondary canals																						Contractor	As required	
	- Tertiary canals																						Contractor	As required	
	- Quaternary canals																						Farmers/PDWRAM		
(4)	Preparation of O&M manual	O&M manual																					Consultant/ Contractor	As required	
(5)	Formation of FWUA	FWUA and WUG																					PDWRAM/ NGO	As required	
(6)	Workshop for tertiary canal system layout	Tertiary canal layout																					PDWRAM/ NGO	As required	
(7)	Training FWUA for water management	Dissemination of water saving system																					PDWRAM/ NGO	As required	
(8)	Implementation of agriculture support programs	Dissemination of improved rice production																					MAFF/PDA /NGO	As required	

Rainy season

**: estimated assuming that Roleang Chrey Regulatot and Intakes,Irrigated Agriculture Improvement Model Irrigation Project and Upper South Irrigated Agriculture Improvement Project have been completed prior to commencement of this project.*

F-4.3.3 Ou Krang Ambel Irrigated Agriculture Improvement Project

(1) Title of Project	Ou Krang Ambel Irrigated Agriculture Improvement Project
(2) Location	District: Samraong Tong, Angk Snuol, Province: Kampng Speu, Kandal
(3) Objective of Project	The project aims to increase of rice production in the Ou Krang Ambel area (2,900ha) by improvement of irrigation system and strengthening of agricultural support services and FWUCs.
(4) Site Description	Ou Krang Ambel Reservoir and irrigation system was constructed on the Krang Ambel River to irrigate about 500 ha in the late 1970s. The catchment area of the reservoir was about 450 km^2. Inflow to the reservoir, however, has been decreasing due to further irrigated agriculture development in the upstream. Construction of Ta Hor Canal was also started in the late 1970s from the Prek Thnot River to the beneficial area. A diversion weir was once constructed in the Prek Thnot river, but it was washed away by a flood. To cope with this problem the Government connected a main canal from Ou Krang Ambel Pond with Ta Hor Canal. The Government extended NMC from Roleang Chrey 14 km, and constructed a diversion channel and Tousamn Ang Check Gate to supply irrigation water from the Prek Thnot River to the reservoir. At present, the irrigation area of the reservoir and Ta Hor Canal mostly receive irrigation water from the Prek Thnot River in addition to the flow in the Krang Ambel River.

Tousamn Ang Check Structure to divert water from NMC to Ou Krang Ambel Reservoir.

Ou Krang Ambel Intake Gate, 4 steel slide gates are manually operated

The downstream apron of the Tousamn Ang Check Structure is eroded and requires some modification work to prevent further erosion. The approach road also needs modification to ease ox-drawn cart and motor cycle traffic.

Ou Krang Ambel Intake functions fairly well at present except for leakage from damaged rubber seals.

Ta Hor Canal water level is lower than the paddy field

End of Ta Hor Canal

Ta Hor Canal is deteriorated due to lack of maintenance. The water level in the canal is not enough high for gravity irrigation. Secondary and tertiary canals and related structures such as turnouts, regulators, and culverts are not sufficiently constructed due to lack of budget. This appears to be one of the important reasons for low agricultural productivity in the area.

Secondary canals and related structures

<table>
<tr><td></td><td>
- The number and length of secondary canals are not sufficient for adequate irrigation.
- The water level is designed lower than the adjacent paddy fields.
- At present, the definition and classification of the secondary and tertiary canals is not clear and not precise, so some existing secondary canals command very large areas in which proper water management activities are not able to be implemented.
- Permanent turnouts which divert water from secondary canals to tertiary canals are rarely constructed. It makes it difficult for farmers to take water from the canal.
- Culverts are not sufficiently provided in the canal causing people difficulty in crossing the canal for daily activities. To solve this, people block the canal by burying pipes resulting in a decrease of flow capacity in the canal.
Tertiary canal systems
- The low density of tertiary canals is causing poor water management.
</td></tr>
<tr><td>(5) Agricultural Development Plan</td><td>
The agriculture development plan indicated in comparison with the present condition is as follows;
Agriculture Development Plan (Paddy Production)
<table>
<tr><td rowspan="2"></td><td colspan="3">With Project</td><td>Present</td><td rowspan="2">Increment</td></tr>
<tr><td>Early Rainy</td><td>Rainy Season</td><td>Annual</td><td>Annual</td></tr>
<tr><td>Cropped Area</td><td>400ha</td><td>2,900ha</td><td>3,300ha</td><td>2,930ha</td><td>370ha</td></tr>
<tr><td>Yield</td><td>3.3t/ha</td><td>2.8t/ha</td><td>2.8 ~ 3.3t/ha</td><td>1.5 ~ 2.1t/ha</td><td>-</td></tr>
<tr><td>Production</td><td>1,320t</td><td>8,120t</td><td>9,440t</td><td>5,091t</td><td>4,349t</td></tr>
</table>
Refer to Appendix D
At a full development stage, an incremental production of paddy of 4,300 t/year from the present level is aimed at.
</td></tr>
<tr><td>(6) Irrigation Development Plan</td><td>
The project is planned to develop irrigated agriculture in 2,900 ha of paddy fields. The project area is scattered downstream of Ou Krang Ambel Pond in Samraong Tong District and Angk Snuol District in Kampong Speu Province and Kandal Province respectively. A supplemental irrigation will be achieved in the entire project area at least 3 years out of six (50% dependability) from the view point of water resources in the rainy season.
Water is diverted from the Prek Thnot River at Roleang Chrey Regulaotr flows in the North Main Canal, Tousamn Check Gate, and Ou Krang Ambel Pond.
To achieve this all canals are proposed to be rehabilitated and improved to maintain proper water level for gravity irrigation. Related structures such as check structures, turnouts are planned at diversion point on the main canal. To avoid the canals being obstacle of public transportation, culvert or bridges are also planned on the canal.
A 4.6 m3/sec will be conveyed to the project area at peak period and depending on the river discharge of the Prek Thnot River. All secondary and tertiary canals are proposed to be rehabilitated by the project, so that water availability in the downstream area will be also improved.
The project proposes to apply participatory approach in the planning tertiary canal system and construction of quaternary canals. Tertiary and quaternary canals layout will be determined through workshop by farmers in the planning stage. Quaternary canals will be constructed by farmers under assist and advice by the government. Formation and strengthen of FWUCs shall be implemented before detailed design work.
</td></tr>
<tr><td>(7) Project Component</td><td>
The followings project components are planned:
(i) Construction works
- Rehabilitation of the Tousamn Check Gate, Ou Krang Ambel Intake Gate, about 21 km of the Ta Hor Canal , existing secondary canals (11.7 km), construction of new secondary canals (8.3 km), and rehabilitation of tertiary canal systems for 2,900 ha, including related structures such as turnouts, checks, culverts and drainage canals
(ii) Procurement of O&M (operation and maintenance) equipment
(iii) Formation and strengthening of FWUC/FWUGs/WUGs
</td></tr>
</table>

	(iv) Agricultural support services - Field Programs, Farmer/Farmers' Group Training Programs (including training of village extension agents), Mass Guidance & Workshops, staff empowerment (v) Engineering Services - Survey, design, preparation of tender documents, and construction supervision - Prepare operation rules and an operation manual for the facilities - Reinforce FWUCs for O&M of the facilities
(8) Required Cost	Total US$7,219,000 *(Refer to Appendix H)*
(9) Executing Agency	MOWRAM and MAFF
(10) Implementation	As shown below

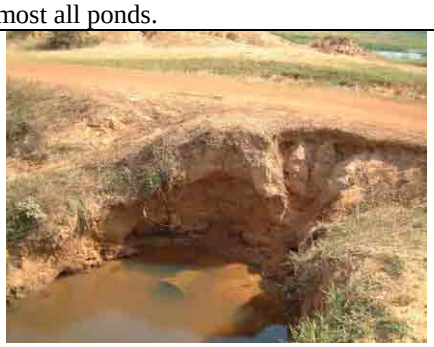
	Activities	Expected Results	2012				2013				2014				2015				In-charge	Equipment	Remarks
			1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12			
(1)	Survey, Design, Preparation of Tender Documents including Drawings	Design reports & drawings, tender docs.																			
	- Topo survey of main and secodnary canals																				
	- Design of main and secodnary canals																		Consultant	As required	
	- Topo survey of tertiary area																				
	- Design of tertiary canal																		Consultant	As required	
(2)	Tender and Contract award	Contract																			
	- Main and secondary canals																		MOWRAM	As required	
	- Tertiary canals																		MOWRAM	As required	
(3)	Construction work of irrigation facilities	Facilities																			
	- Main and secondary canals																		Contractor	As required	
	- Tertiary canals																		Contractor	As required	
	- Quaternary canals																		Farmers/PDOWRAM		
(4)	Preparation of O&M manual	O&M manual																	Consultant/ Contractor	As required	
(5)	Formation of FWUC	FWUA and WUG																	PDOWRAM/ NGO	As required	
(6)	Workshop for tertiary canal system layout	Tertiary canal layout																	PDOWRAM/ NGO	As required	
(7)	Training FWUC for water management	Dissemination of water saving system																	PDWRAM/N GO	As required	
(8)	Implementation of agriculture support services	Dissemination of improved rice production																	MAFF/PDA/ NGO	As required	

Rainy season

**: estimated assuming that Roleang Chrey Regulatot and Intakes have been completed prior to commencement of this project.*

F-4.4 Zone-3 Project

F-4.4.1 Water Harvesting Irrigated Agriculture Improvement Project

(1) Title of Project	Water Harvesting Irrigated Agricultural Improvement Project
(2) Location	District: Chbar Mon, Samraong Tong, Kong Pisei, Angk Snuol Province: Kampong Speu, Kandal
(3) Objective of Project	The project aims to increase rice production in the Zone-3 area (1,200 ha in total) by improvement of the irrigation system, strengthening of agricultural support services and formation of FWUCs
(4) Site Description	There are 49 water harvesting ponds in the project area. Those were mostly constructed in 1970s. Total catchment area of those reservoirs is 181 km2 varying from 22km2 to 10 ha. Storage volume is 22,000,000 m3 in total of all reservoirs varying from 10,000 m3 to 4,900,000 m3 at one pond. All streams flow in each catchmetn area does not have perennial flow, so it should be classified into water harvesting facility. All ponds have been deteriorated due to lack of maintenance. Further, irrigation canals and related structures such as turnouts, regulators, culverts are not sufficiently constructed. Water in the ponds is not efficiently delivered to paddy fields at present because of the reasons above. This appears one of the important reasons of low agricultural productivity in the area. Farmers excavate canal embankment and bury small pipe intakes in the embankment without compacting soils. This frequently causes collapse of the SMC. **Water Harvesting Ponds** - The existing 49 ponds were mostly constructed late 1970s in the project area, to collect rainfall (water harvesting). These have been used for irrigation of paddy fields. They are deteriorated due to adverse soil characteristics and lack of maintenance work. - Intake gates were taken or broken at almost all ponds.   *Erosion at dispersive soil embankment* *Embankment was collapsed due to seepage along buried pipe*
(5) Agricultural Development Plan	The agriculture development plan indicated in comparison with the present condition is as follows; **Cropping Pattern of Rice** See table below. At a full development stage, an incremental production of paddy of 1,200 t/year from the present level is aimed at.
(6) Irrigation Development Plan	The project is planned to develop irrigated agriculture in 1200 ha of paddy fields as a whole. The project area is scattered outside of the command areas of SMC and NMC. Irrigation will be achieved in the entire project area with a probability of 3 years out of 6 years (50% dependability) from the viewpoint of available water in the rainy season. The existing reservoirs are also to be rehabilitated to recover the original design storage capacity. The project proposes to apply a participatory approach in planning the supply canal systems and watercourses. Supply canal and watercourse layout will be determined through workshops with the farmers in the planning stage. Watercourses will be constructed by the farmers with assistance and advice from the government. Formation and strengthening of the FWUC shall be implemented in parallel with project

	Cropping Season	Cropped Area	Yield	Production
Without Project	Rainy Season	1,200ha	1.5 ~ 2.1 t/ha	2,160 t
With Project	Rainy Season	1,200ha	2.8 t/ha	3,360 t

	implementation.
(7) Project Component	(i) Construction works - Rehabilitation of existing water harvesting facilities (reservoirs) at 49 sites - Rehabilitation of existing supply canals and construction of new supply canals of about 18 km. (ii) Procurement of O&M (operation and maintenance) equipment (iii) Formation and strengthening of FWUC/FWUGs/WUGs (iv) Agricultural Support Services - Field Programs, Farmer/Farmers' Group Training Programs (including training of village extension agents), Mass Guidance & Workshops, staff empowerment (v) Engineering Services - Survey, design, preparation of tender documents, and construction supervision - Prepare operation rules and an operation manual for the facilities - Reinforce the farmers organization for O&M of the facilities.
(8) Required Cost	Total: US$7,427,000 *(refer to Appendix H)*
(9) Executing Agency	MOWRAM and MAFF
(10) Implementation	As shown below

	Activities	Expected Results	2010				2011				2012				2013				2014				2015				In-charge	Equipment	Remarks
			1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12			
(1)	Survey, Design, Preparation of Tender Documents including Drawings	Design reports & drawings, tender docs.																											
	- Topo survey of reservoirs & canals by every system																										Consultant	As required	
	- Design of reservoir, intake & canal by every system																										Consultant	As required	
(2)	Tender and Contract award	Contract																											
	- Reservoir & canal system by every system																										MOWRAM	As required	
(3)	Construction work of irrigation facilities	Facilities																											
	- reservoir & canal system by every system																										Contractor	As required	
	- Watercourses by every system																										Contractor/Farmers	As required	
(4)	Preparation of O&M manual by every system	O&M manual																									Consultant	As required	
(5)	Formation of FWUC by every system	FWUC, FWUG and																									PDOWRAM/NGO	As required	
(6)	Workshop for canal system layout by every system	Tertiary canal layout																									Farmers/NGO	As required	
(7)	Training FWUC for water management	Dissemination of water saving system																									PDOWRAM/NGO	As required	
(8)	Implementation of agriculture support programs	Dissemination of improved rice production																									MAFF/PDA/NGO	As required	

Rainy season

F-4.5 Zones Crosscutting Project

F-4.5.1 Roleang Chrey Regulator and Intakes Improvement Project

(1) Title of Project	Roleang Chrey Regulator and Intakes Improvement Project
(2) Location	Village: Roelang Chrey, Commune: Taing Kruoch, District: Samraong Tong, Province: Kampong Speu
(3) Objective of Project	The project aims to make stable supply of water to main canals by improving the Roleang Chrey Regulator, Andong Sla intake and Vat Kroch Intake.
(4) Site Description	Roleang Chrey Regulator, Andong Sla Intake Gate, and Vat Kroch Intake Gate, and approach channels were constructed as main facilities of irrigation systems in the Prek Thnot river basin in early 1970s. The operation of these facilities control and affect irrigation water distribution in about 20,250 ha in Kampong Speu and Kandal provinces. **Roleang Chrey Regulator** - The Regulator has not been well maintained since it was constructed in early 1970s - Almost all gate wheels are not able to rotate due to rusting of shafts, and causing overload to hoist mechanism and difficult to operate precisely - Hoist system are heavily aged - All gates have been deteriorated after installation in early 1970s causing large amount of water leakage - Downstream apron and river side are severely eroded - A small outlet structure is required to control and release irrigation water and maintenance flow to downstream **Andong Sla Intake Gate and Vat Kruoch Intake Gate** - These structures have not been well maintained since it was constructed in early 1970s, - Very large leakage is observed from gates, - Electric parts such as motor and control cabinet were removed, the gates are to be operated manual crank, its operation is limited, - Approach channels need to be rehabilitated to recover the designed flow capacity.  Roleang Chrey Regulator  Water leakage at Andong Slat Intake Gate  *Vat Kruoch Intake Gate*
(5) Project Description	Roleang Chrey Regulator will supply irrigation and domestic water to the areas served by NMC (6,500ha) and SMC (10,200 ha). It is a linchpin of water utilization in the downstream portions of the Prek Thnot river basin. Should it malfunction, it will directly and severely affect irrigation water supply to all the irrigation systems concerned. All gates and hoisting systems are to be rehabilitated. The downstream apron and river

	side slope are severely eroded due to insufficient length of the apron and side slope protection. The downstream apron and river side slope are to be improved to assure the safety of the structure. The Regulator also has to release water to the downstream for the on-going Kandal Stung Irrigation Project (1,950 ha) and planned Tonle Bati Irrigation Project (1,600 ha). The size of the gates, however, are too large to control the amount of water to the downstream, which will vary from less than 1 m3/sec to about 5 m3/sec from month to month. A structure is to be constructed to assure and control the amount of water released to the downstream. Andong Sla Intake Gate and its approach channels are the first facility of NMC. The gates produce a large amount of leakage, and are not able to be operated adequately at present and need rehabilitation and improvement for modernized irrigation water management. Vat Kruoch Intake Gate and its approach channel are the first facilities of SMC. Appropriate operation is not executed at present due to poor condition of facilities. The project is a key, not only to maintain the present situation, but also to achieve sustainable development of the downstream area of 16,700ha of paddy field as a whole.
(6) Project Component	The followings activities are planned: (i) Rehabilitation and Improvement of Roleang Chrey Regulator - Rehabilitation of all gates and hoist systems of the Regulator, - Improvement of downstream apron and river side slope protection - Construction of rive outlet structure at right side of the Regulator - Construction of operators hut (ii) Reconstruction of Intake Gates - Reconstruction of Andong Sla Intake Gate and Vat Kruoch Intke Gate - Rehabilitation of approach channels to the Intake Gates - Construction of power transmission line from Regulator and Intake Gates (iii) Engineering Supporting Services - Survey, design, preparation of tender documents, and construction supervision - To prepare operation rule and operation manual of facilities - To reinforce organization for operation and maintenance of the project facility
(7) Required Cost	US$4,786,000 *(refer to Appendix H)*
(8) Executing Agency	MOWRAM
(9) Implementation	As shown below

	Activities	Expected Results	2009				2010				2011				In-charge	Equipment	Remarks
			1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12			
(1)	Survey, Design, Preparation of Tender Documents including Drawings	Design reports & drawings, tender docs.													Consultant	As required	
(2)	Tender and Contract award	Contract													MOWRAM	As required	
(3)	Construction work	Facilities													Contractor	As required	
(4)	Preparation of gate operation rule and manual	O&M manual													Consultant /Contracto	As required	
(5)	Training for Operator(s)	Upgraded operator(S)													Consultant /MOWRA	As required	

Rainy season

F-4.6 Subject-wise Improvement Projects

F-4.6.1 Technical Guidelines Preparation Project

(1) Title of Project	Technical Guidelines Preparation Project
(2) Location	Irrigation area in Zone-1, 2 and 3
(3) Objective of Project	The project aims at 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.
(4) Site Description	In the Target Area, it is observed that some irrigation facilities are not planned or designed properly. This hinders proper function of irrigation facilities and proper water distribution. In addition, dispersive clay soil which is commonly distributed in the Target Area caused problems on irrigation facilities. Canal embankments constructed by such soil were heavily eroded and damaged by water flow. However, it is not avoidable to use the dispersive clay soil as embankment material since it is very costly to bring other type of soil from very far place. Scientific reason and mechanism of the erosion is not clarified due to lack of basic data.  *A type of damaged canal embankment constructed by dispersive clay soil (so called a dragon hole by local people)*
(5) Project Description	The project activity includes preparation of technical guidelines on irrigation planning, design, construction, operation and maintenance by foreign senior irrigation specialists. Standard drawings of irrigation facilities and check list of works will support the guidelines. The guidelines should be able to be applied to all irrigation projects in the country. It means that the guidelines show only general procedures of planning and design. It should be stressed that planning concept or design criteria need to be prepared for each irrigation project referring the guidelines procedures. As described above, special consideration on dispersive clay soil is required in preparation of the guidelines. Data collection and analysis of the soil in laboratory and on site is required. After collection of such basic data, proper measure for using dispersive clay soil as embankment material will be developed by senior foreign soil mechanical engineers. Effectiveness of such method needs to be confirmed by experimental construction on site. Developed procedure for treatment of dispersive clay soil will be described in the guidelines. The guidelines should be prepared both in English and Khmer languages. The guidelines also need to be prepared by participatory approach. Effectiveness of draft guidelines need to be checked by model PDOWRAM irrigation engineers in actual irrigation development as much as possible. Based on findings in such trial usage of the guidelines, it should be revised. In addition, appropriate irrigation method will be mentioned in the guidelines considering the results of Pilot Projects.
(6) Project Component	- Development of proper measure for using dispersive clay soil for embankment - Preparation of irrigation planning / design / construction supervision / operation and maintenance guideline - Distribution of prepared guidelines - Dissemination activity on proper guidelines usage by MOWRAM
(7) Required Cost	US$ 1,725,000 *(refer to Appendix H)*
(8) Executing Agency	MOWRAM and PDOWRAM
(9) Implementation	As shown below.

Activities	Expected Results	2009								2010												2011			In-charge	Equipment	Remarks
		4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3			
I. Preparation of Practical Guidelines with Trial Usage and Participation of Guideline Users																												
(1) Development of Proper Measure for Using Dispersive Clay Soil for Embankment Material	Technical knowledge																									Consultant MOWRAM	Equipment	-
(2) Preparation of Irrigation Planning Guideline	Guideline																									Consultant MOWRAM PDOWRAM	None	-
(3) Preparation of Irrigation Design Guideline	Guideline																									Consultant MOWRAM PDOWRAM	None	-
(4) Preparation of Irrigation Construction Supervision Guidelines	Guideline																									Consultant MOWRAM PDOWRAM	None	-
(5) Preparation of Irrigation Operation and Maintenance Guideline	Guideline																									Consultant MOWRAM PDOWRAM	None	-
II. Dissemination of Guidelines by MOWRAM to PDOWRAMs																												
(1) Distribution of Prepared Guidelines	PDOWRAMs' understandings																									MOWRAM	None	-
(2) Dissemination Activities on Proper Guidelines Usage by MOWRAM to PDOWRAMs	PDOWRAMs' understandings																									MOWRAM	None	-

F-4.6.2 Irrigated Agriculture On-farm Technology Improvement Pilot Project

(1) Title of Project	Irrigated Agriculture On-farm Technology Improvement Pilot Project
(2) Location	Upstream of the irrigation system where efficient use water is most expected. Zone-1: A tertiary block in Kandal Dom commune which is upstream command area of the South Main Canal. Zone-3: Standard water harvesting irrigation systems will be selected..
(3) Objective of Project	The project aims at establishment of on-farm level efficient water use model in irrigated agriculture area.
(4) Site Description	Hydrological analysis in the Master Plan study concluded that water resources were so limited for agricultural development of the Target Area. Thus, the necessity of efficient irrigation water use is emphasized in the Master Plan. However, in the Target Area, proper irrigation water management is not practiced. The reasons for this improper water management are i) hardware constraints (such as insufficient provision of irrigation facilities) and ii) software constraints (such as lack of water distribution schedules). In some advanced areas, secondary canals, tertiary canals and structures on the secondary canals are currently in existence but water is not used efficiently due to insufficient on-farm facilities and software constraints. The photo on the right shows an advanced area in Kandal Dom commune located upstream of the SMC.  *Turnout Structure on Secondary Canal (RS-3) to Tertiary Canal (RT-2)*
(5) Project Description	The government's responsibility is to operate the major irrigation system, and the FWUCs' responsibility is to operate the minor systems, say on-farm system. However, no on-farm irrigation block in the Target Area is using irrigation water efficiently, so that it is essential to establish a model of efficient water use. As the first step of improvement, on-farm level improvement is required. Efficient water use could be achieved by collaboration with i) FWUCs/FWUGs/WUGs and ii) the government. The project plans to increase the water management capabilities of all the stakeholders at the same time. It is expected that such simultaneous capacity development will make the involved stakeholders realize their responsibilities. If the project activities start without proper irrigation facilities, farmers in the area will be discouraged regarding the project activities. The pilot project areas need to be selected considering this matter. If there could not find proper pilot project area from this viewpoint, minimum facilities should be constructed for smooth execution of proper water management activities. In Zone-3, project approach is quite different from Zone-1 since the available water is so limited. Water management and farming practice should also be conducted in different manner with Zone-1. The Pilot Project activities should be therefore planned and executed in due consideration of the above. The Pilot Project site will be selected considering that the small reservoir functions well for irrigation water supply subject to no provision of additional facilities. The project activity also includes introduction of improved farming practice in irrigated agricultural land. Introduction of improved farming practice could increase rice yield and encourage farmers to join project activities since only water management could not give ant incentive to farmers. The effect of the pilot project will be disseminated to the outer areas of the pilot project by implementing the "Irrigated Agriculture Improvement Model Project" after the pilot project.
(6) Project Component	The following practices will be conducted for Zone-1 - Preliminary landholding map preparation - Water use map preparation - Water loss identification and minimization - FWUC sub-group establishment

	- FWUC administration improvement. - Proper irrigation water use education - Irrigation service plan preparation - On-farm irrigation facility construction - Watercourse construction/rehabilitation - Water management training - FWUC meeting building construction The following practices will be conducted for Zone-3 - Preliminary landholding map preparation - Water use map preparation - FWUC establishment - Reservoir capacity clarification - Irrigation service plan preparation - Water management training The following practices will be conducted for Zone-1 and Zone-3 - Farmer-to farmer ecological SRI extension - Farmers' group strengthening - Experimental trial of improved farming practice - Execution of small scale adaptability tests for planting method, field level water management, fertilizer trail, variety trial, and upland crop cultivation trail
(7) Required Cost	US$800,000 *refer to Appendix H)*
(8) Executing Agency	MOWRAM, MAFF, PDOWRAM, and PDA
(9) Implementation	As shown below.

Activities		Expected Results	2006									2007											2008			In-charge	Equipment	Remarks
			4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3			
I. Government Level Water Management																													
(1)	Preparation of water management manual	Manual																									Consultant MOWRAM PDOWRAM	None	-
(2)	Holding seminar on water management procedure	Government's Understanding																									Consultant MOWRAM PDOWRAM	None	-
II. FWUC and FWUG Level Water Management																													
(1)	Baseline Survey	Survey Result																									Consultant	Vehicle	-
(2)	Explanation of Water Mangement Plan to FWUC and FWUG	Farmers' Understanding																									Consultant	Vehicle	-
(3)	Preparation of Water Distribution Map	Map																									Consultant PDOWRAM	Handheld GPS Vehicle	-
(4)	Measurement of Water Flow in the Canals	Record																									Consultant PDOWRAM	Current Meter Vehicle	-
(5)	Trial Water Distribution with FWUC and FWUG	Record																									Consultant PDOWRAM	Current Meter Vehicle	-
(6)	Preparation of Water Management Manual for FWUC and FWUG	Manual																									Consultant PDOWRAM	None	-
(7)	Provision of Additional On-farm Irrigation Facilities	Facilities																									Consultant PDOWRAM	As Required	-
(8)	Study Tour	Farmers' Understanding																									Consultant	Vehicle	-
III. Farmer Level Water Management																													
(1)	Implementation of Water Saving Farming Practice in Experimental Plot	Improved Farming Skill																									Consultant PDA	Vehicle	-
(2)	Study Tour	Farmers' Understanding																									Consultant PDA	Vehicle	-
IV. Evaluation of Pilot Project Result																													
(1)	Evaluation	Report																									Consultant	None	-

Note: ■ Continuous work ▦ Intermittent work

F-4.6.3 Irrigation Facility Maintenance Capacity Strengthening Pilot Project

(1) Title of Project	Irrigation Facility Maintenance Capacity Strengthening Pilot Project
(2) Location	Model project area in Zone-1, 2 and 3. For Zone-1 and 2, the model project area will be a tertiary block. For Zone-3, the model area will be the area which has small pond.
(3) Objective of Project	Objective of the project is to establish good model of irrigation facility maintenance in irrigated agriculture area.
(4) Site Description	In the Target Area, FWUCs are not active and not many FWUGs are formed. Some FWUCs are collecting water fee for future maintenance of irrigation facilities but most of them do not. Reasons of this inactivity of FWUCs are i) unavailability of water (mainly in dry season when farmers really need the water), and ii) insufficient provision of irrigation facilities (especially for on-farm facilities). 
(5) Project Description	The project activities need to be executed in irrigated agricultural areas which have proper irrigation facilities to control and measure irrigation water. In Zone-3, the small reservoir supplying water to the irrigation area needs to function well. For this, it is indispensable to observe rainfall in advance, to clarify the storage condition of reservoir. If there are no proper irrigation facilities in the Target Area, such facilities should be constructed during the activities. It is also necessary that water is properly distributed to the fields by proper irrigation facilities. If activities start without proper irrigation facilities, farmers in the Target Area will be discouraged regarding the project activities. The project activity is mainly strengthening of FWUC/FWUGs/WUGs, since maintenance of on-farm irrigation facilities should be done by FWUC, FWUGs and WUGs. To maintain such facilities, ISF should be collected from water users and properly saved. Next, long-term rehabilitation plans for the facilities need to be prepared. Saved funds need to be made available for repairing and maintaining on-farm facilities. The long-term rehabilitation plan for the facilities needs to be revised based on the results of such rehabilitation works to reflect the lessons learned. Proper attention of the FWUC leaders should be given to collection and usage of ISF. The projects also include procedures for acquiring budgets/funds for annual maintenance and periodic replacements (for gates, etc.) by a responsible government agency.
(6) Project Component	- Problem analysis of selected FWUCs and FWUGs - Awareness raising campaign on importance of facility maintenance - Preparation of long-term rehabilitation plan by selected FWUCs - Establishment of local rule of selected FWUCs and FWUGs on collection of water fees - Preparation of long-term rehabilitation plan for major facilities by responsible government agency - Setting procedure for acquisition of maintenance cost for large-scale irrigation facilities by responsible government agency
(7) Required Cost	US$ 909,000 *(refer to Appendix H)*
(8) Executing Agency	MOWRAM and PDOWRAM
(9) Implementation	As shown below.

Activities	Expected Results	2009									2010											2011			In-charge	Equipment	Remarks
		4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3			
I. FWUC and FWUG Level Water Management																												
(1) Baseline Survey and Problem Analysis	Survey Result																									Consultant	Vehicle	-
(2) Awareness Raising Campaign	Farmers' Understanding																									Consultant PDOWRAM	Vehicle	-
(3) Study Tour	Farmers' Understanding																									Consultant	Vehicle	-
(4) Preparation of Long-term Rehabilitation Plan for On-farm Facilities	Plan																									Consultant PDOWRAM	None	-
(5) Collection of Water Fees by Established Local Rule by Model FWUC	Collected Fund																									Consultant PDOWRAM	None	-
II. Government Level Water Management																												
(1) Prepaation of Long-term Rehabilitation Plan for Major Facilties	Manual																									Consultant MOWRAM PDOWRAM	None	-
(2) Set Up Procedure for Acquisition of Maintenance Cost for Major Facilities	Government's understanding																									Consultant MOWRAM PDOWRAM	None	-
III. Evaluation of Pilot Project Result																												
(1) Evaluation	Report																									Consultant	None	-

Note: Continuous work Intermittent work

F-4.6.4 River Basin Effective Water Use Awareness Raising Project

(1) Title of Project	Effective Water Use Awareness Raising Project
(2) Location	Irrigated area in Zone-1, 2 and 3 First priority: Zone-1: Second priority: Zone-2: Third priority: Zone-3
(3) Objective of Project	The objective of the project is to raise awareness and knowledge of farmers on efficient water use by introducing the result of "Irrigated Agriculture On-farm Technology Improvement Pilot Project".
(4) Site Description	Result of the participatory survey conducted in the Master Plan study shows that farmers' knowledge on irrigation in the Target Area is limited. Water is not distributed properly and water fee is not paid by beneficiaries. Most of the beneficial farmers seem to misunderstand necessity of such important activities. The reasons of this insufficient knowledge of farmers might be that i) farmers are discouraged by poor water delivery by irrigation system, ii) farmers are not aware of importance of proper operation and maintenance of irrigation system, and iii) farmers do not understand or did not instructed how to operate irrigation system properly.  *A Sample of Secondary Canal not Operated Properly*
(5) Project Description	The project is composed of two stages: <u>Stage-1 (River Basin Water Use Study)</u> In the Master Plan, water availability at Roleang Chrey regulator was estimated by hydrological model analysis. However, the current model will not be fitted if the situation of the upstream area changes in the future. In this connection, a river basin water use study is required. Water users of the Prek Thnot river need to be surveyed and listed periodically (at least every five years). When new water users are found, water allocation rules should be determined that will be fait to both the new water users and existing water users. Another objective of the study is to transfer technology to MOWRAM staff on how to conduct river basin water use studies. It is planned that the study will be executed on a project basis the first time (five years after the Master Plan formulation) and all the technical skills will be transferred to MOWRAM officials in that study period. Each of the following studies will be routinely conducted by MOWRAM every five years. <u>Stage-2 (Awareness Raising Campaign)</u> The project aims at creating mutual understanding among the stakeholders that are related to the irrigation systems. In this regard, upstream farmers play a key role in saving water. The upstream farmers should understand how severe the downstream situation is. Downstream farmers should also understand that the upstream farmers understand that the situation is severe and that the downstream farmers need to start to take action. These kinds of discussions should be entered into by the farmers themselves in the basin level conferences. It is also important that irrigation farmers keep the importance of water saving in their minds and take action for it. To encourage them to take action, dissemination material should be distributed to them. Distribution of calendars with water management schedules might be a good dissemination material for farmers. In addition, various other types of dissemination materials need to be distributed to them after confirming their effects.

	To motivate the farmers to take action, it is important to introduce the possibility of irrigated agriculture as practiced by farmers in the Target Area. Status and effects of the "Irrigated Agriculture On-farm Technology Improvement Pilot Project" need to be introduced to the farmers in the other areas. It is also important that the government should prepare a legal water rights system or a water law urgently.
(6) Project Component	<u>Stage-1 (River Basin Water Use Study)</u> - Acquisition of satellite images of the river basin - Inventory survey of water users in the river basin - River basin vegetation analysis by remote sensing technology - Propose proper water allocations between water users, if required - Propose proper measures for mitigating the effects of deforestation, if required <u>Stage-2 (Awareness Raising Campaign)</u> - Organize seminars on efficient water use at the government level - Organize awareness raising seminars on efficient water use - Establish study tours on efficient water use - Distribution of dissemination material to irrigation farmers - Organize basin level conferences on efficient water use with stakeholders related to irrigation in the Target Area
(7) Required Cost	US$ 633,000 *(refer to Appendix H)*
(8) Executing Agency	MOWRAM, MAFS, PDOWRAM and PDA
(9) Implementation	As shown below.

Activities	Expected Results	2009	2010	2011	2012	In-charge	Equipment	Remarks
		1 2 3 4 5 6 7 8 9 # # #	1 2 3 4 5 6 7 8 9 # # #	1 2 3 4 5 6 7 8 9 # # #	1 2 3			
I. River Basin Water Use Study								
I-1. Understanding of Present Condition								
(1) Acquisition of Satellite Imageries	Satellite Imageries					Consultant	None	-
(2) Inventory Survey of Water Users in the River Basin	Survey Result					Consultant MOWRAM	Vehicle	-
(3) River Basin Vegetation Analysis by Using Remote Sensing Technology	Vegetation Map					Consultant MOWRAM	Vehicle GIS	-
I-2. Preparation of Countermeasure Plan for Identified Problems								
(1) Propose Proper Water Allocation between Water Users	Water Allocation Plan					MOWRAM Consultant	None	-
(2) Propose Measures for Deforestation	River Basin Conservation Plan					MOWRAM Consultant	None	-
II. Awareness Raising Campaign								
II-1. Government Level Awareness Raising								
(1) Seminar on Efficient Water Use	Government's Understanding					MOWRAM MAF PDOWRAM PDA	None	-
II-2. FWUC and Farmers Level Awareness Raising								
(1) Awareness Raising Seminar on Efficient Water Use	FWUGs' and Farmers' Understanding					NGO PDOWRAM	Vehicle	-
(2) Study Tour	FWUGs' and Farmers' Understanding					NGO PDOWRAM	Vehicle	-
(3) Distribution of Dissemination Material	FWUGs' and Farmers' Understanding					NGO PDOWRAM	Vehicle	-
II-3. Basin Level Awareness Raising								
(1) Basin Level Conference on Efficient Water Use	FWUGs' and Farmers' Understanding					All	None	-

Note: ▬ Continuous work ▭ Intermittent work

Tables

Table F1.1.1
1 of 8 Results of Inventory Survey

No.	Code	Name of Irrigation System	Commune	Village	UTM Reference X	UTM Reference Y	Year of construction	System Status	First damage and other main damage	First rehabilitation & recent rehab.	Donor	ER: Established & registered, EN: Established but not registered, N: Not established	NMC: North Main Canal from Roleang Chrey Regulator, SMC: South Main Canal from Roleang Chrey Regulator	E: Earthfill R: Rockfill C: Concrete	Reservoir	Catchment area (km2)	Height of dam (m)	Length of dam (m)	Effective storage (10^6m	G: Gravity, P: Pump, TL: Traditional lifting, PSTN: Pumping station	E: Every year, S: Some year, N: No damage	P: Pond, I: Intake, C: Canal, R: Structures, D: Drains	Cost for rehab. (US$1,000)	Paddy field: Existing Area (ha) Wet	Existing Area (ha) No. of house hold	Existing Area (ha) Dry incl. recess	Existing Area (ha) No. of house hold	Potential Area (ha) Wet	Potential Area (ha) No. of house hold	Potential Area (ha) Dry incl. recess.	Potential Area (ha) No. of house hold	Wet
Kampong Speu Province																																
II Chbar Mom District																																
Area <100ha																																
1	CM1-2	Chanke	Chbar Morn	Ta Mol	444991	1270504	1979	Fully Function	The system was damaged 2000	2003	Seila	N	Chrork Chhlik	E	7.0	3.5	750	0.45	G, P	N		12.0	45	64	-	-	65	91	-	-	1.3
Sub-total (A<100ha)															1	7.0						12.0	45	64	-	-	65	91	-	-	1
Area >100ha																																
1	CM3-2	O KamPis	Roka Thum	Tuol Thnong			1977	Fully Function	System was damaged 1985	1992, 1995, 2001	Prasac & Mowram	EN	Chan Kie stream & reservoir	E	13.0	4.5	1,150	1.84	G, P	S	P, C, R	54.2	280	407	243	405	900	1,393	250	416	7
1b	CM3-2	O KamPis	Roka Thum																													
1c	CM3-2	O KamPis	Roka Thum																													
Sub-total (A>100ha)															1	13.0																
III Samraong Tong District																						54.2	280	407	243	405	900	1,393	250	416	7
Area <100ha																																
1	ST1-2	Prey Sya	Roleang Chek	Pring	453132	1264253	1976	Fully Function	System was damaged 1982	2000, 2002	Mowram	EN	SMC	E	3.0	4.0	350	0.31	G, P	S	P, I, C, R	24.0	60	120	10	20	60	120	10	20	20
2	ST1-3	Prey Svay	Roleang Chek	Pring	451822	1264305	1975	Fully Function	Dam was damaged 1990	2000, 2002	WFP	EN	SMC	E	1.5	6.5	700	0.84	G, P	S	P, I, C, R	18.0	45	100	5	18	45	100	5	18	10
3	ST1-4	Krang Speu	Roleang Chek	Krang Speu	456779	1265252	1977	Partly Function	Dam was broken in 1983	1990	People	N	SMC	E	1.5	4.5	300	0.12	G, P	S	P, I, C, R	10.0	23	42	5	10	23	42	5	10	8
4	ST1-6	Andoung Preng	Roleang Chek	Andoung Preng	455940	1266476	1977	Mal Function	Dam was broken in 1977			N	SMC	E	0.7	4.0	300	0.12	G, P	E	P, I, C, R	15.0	-	-	-	-	35	36	-	-	-
5	ST1-7	O Rumchek	Roleang Chek	Prey Kdei	455793	1262077	1977	Partly Function	Dam was damaged in 1982, 1991	1984	People	N	-	E	3.0	4.4	500	0.30	G, P	S	P, I, C, R	17.0	30	47	-	-	42	87	-	-	-
6	ST1-8	Prey Khyeay	Roleang Chek	Moha Leap	452023	1262784	1984	Fully Function		1995, 2002	WFP	N	-	E	1.0	3.2	600	0.24	G, P	S	P, I, C, R	10.0	19	37	-	-	19	35	-	-	-
7	ST1-9	Prey Robang	Roleang Chek	Banla S'et	453696	1261941	1977	Partly Function	System was damaged 1982	1995, 2003	WFP	EN	-	E	1.0	4.8	300	0.12	G, P	S	P, I, C, R	10.0	17	29	-	-	23	53	-	-	3
8	ST2-2	Prey Kdei	Kahaeng	Prey Kdei	443831	1261704	1980	Fully Function	System was damaged 1991	1993, 2003	Seila, People	N	-	E	4.0	3.0	200	0.116	G, P	S	P, I, C, R	7.0	17	31	-	-	17	31	-	-	-
9	ST2-3	Krapeu Chaeth	Kahaeng	Trapeang Chrov	440552	1261697	1981	Fully Function	System was damaged 1991	1997, 2002	Seila, People	N	Thmor Pauk	E	4.5	3.5	225	0.14	G, P	S	P, I, C, R	10.0	22	60	-	-	22	80	-	-	3
10	ST3-1	Kahoun	Khtum Krang	Kahon	445536	1276701	1976	Mal Function	Dam was damaged in 1982, 1985	1989, 1998	People	N	-	E	1.5	2.5	985	0.135	G, P	E	P, I, C, R	20.0	12	20	-	-	46	95	-	-	-
11	ST3-2	Kbal Trolach	Kchomkrain g	Kbal Trolach	0445284	1273819	1977	Mal Function	System was damaged 1982	1981		N	-	E	0.1	2.5	588	0.05	G, P	E	P, I, C, R	6.0	-	-	-	-	15	35	-	-	-
12	ST3-3	Chamnom	Khtum Krang	Chrork Ban Sokh	442335	1274372	1980	Mal Function	System was broken 1994, 2000-2005	1995	People	N	Stream	E	1.0	4.0	800	0.14	G, P	S	P, I, C, R	10.0	15	25	-	-	20	31	-	-	5
13	ST3-4	Yos Chour	Khtum Krang	Yos Chour	441835	1273819	1977	Mal Function	Dam was broken in 1985, 1983, 2000-	1989, 1998	People	N	Ou Kam Bat	E	0.7	3.4	200	0.105	G, P	E	P, I, C, R	6.0	10	20	-	-	15	31	-	-	-
14	ST3-5	Khvan	Khtum Krang	Khvan	439822	1276359	1976	Mal Function	System was broken 1982, 1996, 2000-	1990, 1998	People	N	-	E	1.3	4.0	600	0.21	G, P	E	P, I, C, R	16.0	20	29	-	-	40	63	-	-	-
15	ST3-6	Sab Ngor	Khtum Krang	Sab Ngor	440253	1274053	1977	Mal Function	System was broken in 1981, 1991, 2000-	1987, 1995	People	N	-	E	1.2	4.0	800	0.14	G, P	S	P, I, C, R	10.0	15	18	-	-	24	59	-	-	4
16	ST4-2	O'Sambour	Kraing Ampil	O'Sambour	446091	1256756	1978	Partly Function	System was damaged 1981	1985	People	N	Stream	E	3.0	4.5	50	0.50	G, P	S	P, I, C, R	40.0	80	181	-	-	95	210	-	-	13
17	ST4-3	Doun Sokh	Krang Ampil	Thlok Doun	449521	1255620	1982	Partly Function	System was broken 1999	1998	People	N	-	E	5.0	5.0	800	0.27	G, P	S	P, I, C, R.	20.0	29	38	-	-	44	58	-	-	-
18	ST4-4	Ta Nong	Krang Ampil	Ta Nong	451039	1254245	1978	Partly Function	System was damaged 1995	1995, 1997, 2002-	People	N	-	E	7.0	4.7	350	0.28	G, P	S	P, I, C, R	20.0	50	69	-	-	50	69	-	-	12
19	ST5-1	Trapeang Ta Moan	Pneay	Trapeang Ta Moan	457914	1275738	1983	Partly Function	System was damaged 1990, 2001-2005	2000, 2001-2005	People	N	-	E	2.0	2.4	270	0.054	G, P	S	P, I, C, R	10.0	10	17	-	-	20	45	-	-	-
20	ST5-2	Prey Sbaov	Pneay	Po	453735	1277273	1983	Partly Function	Dam was damaged 1992, 1999-2005	1999-2005	People	N	-	E	2.0	2.5	626	0.18	G, P	E	P, I, C, R	5.0	7	18	-	-	10	20	-	-	-
21	ST5-3	Trapeang Chrey	Pneay	Krang Chhuol	448635	1272297	1977	Partly Function	Syatem was broken 1983	1999	People	N	-	E	3.4	3.2	725	0.195	G, P	E	P, I, C, R	12.0	14	31	-	-	28	51	-	-	-
22	ST7-2	Samraong Tong Leu	Samraong Tong	Samraong Leu	453289	1272785	1955	Mal Function	Syatem was damaged 1960, 2000	1981	People	N	Toach stream	E	0.1	4.3	130	0.14	G, P	E	P, I, C, R	14.0	-		-	-	35	64	-		
23	ST7-3	Ang Tunloap	Samrong Tong	Ang Tunloap	455639	1273676	1977	Fully Function	System was damaged 1981	1982, 1992	World Vision	N	-	E	1.0	4.0	1,000	0.016	G, P	S		30.0	30	95	-	-	70	130	-	-	15
24	ST7-4	Samraong Tong Tboung	Samraong Tong	Samraong Tong Tboung	453468	1271357	1977	Fully Function	Syatem was damaged 1980	1998-2005	WFP	N	Thoach stream	E	0.1	2.9	100	0.10	G, P	S	P, I, C, R	20.0	40	75	5	18	45	95	10	25	14
25	ST9-1	Svay Ta Vong	Saen Dei	Svay Ta Vong	462005	1258730	1978	Fully Function	Syatem was damaged 1985	1990, 2000	Mowram	N	SMC	R	3.8	3.6	600	0.24	G, P	S	P, I, C, R	14.0	35	67	-	-	35	66	-	-	-

Table F1.1.1
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No.	Code	Name of Irrigation System	Upland crops: Existing Area (ha) No. of house hold	Existing Area (ha) Dry incl. recess.	Existing Area (ha) No. of house hold	Potential Area (ha) Wet	Potential Area (ha) No. of house hold	Potential Area (ha) Dry incl. recess.	Potential Area (ha) No. of house hold	Dischargerecord	Rainfall (mm)	Daily rainfall record (mm)	Design reports	Require rehab. Reserv.	Intake facility	Require rehab. Intake	Pump sta.	Require rehab. Pump sta.	Length of main canal (km)	Total no. of structures	Length of secdary canals (km)	Total no. of structures	Length of tertiary canals	Total no. of structures	Length of drainage canals	Length of inspect road (km)	C: Community, G: Government, T: Temple, O: Others O&M of Pond responsible org.	C: Community, G: Government, T: Temple, O: Others O&M of canals responsible org.	Y: Collected every year, S: Collected if there is water. Collection of water fee	F: Flat, U: Undulated Flatness of paddy fields	M: Malaria, D: Dengue, E: Encephalitis, S: Schistosomiasis or trematode, O: Others Water-borne disease	S: Serious, YN: Yes, but not serious, N: No erosion Erosion and wash away soils	NO: No cooperation of farmers, NF: No FWUC or weak. Problem on administration	NW: Water not enough, NS: No supporting services Problem on technology of irrig or agri.	NO: No cooperation of farmers, NF: No FWUC or weak NB: No budget for Problem on O&M of facilities
Kampong Speu Province																																	
II	Chbar Mom District																																
	Area <100ha																																
1	CM1-2	Chanke	26	-	-	2.5	22	-	-	N	1,128	A	N		Gate×1								0.12				G	G						
	Sub-total (A<100ha)		26	-	-	3	22	-	-																								
	Area >100ha																																
1	CM3-2	O KamPis	24	4	13	30	100	30	100		1,178	A	N		Gate×1						4.74		4.75				G		N	U	D, S	YN	NO		NO
1b	CM3-2	O KamPis																																
1c	CM3-2	O KamPis													Gate×1																			
	Sub-total (A>100ha)		24	4	13	30	100	30	100						Gate×1																			
III	Samraong Tong Dis																																
	Area <100ha																																
1	ST1-2	Prey Sya	25	15	19	20	25	15	19	N	1,222	A	A		Gate×1								4.50				G	G	N	U	N	U	S	NW	NO
2	ST1-3	Prey Svay	20	15	25	10	20	15	25	N	1,222	A	A		Gate×1								1.30				G	G	N	U	S	N	NO	NW	NO
3	ST1-4	Krang Speu	17	5	10	8	17	5	10	N	1,222	A	N		-								-				G	G	N	U	S	N	NO	NW	NO
4	ST1-6	Andoung Preng	-	-	-	3	8	4	10	N	1,222	A	N		-								-				G	G	N	U	S	N	NO	NW	NO
5	ST1-7	O Rumchek	-	-	-	7	13	5	12	N	1,222	A	N		Gate×2								2.90				G	G						
6	ST1-8	Prey Khyeay	-	4	10	-	-	5	13	N	1,222	A	N		Gate×2								-				G	G						
7	ST1-9	Prey Robang	8	3	7	3	5	4	11	N	1,222	A	N		Gate×1								0.20				G	G						
8	ST2-2	Prey Kdel	-	-	-	-	-	-	-	N	1,222	A	A		Gate×1								0.20				G	G	N	U	S	N	NO	NW	NO
9	ST2-3	Krapeu Chedh	7	4	8	4	10	5	11	N	1,073	A	A		Gate×1								0.20				G	G	N	U	S	N	NO	NW	NO
10	ST3-1	Kahoun	-	-	-	-	-	-	-	N	1,093	A	N		-								-				G	G	N	U	S	N	NO	NW	NO
11	ST3-2	Kbal Trolach	-	-	-	-	-	-	-	N	1,092	A	N		Pipe×1								-				G	G	N	U	S	N	NO	NW	NO
12	ST3-3	Chamnom	10	3	7	10	18	4	9	N	1,093	A	N		-								-				G	G	N	U	S	N	NO	NW	NO
13	ST3-4	Yos Chour	-	-	-	-	-	-	-	N	1,093	A	N		-								-				G	G						
14	ST3-5	Khvan	-	-	-	10	18	6	12	N	1,093	A	N		Gate×1								-				G	G						
15	ST3-6	Sab Ngor	10	3	8	4	10	3	8	N	1,093	A	N		Gate×1								-				G	G						
16	ST4-2	O'Sambour	21	5	11	17	41	10	20	N	805	A	N		Gate×1								0.60				G	G	N	U	S	N	NO	NW	NO
17	ST4-3	Doun Sokh	-	-	-	4	5	4	8	N	805	A	N		-								-				G	G	N	U	S	N	NO	NW	NO
18	ST4-4	Ta Nong	17	5	10	12	17	5	10	N	805	A	N		-								-				G	G	N	U	S	N	NO	NW	NO
19	ST5-1	Trapeang Ta Moan	-	-	-	-	-	-	-	N	1,222	A	N		-								-				G	G	N	U	S	N	NO	NW	NO
20	ST5-2	Prey Sbaov	-	-	-	-	-	-	-	N	1,222	N	N		-								-				G	G	N	U	S	N	NO	NW	NO
21	ST5-3	Trapeang Chrev	-	-	-	-	-	-	-	N	1,222	A	A		Gate×1								0.25				G	G						
22	ST7-2	Samraong Tong Leu				11	27			N	1,222	A	N										-				G	G	N	U	S	N	NO	NW	NO
23	ST7-3	Ang Tunloap	36	-	-	25	62	5	15	N	1,222	A	N		Gate×2								0.10				G	G	N	U	S	N	NO	NW	NO
24	ST7-4	Samraong Tong Thoung	38	5	14	22	47	6	13	N	1,222	A	N		Gate×2								0.20				G	G	N	U	S	N	NO	NW	NO
25	ST9-1	Svay Ta Vong	-	7	10	-	-	7	10	N	1,222	A	A		Gate×1								0.40				G	G	N	U	S	N	NO	NW	NO

Table F1.1.1
3 of 8 Results of Inventory Survey

No.	Code	Name of Irrigation System	Commune	Village	UTM Reference		Year of construction	System Status	First damage and other main damage	First rehabilitation & recent rehab.	Donor	ER: Established & registered, EN: Established but not registered, N: Not established	NMC: North Main Canal from Roleang Chrey Regulator, SMC: South Main Canal from Roleang Chrey Regulator	E: Earthfill R: Rockfill C: Concrete					G: Gravity, P: Pump, TL: Traditional lifting, PSTN: Pumping station	E: Every year, S: Some year, N: No damage	P: Pond, I: Intake, C: Canal, R: Structures, D: Drains		Paddy field							
					X	Y			Damages	Rehabilitation Work		FWUC	Source of Water	Reservoir	Catchment area (km2)	Height of dam (m)	Length of dam (m)	Effective storage (10^6m	Type of Irrigation	Flood damage	Req. of rehab.	Cost for rehab. (US$1,000)	Existing Area (ha)				Potential Area (ha)			
																							Wet	No. of house hold	Dry incl. recess	No. of house hold	Wet	No. of house hold	Dry incl. recess.	No. of house hold	Wet
26	ST9-2	Prey Sya	Saen Del	Prey Sya	455914	1256650	1978	Mal Function	System was damaged 1985	1990-1995	People	N	Stream	E	1.5	4.3	400	0.24	G, P	S	P, I, C, R	12.0	-	-	-	-	30	45	-	-	-
27	ST9-5	Tuol Ta Sokh	Saen Del	Tuol Ta Sok	461476	1255154	1981	Fully Function	System was damaged 1990	1998, 2000-	People	N	-	E	1.0	2.5	410	0.12	G, P	S	P, I, C, R	6.0	15	35	-	-	15	35	-	-	-
28	ST9-6	Trapeang Damrei	Saen Del	Trapeang Damrei	458031	1259009	1977	Partly Function	System was damaged 1981, 1995	1989	People	N	-	E	1.0	3.7	350	0.105	G, P	S	P, I, C, R	12.0	20	45	-	-	30	15	-	-	-
29	ST9-7	Doun Keo	Saen Del	Saen Del	461786	1257136	1976	Partly Function	System was damaged 1980-1993	1993, 2003	People & Pdwram	N	-	E	1.2	2.5	480	0.138	G, P	S	P, I, C, R	14.0	30	45	-	-	35	62	-	-	-
30	ST10-2	Prey Rongeang	Skuh	Prey Rongeang	445745	1263016	1979	Mal Function	System was damaged 1992, 2000-2005	1998, 2000-2005	People	EN	-	E	0.8	4.3	450	0.27	G, P	S	P, I, C, R	7.0	10	15	-	-	17	30	-	-	-
31	ST10-3	Prey Thnaing	Skuh	Prey Peung	445844	1260273	1977	Partly Function	System was damaged 1980, 1991	1981, 1992	People	N	-	E	-	5.4	400	0.16	G, P	S	P, I, C, R	10.0	19	27	-	-	25	39	-	-	4
32	ST10-4	Svay Dangkum	Skuh	Svay Dangkum	451335	1260252	1977	Partly Function	Dam was damaged 1989, 1996-2005	1996	People	N	-	E	1.5	4.3	270	0.10	G, P	S	P, I, C, R	7.0	10	16	-	-	17	30	-	-	-
33	ST10-5	Daun At	Skush	Daun At	451123	1259286	1977	Partly Function	System was damaged 1982, 1990	1983, 1991	People	N	-	E	5.0	5.0	1,180	1.20	G, P	S	P, I, C, R	40.0	60	88	-	-	100	131	-	-	6
34	ST10-6	O Snao	Skuh	O Snao	452518	1261108	1977	Partly Function	System was damaged 1983, 1990-2001	1989	People	N	-	E	1.0	6.5	300	0.12	G, P	S	P, I, C, R	10.0	10	16	-	-	20	55	3	8	-
35	ST10-7	Kouk Rongeang	Skuh	Kuok Rongeang	449732	1262364	1978	Partly Function	Dam was broken 1984	1991	People	N	Ou Peam	E	4.0	3.4	400	0.24	G, P	E	P, I, C, R	10.0	10	20	-	-	25	70	-	-	4
36	ST11-2	Tumpeam	Tang Kruoch	Tum Pean	437271	1271022	1977	Partly Function	System was broken 1982, 1990-2003	1834, 2003	People & Setha	N	Kor Ky stream	E	2.0	6.0	480	0.404	G, P	E	P, I, C, R	33.0	55	98	4	6	82	231	5	8	8
37	ST11-3	O Koki	Tang Kruoch	Tang Kruoch	435847	1267704	1977	Fully Function	System was damaged 1981	1982, 1993	Ministry of Defense	N	Kor Ky stream	E	22.0	7.0	1,100	0.245	G, P	S	P, I, C, R	20.0	20	33	5	9	40	57	5	10	10
38	ST11-4	Krang Mkak	Tang Kruoch	Krang Mkak	437570	1268476	1980	Mal Function	System was damaged 1995, 2000-2005	1997	People	N	-	E	1.0	4.5	190	0.043	G, P	S	P, I, C, R	8.0	15	30	-	-	18	34	-	-	-
39	ST11-5	Khla Khamko	Tang Kruoch	Thmei	437740	1267296	1977	Fully Function	System was damaged 1980, 1994-1998	1985, 1999	People	N	-	E	1.2	3.0	275	0.04	G, P	E	P, I, C, R	5.0	7	10	-	-	10	18	-	-	-
40	ST11-6	Prey Kol	Tang Kruoch	Mkak	447204	1268143	1976	Mal Function	System was damaged 1989, 2000-2005	1991	People	N	Ou Kam Bat	E	1.6	3.0	230	0.061	G, P	E	P, I, C, R	5.0	7	6	-	-	13	10	-	-	-
41	ST11-7	Krues Thum	Tang Kruoch	Chong Thnal	436945	1269670	1978	Fully Function	System was broken 1981	1982, 1990-	People	N	-	E	1.8	3.5	200	0.129	G, P	S	P, I, C, R	8.0	8	10	-	-	18	19	-	-	5
42	ST11-9	Doung Chraing	Tang Kruoch	Krus Thom	435933	1270701	1990	Mal Function	System was damaged 1982, 1989	1985, 1991	People	N	-	E	1.5	3.5	140	0.106	G, P	S	P, I, C, R	8.0	10	19	-	-	15	31	-	-	5
43	ST12-2	Kraing Makak	Thormda Or	Mkak	442968	1255303	1978	Mal Function	System was damaged 1987, 1992	1989	People	N	-	E	5.5	4.0	400	0.16	G, P	S	P, I, C, R	25.0	33	82	-	-	60	113	-	-	-
44	ST12-3	Mon	Thommada Ar	Mon	427903	1121465	1978	Fully Function	Dam was damaged 1983, 1989	1988, 2004	People	N	Thmor Pouk	E	1.3	3.0	315	0.11	G, P	S	P, I, C, R	11.0	16	31	-	-	26	50	-	-	5
45	ST12-4	Del Kraham	Thommada Ar	Del Kraham	440251	1256982	1978	Mal Function	System was damaged 1984, 1997, 2002	1985, 1991	People	N	Thmor Pouk	E	1.3	5.4	317	0.27	G, P	E	P, I, C, R	20.0	13	19	-	-	47	77	-	-	3
46	ST12-5	Kraing Svay	Thormda Or	Krang Svay	438984	1253800	1977	Fully Function	System was damaged 1981	1982	People	N	-	E	7.0	4.5	730	0.58	G, P	S	P, I, C, R	40.0	70	135	-	-	105	202	-	-	11
47	ST12-6	Thlok Dankor	Thommada Ar	Thlok Dankor	444552	1259020	1982	Fully Function	System was damaged 1991, 1999	1995, 2002-2005	People	N	-	E	1.0	5.0	350	0.014	G, P	S	P, I, C, R	10.0	13	26	-	-	23	39	-	-	3
48	ST12-7	Ang Satha	Thommada Ar	Trapeang Leap	445227	1256073	1978	Mal Function	Dam was damaged 1997, 2000-2005	1989	People	N	Mountain stream	E	8.0	5.5	500	0.26	G, P	E	P, I, C, R	20.0	10	15	-	-	45	65	-	-	-
49	ST15-1	Tbaes	Voasa	Tang Kumpi	455088	1269163	1977	Mal Function	Dam was damage 1981,	1985, 2003	Prime Min.	N	Tock and Tom stream	E	3.5	4.2	449	0.25	G, P	E	P, I, C, R	35.0	40	62	2	-	85	180	5	25	12
50	ST15-2	Tuol Samnang	Voa Sor	Tuol Samnang	452722	1271399	1976	Mal Function	System was damaged 1980	-	-	N	Thom stream	E	1.0	4.2	123	0.03	G, P	E	P, I, C, R	20.0	-	-	-	-	45	106	12	25	13
51	ST15-3	Kraing Pongror	Voir Sar	Kraing Pongror	433509	1131027	1977	Fully Function	System was damaged 1980, 1985	1981, 1990, 2004	World Vision	N	Thom stream	E	2.0	5.0	560	0.125	G, P	S	P, I, C, R	30.0	17	99	3	8	75	113	5	15	17
52	ST15-4	Kveth	Voasa	Chamkar Bos	451236	1273152	1977	Fully Function	System was damaged 1982	1985, 2003	Pdwram	N	-	E	2.2	3.0	510	0.204	G, P	S	P, I, C, R	5.0	12	28	-	-	12	31	-	-	-
Sub-total (A<100ha)														52	134.3							805.0	1,139	2,177	39	89	1,911	3,572	85	184	211
Area >100ha																															
1	ST1-1	Anlong Por	Roleang Chak	Veal	454526	1264244	1976	Partly Function	System was broken 1985	1986, 2001-	WFP & Mowram	EN	SMC	R	4.0	5.5	800	1.44	G, P	N	P, I, C, R		125	355	15	25	125	355	15	25	15

Table F1.1.1
4 of 8

No.	Code	Name of Irrigation System	Upland crops							Dischrge record	Rainfall (mm)	Daily rainfall record (mm)	Design reports	Require rehab Reserv.	Intake facility	Require rehab, Intake	Pump sta.	Require rehab, Pump sta.	Length of main canal (km)	Total no. of structures	Length of secdary canals (km)	Total no. of structures	Length of tertiary canals	Total no. of structures	Length of drainage canals	Length of inspect road (km)	C: Community, G: Government, T: Temple, O: Others	C: Community, G: Government, T: Temple, O: Others	Y: Collected every year, S: Collected if there is water,	F: Flat, U: Undulated	M: Malaria, D: Dengue, E: Encephalitis, S: Schistosomiasis or trematode, O: Others	S: Serious, YN: Yes, but not serious, N: No erosion	NO: No cooperation of farmers, NF: No FWUC or weak,	NW: Water not enough, NS: No supporting services	NO: No cooperation of farmers, NF: No FWUC or weak NB: No budget for
			Existing Area (ha)			Potential Area (ha)																														
			No. of house hold	Dry incl. recess.	No. of house hold	Wet	No. of house hold	Dry incl. recess.	No. of house hold																		O&M of Pond responsible org.	O&M of canals responsible org.	Collection of water fee	Flatness of paddy fields	Water-borne disease	Erosion and wash away soils	Problem on adiministration	Problem on technology of irrig or agri.	Problem on O&M of facilities
26	ST9-2	Prey Sya	-	-	-	-	-	-	-	N	1,222	N	N		-								-				G	G	N	U	S	N	NO	NW	NO
27	ST9-5	Tuol Ta Sokh	-	-	-	-	-	5	15	N	1,222	A	N		Gate×1								-				G	G	N	U	S	N	NO	NW	NO
28	ST9-6	Trapeang Damrei	-	-	-	-	-	-	-	N	1,222	A	N		Gate×2								.0.3				G	G	N	U	S	N	NO	NW	NO
29	ST9-7	Doun Keo	-	2	7	-	-	3	10	N	1,222	A	A		Gate×2								0.30				G	G	N	U	S	N	NO	NW	NO
30	ST10-2	Prey Rongeang	-	-	-	5	10	4	9	N	841	N	N		-								-				G	G	N	U	S	N	NO	NW	NO
31	ST10-3	Prey Thnaing	8	3	5	5	9	4	7	N	841	A	N		Gate×1								-				G	G	N	U	S	N	NO	NW	NO
32	ST10-4	Svay Dangkum	-	-	-	2	5	5	9	-	841	A	N		-								-				G	G	N	U	S	N	NO	NW	NO
33	ST10-5	Daun At	18	4	12	23	60	12	29	N	805	A	N		Gate×1								1.30				G	G	N	U	S	N	NO	NW	NO
34	ST10-6	O Snao	-	-	-	2	6	2	6	N	841	A	N		-								-				G	G	N	U	S	N	NO	NW	NO
35	ST10-7	Kouk Rongeang	8	2	5	6	21	4	10	N	841	A	N		Gate×1								0.20				G	G	N	U	S	N	NO	NW	NO
36	ST11-2	Tumpeam	10	6	9	10	17	10	15	N	1,093	A	N		Gate×3								0.90				G	G	N	U	S	N	NO	NW	NO
37	ST11-3	O Koki	17	10	18	10	17	10	18	N	1,093	A	N		Gate×1								10.00				G	G	N	U	S	N	NO	NW	NO
38	ST11-4	Krang Mkak	-	-	-	-	-	-	-	N	1,093	A	N		Gate×1								-				G	G	N	U	S	N	NO	NW	NO
39	ST11-5	Khla Khamko	-	-	-	-	-	-	-	N	1,073	A	N		Gate×1								-				G	G							
40	ST11-6	Prey Kof	-	-	-	-	-	-	-	N	1,093	A	N		-								-				G	G							
41	ST11-7	Krues Thum	10	-	-	5	9	-	-	N	1,093	A	N		Gate×1								-				G	G							
42	ST11-9	Doung Chraing	9	3	7	5	8	3	7	N	1,093	A	N		Gate×1								-				G	G	N	U	S	N	NO	NW	NO
43	ST12-2	Kraing Makak	-	-	-	27	50	-	-	N	805	A	N		Gate×2								0.50				G	G	N	U	S	N	NO	NW	NO
44	ST12-3	Mon	17	4	14	10	20	7	14	N	805	N	N		-								-				G	G	N	U	S	N	NO	NW	NO
45	ST12-4	Del Kraham	7	10	14	7	3	5	10	N	805	A	N		-								-				G	G	N	U	S	N	NO	NW	NO
46	ST12-5	Kraing Svay	37	-	-	15	43	-	-	N	805	A	N		Gate×1								1.60				G	G	N	U	S	N	NO	NW	NO
47	ST12-6	Thlok Dankor	8	5	14	3	8	5	14	N	805	A	N		-								-				G	G	N	U	S	N	NO	NW	NO
48	ST12-7	Ang Satha	-	-	-	10	17	6	9	N	805	A	N		Gate×1								0.30				G	G	N	U	S	N	NO	NW	NO
49	ST15-1	Tbaes	19	5	17	35	73	5	17	N	1,222	A	N		-								2.90				G	G	N	U	S	N	NO	NW	NO
50	ST15-2	Tuol Samnang	35	-	-	-	-	-	-	N	1,222	A	N		Gate×3								0.30				G	G	N	U	S	N	NO	NW	NO
51	ST15-3	Kraing Pongror	33	3	8	35	48	5	10	N	1,222	A	A		Gate×1 Pipe×								0.50				G	G	N	U	S	N	NO	NW	NO
52	ST15-4	Kveth	-	-	-	12	28	-	-	N	1,222	A	N		Gate×2								0.25				G	G	N	U	S	N	NO	NW	NO
	Sub-total (A<100ha)		443	131	267	397	793	203	421																											
	Area >100ha																																			
1	ST1-1	Anlong Por	25	15	25	15	25	15	25	N	1,222	A	A	Gate	Gate×1	Gate			0.3	4			0.51			0.3		G	N	U	S	YN	NO	NW	NF

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Table F1.1.1
5 of 8 Results of Inventory Survey

No.	Code	Name of Irrigation System	Commune	Village	UTM Reference X	UTM Reference Y	Year of construction	System Status	First damage and other main damage	First rehabilitation & recent rehab.	Donor	ER: Established & registered, EN: Established but not registered, N: Not established	NMC: North Main Canal from Roleang Chrey Regulator, SMC: South Main Canal from Roleang Chrey Regulator	E: Earthfill R: Rockfill C: Concrete	Reservoir	Catchment area (km2)	Height of dam (m)	Length of dam (m)	Effective storage (10^6m	G: Gravity, P: Pump, TL: Traditional lifting, PSTN: Pumping station	E: Every year, S: Some year, N: No damage	P: Pond, I: Intake, C: Canal, R: Structures, D: Drains	Cost for rehab. (US$1,000)	Paddy field							
																								Existing Area (ha)				Potential Area (ha)			
									Damages	Rehabilitation Work	FWUC	Source of Water								Type of Irrigation	Flood damage	Req. of rehab.		Wet	No. of house hold	Dry incl. recess	No. of house hold	Wet	No. of house hold	Dry incl. recess.	No. of house hold	Wet
2	ST1-5	Bak Thmenh	Roleang Chak	Bak Thmenh	449589	1263430	1977	Partly Function	System was broken 1980	1982, 1989, 2001	Prasac & Mowram	EN	SMC	R	52.0	6.5	1,200	1.89	G, P	N	P, I, C, R		215	420	30	65	316	530	30	65	40
2b	ST1-5	Bak Thmenh	Roleang Chak	Bak Thmenh																											
2c	ST1-5	Bak Thmenh	Roleang Chak	Bak Thmenh																											
3	ST2-1	O Veng	Kahaeng	O Veng	442290	1263618	1978	Partly Function	System was broken 1983	1997, 2001, 2002-	Japan, WFP & Mowram	EN	Stream	E	9.0	4.5	400	0.24	G, P	N	P, I, C, R	48.0	150	300	20	50	210	474	30	61	40
3b	ST2-1	O Veng	Kahaeng	O Veng																											
3c	ST2-1	O Veng	Kahaeng	O Veng																											
4	ST4-1	Chondal Kaich	Kraing Ampil	Srea Pho	448787	1252359	1977	Mal Function	System was damaged 1980	1981	People	N	Stream	E	8.0	5.9	1,300	4.90	G, P	N	P, I, C, R	435.0	20	35	-	-	740	819	-	0	10
4b	ST4-1	Chondal Kaich	Kraing Ampil	Srea Pho																											
5	ST6-1	Daun Try	Releang Kreul	Doun Try	458154	1262166	1976	Fully Function	System was damaged 1988	1990, 2002, 2003-	WFP & Mowram	EN	Stream	E	7.0	6.5	820	0.82	G, P	N	P, I, C, R	15.0	200	285	30	43	200	285	30	43	15
6	ST7-1	Rong Kor	Samrong Tong	Rong Kor	454024	1272508	1977	Partly Function	System was partly function since 1985	1980, 1985, 2003	Mowram	EN	NMC and Chan Thnal stream	R	3.0	4.5	800	0.12	G, P	N	P, I, C, R		80	89	-	-	125	139	-	-	5
6b	ST7-1	Rong Kor	Samrong Tong	Rong Kor																											
7	ST9-3	Ta Kao	Saen Dei	Mohalumpeang	454255	1259511	1978	Fully Function	System was broken 1983	1984, 2000-	People	N	Stream	E	13.0	7.0	750	0.73	G, P	N	P, I, C, R		115	230	10	15	155	401	15	30	15
7b	ST9-3	Ta Kao	Saen Dei	Mohalumpeang																											
8	ST9-4	Prey Rumduol	Saen Dei	Prey Rumduol	461780	1262099	1976	Partly Function	System was partly function since 1985	1981, 2002, 2004	H.E. Mong Somphorn	EN	SMC & stream from mountain	R	1.5	4.5	1,080	1.72	G, P	N	P, I, C, R	61.8	110	146	-	-	550	786	-	-	9
8b	ST9-4	Prey Rumduol	Saen Dei	Prey Rumduol																											
9	ST10-1	Trapeang Talong	Skous	Trapeang Talong	445535	1261339	1977	Partly Function	Dam was broken 1985	2000	People	N	-	R	1.2	5.5	1,000	1.20	G, P	N	P, I, C, R		65	73	-	-	104	179	-	-	5
10	ST11-1	Rolaing Chrey	Taing Kruoch	Rolaing Chrey	439874	1264886	1973	Partly Function	System was partly function since 1976	Many times, 2005	Mowram	EN	Prek Thnot river		3.9	10.0	2,405	5.00	G, P	N	P, I, C, R	1,208.1	7,662	11,266	500	435	11,303	16,506	800	1,176	500
11	ST11-8	Andaung Sla Thmey	Taing Kruoch	Andaung Sla	439221	1266084	1977	Partly Function	System was damaged 1984	2005	People	N	Ou Chheu Tea Kramum	E	16.0	3.5	310	0.98	G, P	N	P, I, C, R		90	106	7	10	170	230	10	17	15
12	ST12-1	Thmor Pouk	Thommada Ar	Prey Veav	439870	1254893	1977	Partly Function	System was damaged 1981	1984, 1999	People	EN	Ou Anlong Rumlich	E	3.0	10.0	1,200	4.9	G, P	N	P, I, C, R	90.8	265	335	10	17	770	910	30	47	60
12b	ST12-1	Thmor Pouk	Thommada Ar	Prey Veav																											
13	ST12-8	Phum Krang	Thommada Ar	Kraing	442912	1259789	1977	Fully Function	System was damaged 1984	1987, 1994, 2000-	People	N	Poum Krang	E	18.0	5.8	1,200	0.72	G, P	N	P, I, C, R		150	184	15	29	175	221	30	51	20
14a	ST13-1	O Krang Ambel (N6)	Trapeang Kong	Anthong Kong	456861	1268572	1977	Partly Function	System was broken 1980	1983, 1985, 2003-	Prime Min.	EN	NMC & Krang Ampel pond	E	113.0	5.4	850	0.85	G, P	N	P, I, C, R		498	725	35	76	508	918	70	140	25
14b	ST13-1	O Krang Ambel (N6-2)	Trapeang Kong																												
Sub-total (A>100ha)														13	252.6							1,878.7	9,745	14,549	672	765	15,451	22,751	1,060	1,655	774
V Kong Pisei District																															
Area <100ha																															
1	KP5-1	Sala Krous	Preah Nipean	Sala Kruos	470070	1260606	1982	Partly Function	System was broken som part 1990-2003			EN	-	E	8.0	4.5	1,060	0.848	G, P	S	P, I, C	42.0	46	78	5	10	85	141	5	30	-
2	KP5-2	Boeng Chram Khang	Preah Nipean	Chram Khang Cheung	472776	1260544	1953	Partly Function	Dam was broken 1979-2003			EN	-	E	8.0	2.5	1,000	0.75	P	N	I	30.0	40	54	-	-	80	40	-	-	-
3	KP8-1	Pring Tuek	Roka Kaoh	Pring Tuek	459222	1257495	1977	Partly Function	No rehabilitation work was done			EN	-	E	1.0	5.1	250	0.15	G, P	S	P, I, C	40.5	15	30	3	5	20	40	6	8	-
4	KP8-2	O Ta Pung	Roka Kaoh	O Ta Pung	465847	1261128	1982	Partly Function	Dam was eroded 1990-			EN	-	E	5.0	4.2	480	0.23	G, P	S	P, I	40.5	20	40	4	-	35	50	5	8	-
5	KP8-3	Day Krohorm	Rokar Koah	Dei Krahorm	463055	1258187	1977	Partly Function	The system was damaged 1990-2002	2003	Mowram	EN	SMC	E	12.0	4.3	1,000	0.8	G, P	S	I, R	40.5	65	92	1	5	100	142	15	35	-
6	KP8-4	Samdech Sang Choun	Roka Kaoh	Prey Khvav	466947	1260586	1969	Partly Function	Dam was broken 1979-			EN	-	E	2.0	3.5	480	0.22	G, P	S	P, I, C	42.0	20	78	4	10	30	76	8	15	-
Sub-total (A<100ha)														6	34.0							235.5	206	370	17	30	350	489	39	96	-
Area >100ha														0	0.0							0.0	-	-	-	-	-	-	-	-	-
Sub-total (A>100ha)														59	175.3							1,052.5	1,381	2,611	56	119	2,326	4,152	104	260	212
Sub-total of Kampong Speu Province (A<100 ha)																															

Table F1.1.1
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No.	Code	Name of Irrigation System	Upland crops: Existing Area (ha) No. of house hold	Dry incl. recess.	No. of house hold	Potential Area (ha) Wet	No. of house hold	Dry incl. recess.	No. of house hold	Dischc harge record	Rainf all (mm)	Daily rainfall record (mm)	Desig n repor ts	Requir e rehab Reserv	Intake facility	Require rehab. Intake	Pump sta.	Requir e rehab. Pump sta.	Length of main canal (km)	Total no. of struct ures	Length of secdary canals (km)	Total no. of struct ures	Lengt h of tertira y canals	Total no. of struct ures	Length of drainag e canals	Length of Inspect road (km)	C: Community, G: Government, T: Temple, O: Others O&M of Pond responsibl e org.	C: Community, G: Government, T: Temple, O: Others O&M of canals responsibl e org.	Y: Collected every year, S: Collected if there is water. Collection of water fee	F: Flat, U: Undulated Flatne ss of paddy fields	M: Malaria, D: Dengue, E: Encephalitis, S: Schistosomiasis or trematode, O: Others Water-borne disease	S: Serious, YN: Yes, but not serious, N: No erosion Erosion and wash away soils	NO: No cooperation of farmers, NF: No FWUC or weak. Problem on adiministr ation	NW: Water not enough, NS: No supporting services Problem on technolog y of irrig or agri.	NO: No cooperation of farmers, NF: No FWUC or weak NB: No budget for Problem on O&M of facilities
2	ST1-5	Bak Thmenh	81	15	31	45	102	15	40	N	1,209	A	A	N	Gate×1	N					2.0		5.3					G	N	U	S	YN	NO	NW	NF
2b	ST1-5	Bak Thmenh													Gate×1	N																		
2c	ST1-5	Bak Thmenh													Gate×4	N																		
3	ST2-1	O Veng	81	33	70	41	82	35	70	N	1,073	A	A	N	Gate×1	N					2.5	9	23.8	4				C	N	U	S	YN	NO	NW	NF
3b	ST2-1	O Veng													Gate×2	N																		
3c	ST2-1	O Veng													Gate×1	N																		
4	ST4-1	Chondal Kaich	14	7	10	15	19	8	13	N	805	A	N	Dam & gate	Gate×1	Gate							0.2					G	N	U	S	YN	NO	NW	NF
4b	ST4-1	Chondal Kaich													Gate×1																			
5	ST6-1	Daun Try	16	12	14	15	16	12	14	N	1,222	A	A	N	Gate×1	Gate					6.34	3	2.5					G	N	U	S	YN	NO	NW	NF
6	ST7-1	Rong Kor	15	2	8	14	37	4	15	N	1,209	A	N	Gate	Gate×1	Gate				1	0.5		3.78			0.5		C	N	U	S	YN	NO	NW	NF
6b	ST7-1	Rong Kor													Gate×1																			
7	ST9-3	Ta Kao	25	10	14	20	37	15	29	N	1,209	A	N	Dam	Gate×1	N					0.4		0.1				G	G	N	U	S	YN	NO	NW	NF
7b	ST9-3	Ta Kao													Gate×1	N																		
8	ST9-4	Prey Rumduo	35	4	19	25	55	9	21	N	1,209	A	N	Dam	Gate×1	Gate				2	2.11		3.61			2.1	G	G	N	U	S	YN	NO	NW	NF
8b	ST9-4	Prey Rumduo													Gate×1	Gate																		
9	ST10-1	Trapeang Talong	7	4	6	10	15	6	9	N	805	A	N	N	Gate×1	Gate					0.4		0.8			0.4	G	G	N	U	S	YN	NO	NW	NF
10	ST11-1	Roleing Chrey	2,500	150	750	1,500	7,500	500	2,500	A	1,178	A	A	N	Gate×5	Gate			74.18	44	26.27		57.07		34.27	37.5		C	N	U	S	YN	NO	NW	NF
11	ST11-8	Andaung Sla Thmey	20	10	15	15	20	10	15	N	1,073	A	N	Dam	Gate×4	Gate					2.00		0.23				G	G	N	U	S	YN	NO	NW	NF
12	ST12-1	Thmor Pouk	70	15	17	65	79	30	48	N	805	A	N	Dam	Gate×4	Gate			3.50	1	3.60		3.7					G	N	U	S	YN	NO	NW	NF
12b	ST12-1	Thmor Pouk													Gate×1																			
13	ST12-8	Phum Krang	34	15	29	40	65	30	51	N	805	A	N	Dam	Gate×2	Gate							2.5					G	N	U	S	YN	NO	NW	NF
14a	ST13-1	O Krang Ambel (N5)	50	15	31	50	101	40	82	N	1,209	A	A		Gate×4				7.5	5			5.66			7.5		G	N	U	S	YN	NO	NW	NF
14b	ST13-1	O Krang Ambel (N5-2)													Gate×2				6.23	14														
	Sub-total (A>100ha)		2,973	307	1,039	1,870	8,153	729	2,930																									
V	Kong Pisei District																																	
	Area <100ha																																	
1	KP5-1	Sala Krous	-	5	10	-	-	15	30	N	1,038	A	N		Pipe×2								11.5				G	G	N	U	S	YN	N	NW	NF
2	KP5-2	Boeng Chram Khang	-	15	25	-	-	10	15	N	1,038	A	N		-								-				G	G	N	U	S	YN	N	NW	NF
3	KP8-1	Pring Tuek	-	3	5	-	-	6	8	N	1,038	A	N		Gate×2								-				G	G	N	U	S	YN	N	NW	NF
4	KP8-2	O Ta Pung	-	4	6	-	-	5	8	N	1,038	A	N		Gate×2								1.20				G	G	N	U	S	YN	N	NW	NF
5	KP8-3	Day Krohorm	-	10	15	-	-	15	35	N	1,038	-	N		Gate×1 Pipe×								7.85				G	G	N	U	S	YN	N	NW	NF
6	KP8-4	Samdech Sang Choun	-	4	10	-	-	8	15	N	1,038	A	N		Gate×4								-				C	C	N	U	S	YN	N	NW	NF
	Sub-total (A<100ha)		-	41	71	-	-	59	111																		G	G	N	U	S	YN	N	NW	NF
	Area >100ha																																	
	Sub-total (A>100ha)		-	-	-	-	-	-	-																									
	Sub-total of Kampong S		469	172	338	400	815	262	532																									

Table F1.1.1
7 of 8 Results of Inventory Survey

No.	Code	Name of Irrigation System	Commune	Village	UTM Reference X	UTM Reference Y	Year of construction	System Status	First damage and other main damage	First rehabilitation & recent rehab.	Donor	ER: Established & registered, EN: Established but not registered, N: Not established	NMC: North Main Canal from Roleang Chrey Regulator, SMC: South Main Canal from Roleang Chrey Regulator	E: Earthfill R: Rockfill C: Concrete	Reservoir	Catchment area (km2)	Height of dam (m)	Length of dam (m)	Effective storage (10^6m	G: Gravity, P: Pump, TL: Traditional lifting, PSTN: Pumping station	E: Every year, S: Some year, N: No damage	P: Pond, I: Intake, C: Canal, R: Structures, D: Drains	Cost for rehab. (US$1,000)	Paddy field								
																								Existing Area (ha)				Potential Area (ha)				
									Damages	Rehabilitation Work		FWUC	Source of Water							Type of irrigation	Flood damage	Req. of rehab.		Wet	No. of house hold	Dry incl. recess	No. of house hold	Wet	No. of house hold	Dry incl. recess.	No. of house hold	Wet
Sub-total of Kampong Speu Province (A>100 ha)																																
Total of Kampong Speu province															14	285.6							1,932.9	10,025	14,956	915	1,170	16,351	24,144	1,310	2,071	781
Kandal Province															73	440.8							2,985.4	11,408	17,567	971	1,289	18,877	28,296	1,414	2,331	993
I Ang Snoul District																																
Area <100ha																0.0							0.0	0	0	0	0	0	0	0	0	0
Area >100ha																																
1	ANS-1	Toin Or reservoir	Ovleok	Ang Sleang	470344	1279482	1977	No Function	Reserv was broken 1979	2001	Social fund	N	Stream	E			3.5	1,900		G	N			180	290			299	403			
2	ANS-2	Domnak Ampil main	Domnak Ampil	Domnak Ampil	464000	1272109	2002	Fully Function		2002	Prime Min.	EN	NMC							G, P	N		125.0	220	830			385	1,100			
3	ANS-3	Ta Hor Canal	Lom Hach	Lom Hach	464870	1267095	1977	Partly Function	Canals was broken 1980	2002	Mowram	EN	NMC							G, P	N		150.0	1,319	782			1,319				
4	ANS-4	Ta Hor Canal	Prey Pouch	Prey Pouch	467349	1267487	1977	Partly Function	System was broken 1980	2002	Mowram	EN	To Hor canal							G, P	N		195.0	498	970			1,098	1,272			
5	ANS-5	Ta Hor Canal	Kraing Mkak	Krang Mkak	470517	1268794	1977	Partly Function	System was broken 1980	2002, 2004-05	Mowram, JSC	EN	To Hor canal							G, P	S		90.0	640	793			670	793			
6	ANS-6	Prey Kla Reservoir	Krang Mkak	Prey Kla	477542	1268141	1976	Partly Function		1979	People	N	To Hor canal	E			7.0	1,500		G, P	N	Pond, Intake	92.2	100	650			158	650			
7	ANS-7	Ta Hor Canal	Boeng Thum	Boeng Thum	472740	1268835	1977	Partly Function	System was broken 1980	2002	Mowram	EN	To Hor canal							G, P	N		150.0	1,132	600			1,132				
8	ANS-8	Boeng Oendaeng	Boeng Thum	Boeng Thum			1978	Partly Function				N	Prek Thnot	E			5.0	1,000	0.24	G, P	S		90.0	60		10		280		60		
Sub-total (A>100ha)															3	0.0							892.2	4,139	4,915	10	-	5,321	4,218	60	-	-
II Kandal Stung District																																
Area <100ha																																
Area >100ha																																
1	KDS-1	Rolean Kaen	Roleang Kaen	Stung	465050	1266429	2003	Partly Function		2003	Prime Min.	N	SMC							P	N		75.0	512	1,029			512				
2	KDS-2	Roka canal/ Preak Trang	Roka	Boeng	469092	1264882	1976	Partly Function		1983, 2003	Community	N	Stueng Touch and Preak Thnot	E			5.0	1,100		P	N		160.0	414	618			414				
3	KDS-3	Daeum Rues canal/ reservoir	Daeum Rues	Tunsay Kearch	474348	1262967	1978	Partly Function		2003	Community	N	Stueng Touch and Preak Thnot	E			4.5	100	0.6	P	N		140.0	1,030	1,669			1,030				
Sub-total (A>100ha)															2	0.0							375.0	1,956	3,316	-	-	1,956	-	-	-	-
Sub-total of Kandal Province (A<100 ha)															0	0.0							0.0	-	-	-	-	-	-	-	-	-
Sub-total of Kandal Province (A>100 ha)															5	0.0							1,267.2	6,095	8,231	10	-	7,277	4,218	60	-	-
Total of Kandal province															5	0.0							1,267.2	6,095	8,231	10	-	7,277	4,218	60	-	-
Total of Target Area (A<100 ha)															59	175.3							1,052.5	1,381	2,611	56	119	2,326	4,152	104	260	212
Total of Target Area (A>100 ha)															19	265.6							3,200.2	16,120	23,187	925	1,170	23,628	28,362	1,370	2,071	781
Total of Target Area															78	440.8							4,252.7	17,501	25,798	981	1,289	25,954	32,514	1,474	2,331	993

Summation by water resource		Inventory Area
Total by North Rolean Chrey	No. of system=	18
	Sub total area (ha)=	5,445
Total by South Rolean Chrey	No. of system=	18
	Sub total area (ha)=	#####
Total by Small Tributary=	No. of system=	49
	Sub total area (ha)=	1,796
Total	Total system=	85
	Total area (ha)=	#####

Summary by type of irrigation		Inventory Area
Irrigated by Gravity or Pump	No. of system=	80
	Sub total area (ha)=	15,325
Irrigaed by Pump	No. of system=	4
	Sub total area (ha)=	1,996
Irrigaed by Gravity	No. of system=	1
	Sub total area (ha)=	180
	Total area (ha)=	17,501

Table F1.1.1
8 of 8

No.	Code	Name of Irrigation System	Upland crops: Existing Area (ha) No. of house hold	Dry incl. recess.	No. of house hold	Potential Area (ha) Wet	No. of house hold	Dry incl. recess.	No. of house hold	Dischc harge record	Rainf all (mm)	Daily rainfall record (mm)	Desig n repor ts	Requir e rehab Reserv	Intake facility	Require rehab. Intake	Pump sta.	Requir e rehab. Pump sta.	Length of main canal (km)	Total no. of struct ures	Length of secdary canals (km)	Total no. of struct ures	Lengt h of tertia y canals	Total no. of struct ures	Length of dralang e canals	Length of inspect road (km)	C: Community, G: Government, T: Temple, O: Others O&M of Pond responsibl e org.	C: Community, G: Government, T: Temple, O: Others O&M of canals responsibl e org.	Y: Collected every year, S: Collected if there is water, Collection of water fee	F: Flat, U: Undulated Flatne ss of paddy fields	M: Malaria, D: Dengue, E: Encephalitis, S: Schistosomiasis or trematode, O: Others Water-borne disease	S: Serious, YN: Yes, but not serious, N: No erosion Erosion and wash away soils	NO: No cooperation of farmers, NF: No FWUC or weak Problem on adiministr ation	NW: Water not enough, NS: No supporting services Problem on technolog y of irrig or agri.	NO: No cooperation of farmers, NF: No FWUC or weak NB: No budget for Problem on O&M of facilities
Sub-total of Kampong			2,997	311	1,052	1,900	6,253	759	3,030																									
Total of Kampong Speu			3,466	483	1,390	2,300	9,068	1,021	3,562																									
Kandal Province																																		
I Ang Snoul District																																		
Area <100ha			0	0	0	0	0	0	0																									
Area >100ha																																		
1	ANS-1	Toln Or reservoir								N	N	N	N	Dam	Gatex 3, Gatex	Gate			1.0	11	4.0	3	5.4	2					N	F	O	YN	NF	NW	NF
2	ANS-2	Domnak Ampil mein								N	N	N	N		Gatex 3	Culvert			1.1	1	7.0	3	13.0						N	F	O	YN	NF	NW	NF
3	ANS-3	Ta Hor Canal								N	N	N	N		Gatex 2, Gatex 18	Culvert	Lom Hach, 0.4-0.5m, 180HP		4.0	4	9.0	8	11.0	12					N	F	O	YN	NF	NW	NF
4	ANS-4	Ta Hor Canal								N	N	N	N		Gatex 4, Gatex	Culvert			3.7	1	11.16	8	7.45						N	F	O	YN	NF	NW	NF
5	ANS-5	Ta Hor Canal								N	N	N	N		Gatex 14, Gatex	Gate			2.48	3	6.77	10	20.33	4					N	F	O	YN	NF	NW	NF
6	ANS-6	Prey Kla Reservoir								N	N	N	N		Gatex 4	Culvert					4.0	4	3.0				Community	Community	N	F	S	YN	NF	NW	NF
7	ANS-7	Ta Hor Canal								N	N	N	N		Gatex 4, Gatex 10	Gate			4.0	2	10.7	8	33.62	10					N	F	O	YN	NF	NW	NF
8	ANS-8	Boeng Oandaeng								N		N			Gatex 2														N	F	O	YN	NF	NW	NF
Sub-total (A>100ha)			-	-	-	-	-	-	-																									
II Kandal Stung District																																		
Area <100ha																																		
Area >100ha																																		
1	KDS-1	Rolean Kaen								N	N	N	N		Gatex 5, Gatex		Hun Sen 21st		0.7	1	9.0	2	10.3	5					N	U	O	YN	NF	NW	NF
2	KDS-2	Roka canal/ Preak Trang								N	N	N	N		Gatex 9, Gatex 5		Hun Sen 34th, 0.5m, 120/40 HP	Culvert			18.2	14	3.21						N	F	O	YN	NF	NW	NF
3	KDS-3	Daeum Rues canal/ reservoir								N	N	N	N		Gatex 9, Gatex 5	Culvert	Hun Sen 30th, 0.5m				18.2	14	17.3						N	F	O	YN	NF	NW	NF
Sub-total (A>100ha)			-	-	-	-	-	-	-																									
Sub-total of Kandal Prov			-	-	-	-	-	-	-																									
Sub-total of Kandal Prov			-	-	-	-	-	-	-																									
Total of Kandal province			-	-	-	-	-	-	-																									
Total of Target Area (A<			469	172	338	400	815	262	532																									
Total of Target Area (A<			2,997	311	1,052	1,900	6,253	759	3,030																									
Total of Target Area			3,466	483	####	2,300	9,068	####	3,562																									

Table F2.2.1 Estimated Dependable Inflow to Ou Krang Ambel Pond

(including spillout from upstream pond)

80 % dependable 5-day mean discharge

(unit; m^3/sec)

5-day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1-5	0.428	0.157	0.143	0.158	0.546	0.741	2.284	7.665	8.600	11.752	5.764	1.946
6-10	0.446	0.152	0.152	0.179	0.478	1.738	4.623	8.640	7.234	12.184	3.782	2.099
11-15	0.442	0.142	0.194	0.231	0.397	0.813	2.276	3.601	4.602	12.823	1.994	0.501
16-20	0.444	0.124	0.221	0.354	0.840	0.928	2.502	3.313	6.557	16.272	1.703	0.338
21-25	0.294	0.132	0.216	0.640	1.561	1.024	1.895	5.328	9.589	9.378	1.087	0.659
26-end	0.229	0.156	0.165	0.529	0.493	1.276	4.958	6.055	15.434	9.657	0.640	0.407

Table F2.2.2 Estimated Dependable Mean 5-day Discharge of Small Tributary

(From catchement area of 10 km^2)

80 % dependable mean 5-day discharge

(unit; m^3/sec)

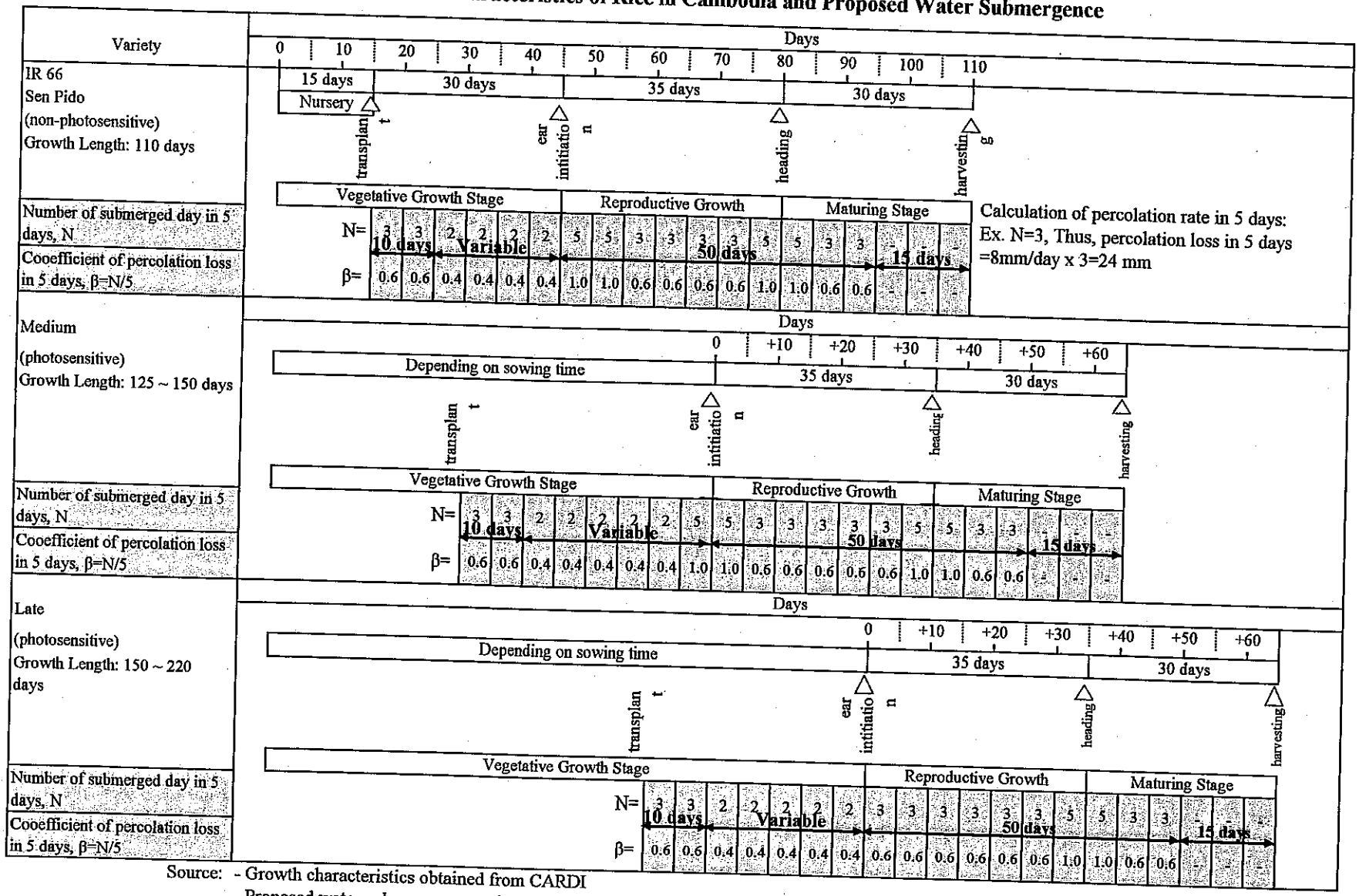
5-day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1-5	0.000	0.000	0.000	0.002	0.007	0.009	0.034	0.122	0.105	0.138	0.036	0.004
6-10	0.000	0.000	0.001	0.002	0.005	0.026	0.074	0.139	0.081	0.147	0.001	0.006
11-15	0.000	0.000	0.002	0.003	0.004	0.010	0.033	0.052	0.036	0.158	0.000	0.000
16-20	0.000	0.000	0.002	0.005	0.012	0.012	0.037	0.047	0.069	0.205	0.000	0.000
21-25	0.000	0.000	0.002	0.010	0.024	0.014	0.027	0.082	0.122	0.098	0.000	0.000
26-end	0.000	0.000	0.001	0.008	0.006	0.018	0.080	0.094	0.223	0.103	0.000	0.000

Table F2.3.1 Minimum Responsible Discharge from Roleang Chrey Regulator

(unit; m^3/sec)

5-day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1-5	2.4	2.0	0.6	0.7	1.8	2.9	4.7	3.0	1.4	2.2	3.0	3.2
6-10	2.4	2.0	0.6	0.7	1.8	2.9	4.7	3.0	1.4	2.2	2.9	3.1
11-15	2.4	2.0	0.6	0.7	1.8	2.9	4.7	3.0	1.4	2.2	2.9	3.1
16-20	2.0	1.9	0.6	0.8	2.3	2.9	4.5	2.6	1.6	2.1	2.9	3.3
21-25	2.0	1.9	0.6	0.8	2.3	2.9	4.6	2.6	1.6	2.1	2.9	3.3
26-end	2.0	1.9	0.6	0.8	2.3	2.9	4.6	2.6	1.6	2.1	2.9	3.3

Table 2.4.1 Growth Characteristics of Rice in Cambodia and Proposed Water Submergence



Source: - Growth characteristics obtained from CARDI
- Proposed water submergence made by Study Team

Table 2.4.2 Irrigation Water Requirement for Early Rice by Transplanting

Item		Apr						May						Jun						Jul						Aug			
		1-5	6-10	11-15	16-20	21-25	26-30	1-5	6-10	11-15	16-20	21-25	26-31	1-5	6-10	11-15	16-20	21-25	26-30	1-5	6-10	11-15	16-20	21-25	26-31	1-5	6-10	11-15	16-20
ETo	(mm/day)	6.0	6.0	6.0	6.0	6.0	6.0	5.6	5.6	5.6	5.6	5.6	5.6	5.2	5.2	5.2	5.2	5.2	5.2	4.6	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7
Percolation, P	(mm/day)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
After transplanting, β		0.6	0.6																										
In vegetation, β				0.4	0.4	0.4																							
In reproductive, β							1.0	1.0	0.6	0.6	0.6	0.6	1.0	1.0															
In maturing, β																													
Effective Rain, ER	(mm/day)	0.6	0.6	0.6	0.6	0.6	0.6	2.3	2.3	2.3	2.3	2.3	1.9	1.6	0.6	0.6	-	-	-										
Overall irrigation efficiency	66%														1.6	1.6	1.6	1.6	1.6	1.9	1.9	1.9	1.9	1.9	1.6	2.0	2.0	2.0	2.0
1st block																													
Land preparation, LP	(mm/day)	7.4	10.9	14.4	17.8																								
Percolation, P×β	(mm/day)					4.8	4.8	3.2	3.2	3.2	8.0	8.0	4.8	4.8	4.8	4.8	8.0	8.0	4.8	4.8	0.0	0.0	0.0						
Crop coefficient, Kc						1.10	1.10	1.10	1.10	1.10	1.05	1.05	1.05	1.05	1.05	1.05	1.05	0.95	0.95	0.95	0.00	0.00	0.00						
Consumptive use, EToxKc + Pxβ	(mm/day)					11.4	11.4	9.4	9.4	9.4	13.9	13.9	10.7	10.2	10.2	10.2	13.4	12.9	9.7	9.2	0.0	0.0	0.0						
FW=ETc + P - ER	(mm/day)					10.8	10.8	7.0	7.0	7.0	11.6	11.6	8.8	8.6	8.6	8.6	11.8	11.3	8.1	7.2	0.0	0.0	0.0						
Net field water req FW +LP	(mm/day)	7.4	10.9	14.4	17.8	10.8	10.8	7.0	7.0	7.0	11.6	11.6	8.8	8.6	8.6	8.6	11.8	11.3	8.1	7.2	0.0	0.0	0.0						
Unit diversion water requirement	(mm/day)	11.2	16.5	21.7	27.0	16.3	16.3	10.7	10.7	10.7	17.5	17.5	13.3	13.1	13.1	13.1	17.9	17.1	12.3	11.0	0.0	0.0	0.0						
Unit diversion water requirement	(l /sec/ha)	1.29	1.90	2.52	3.13	1.89	1.89	1.24	1.24	1.24	2.03	2.03	1.53	1.51	1.51	1.51	2.07	1.98	1.42	1.27	0.00	0.00	0.00						
2nd block																													
Land preparation, LP	(mm/day)		7.4	10.9	14.4	17.8																							
Percolation, P×β	(mm/day)						4.8	4.8	3.2	3.2	3.2	8.0	8.0	4.8	4.8	4.8	4.8	8.0	8.0	4.8	4.8	0.0	0.0	0.0						
Crop coefficient, Kc							1.10	1.10	1.10	1.10	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	0.95	0.95	0.95	0.00	0.00	0.00					
Consumptive use, EToxKc + Pxβ	(mm/day)						11.4	11.0	9.4	9.4	9.4	13.9	13.9	10.2	10.2	10.2	10.2	13.4	12.9	9.2	9.2	0.0	0.0	0.0						
FW=ETc + P - ER	(mm/day)						10.8	8.6	7.0	7.0	7.0	11.6	12.0	8.6	8.6	8.6	8.6	11.8	11.3	7.2	7.2	0.0	0.0	0.0						
Net field water req FW +LP	(mm/day)		7.4	10.9	14.4	17.8	10.8	8.6	7.0	7.0	7.0	11.6	12.0	8.6	8.6	8.6	8.6	11.8	11.3	7.2	7.2	0.0	0.0	0.0						
Unit diversion water requirement	(mm/day)		11.2	16.5	21.7	27.0	16.3	13.1	10.7	10.7	10.7	17.5	18.1	13.1	13.1	13.1	13.1	17.9	17.1	11.0	11.0	0.0	0.0	0.0						
Unit diversion water requirement	(l /sec/ha)		1.29	1.90	2.52	3.13	1.89	1.52	1.24	1.24	1.24	2.03	2.10	1.51	1.51	1.51	1.51	2.07	1.98	1.27	1.27	0.00	0.00	0.00						
3rd block																													
Land preparation, LP	(mm/day)			7.4	10.9	14.4	17.8																						
Percolation, P×β	(mm/day)							4.8	4.8	3.2	3.2	3.2	8.0	8.0	4.8	4.8	4.8	4.8	8.0	8.0	4.8	4.8	0.0	0.0	0.0					
Crop coefficient, Kc								1.10	1.10	1.10	1.10	1.10	1.05	1.05	1.05	1.05	1.05	1.05	1.05	0.95	0.95	0.95	0.00	0.00	0.00					
Consumptive use, EToxKc + Pxβ	(mm/day)							11.0	11.0	9.4	9.4	9.4	13.9	13.4	10.2	10.2	10.2	10.2	13.4	12.4	9.2	9.2	0.0	0.0	0.0					
FW=ETc + P - ER	(mm/day)							8.6	8.6	7.0	7.0	7.0	12.0	11.8	8.6	8.6	8.6	8.6	11.8	10.4	7.2	7.2	0.0	0.0	0.0					
Net field water req FW +LP	(mm/day)			7.4	10.9	14.4	17.8	8.6	8.6	7.0	7.0	7.0	12.0	11.8	8.6	8.6	8.6	8.6	11.8	10.4	7.2	7.2	0.0	0.0	0.0					
Unit diversion water requirement	(mm/day)			11.2	16.5	21.7	27.0	13.1	13.1	10.7	10.7	10.7	18.1	17.9	13.1	13.1	13.1	13.1	17.9	15.8	11.0	11.0	0.0	0.0	0.0					
Unit diversion water requirement	(l /sec/ha)			1.29	1.90	2.52	3.13	1.52	1.52	1.24	1.24	1.24	2.10	2.07	1.51	1.51	1.51	1.51	2.07	1.83	1.27	1.27	0.00	0.00	0.00					
4th block																													
Land preparation, LP	(mm/day)				7.4	10.9	14.4	16.0																					
Percolation, P×β	(mm/day)								4.8	4.8	3.2	3.2	3.2	8.0	8.0	4.8	4.8	4.8	4.8	8.0	8.0	4.8	4.8	0.0	0.0	0.0				
Crop coefficient, Kc									1.10	1.10	1.10	1.10	1.10	1.05	1.05	1.05	1.05	1.05	1.05	1.05	0.95	0.95	0.95	0.00	0.00	0.00				
Consumptive use, EToxKc + Pxβ	(mm/day)								11.0	11.0	9.4	9.4	9.4	13.4	13.4	10.2	10.2	10.2	10.2	12.8	12.4	9.2	9.2	0.0	0.0	0.0				
FW=ETc + P - ER	(mm/day)								8.6	8.6	7.0	7.0	7.4	11.8	11.8	8.6	8.6	8.6	8.6	10.9	10.4	7.2	7.2	0.0	0.0	0.0				
Net field water req FW +LP	(mm/day)				7.4	10.9	14.4	16.0	8.6	8.6	7.0	7.0	7.4	11.8	11.8	8.6	8.6	8.6	8.6	10.9	10.4	7.2	7.2	0.0	0.0	0.0				
Unit diversion water requirement	(mm/day)				11.2	16.5	21.7	24.2	13.1	13.1	10.7	10.7	11.3	17.9	17.9	13.1	13.1	13.1	13.1	16.5	15.8	11.0	11.0	0.0	0.0	0.0				
Unit diversion water requirement	(l /sec/ha)				1.29	1.90	2.52	2.80	1.52	1.52	1.24	1.24	1.30	2.07	2.07	1.51	1.51	1.51	1.51	1.91	1.83	1.27	1.27	0.00	0.00	0.00				
5th block																													
Land preparation, LP	(mm/day)					7.4	10.9	13.0	16.0																				
Percolation, P×β	(mm/day)									4.8	4.8	3.2	3.2	3.2	8.0	8.0	4.8	4.8	4.8	4.8	8.0	8.0	4.8	4.8	0.0	0.0	0.0		
Crop coefficient, Kc										1.10	1.10	1.10	1.10	1.10	1.05	1.05	1.05	1.05	1.05	1.05	1.05	0.95	0.95	0.00	0.00	0.00			
Consumptive use, EToxKc + Pxβ	(mm/day)									11.0	11.0	9.4	9.4	8.9	13.4	13.4	10.2	10.2	10.2	9.6	12.8	12.4	9.2	9.2	0.0	0.0	0.0		
FW=ETc + P - ER	(mm/day)									8.6	8.6	7.0	7.4	7.3	11.8	11.8	8.6	8.6	8.6	7.7	10.9	10.4	7.2	7.2	0.0	0.0	0.0		
Net field water req FW +LP	(mm/day)					7.4	10.9	13.0	16.0	8.6	8.6	7.0	7.4	7.3	11.8	11.8	8.6	8.6	8.6	7.7	10.9	10.4	7.2	7.2	0.0	0.0	0.0		
Unit diversion water requirement	(mm/day)					11.2	16.5	19.7	24.2	13.1	13.1	10.7	11.3	11.0	17.9	17.9	13.1	13.1	13.1	11.6	16.5	15.8	11.0	11.0	0.0	0.0	0.0		
Unit diversion water requirement	(l /sec/ha)					1.29	1.90	2.28	2.80	1.52	1.52	1.24	1.30	1.28	2.07	2.07	1.51	1.51	1.51	1.35	1.91	1.83	1.27	1.27	0.00	0.00	0.00		
6th block																													
Land preparation, LP	(mm/day)						7.4	10.0	13.0	16.0																			
Percolation, P×β	(mm/day)										4.8	4.8	3.2	3.2	3.2	8.0	8.0	4.8	4.8	4.8	4.8	8.0	8.0	4.8	4.8	0.0	0.0	0.0	
Crop coefficient, Kc											1.10	1.10	1.10	1.10	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	0.95	0.95	0.95	0.00	0.00	0.00	
Consumptive use, EToxKc + Pxβ	(mm/day)										11.0	11.0	9.4	8.9	8.9	13.4	13.4	10.2	10.2	9.6	9.6	12.8	12.4	9.2	9.2	0.0	0.0	0.0	
FW=ETc + P - ER	(mm/day)										8.6	8.6	7.4	7.3	7.3	11.8	11.8	8.6	8.6	7.7	7.7	10.9	10.4	7.2	7.6	0.0	0.0	0.0	
Net field water req FW +LP	(mm/day)						7.4	10.0	13.0	16.0	8.6	8.6	7.4	7.3	7.3	11.8	11.8	8.6	8.6	7.7	7.7	10.9	10.4	7.2	7.6	0.0	0.0	0.0	
Unit diversion water requirement	(mm/day)						11.2	15.2	19.7	24.2	13.1	13.1	11.3	11.0	11.0	17.9	17.9	13.1	13.1	11.6	11.6	16.5	15.8	11.0	11.4	0.0	0.0	0.0	
Unit diversion water requirement	(l /sec/ha)						1.29	1.76	2.28	2.80	1.52	1.52	1.30	1.28	1.28	2.07	2.07	1.51	1.51	1.35	1.35	1.91	1.83	1.27	1.32	0.00	0.00	0.00	

Table F2.4.3 Calculation of Unit and Total Diversion Water Requirement

(Sample)

Early Paddy (April - July)

Cropping Area (ha)= 2,700

Month/5-da	Area factor									1.00	m3/sec
Jan 1-5										0.00	0.0
6-10										0.00	0.0
11-15										0.00	0.0
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Feb 1-5										0.00	0.0
6-10										0.00	0.0
11-15										0.00	0.0
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Mar 1-5										0.00	0.0
6-10										0.00	0.0
11-15										0.00	0.0
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Apr 1-5	0.14									0.14	0.4
6-10	0.21	0.14								0.35	0.9
11-15	0.28	0.21	0.14							0.63	1.7
16-20	0.34	0.28	0.21	0.14						0.97	2.6
21-25	0.21	0.34	0.28	0.21	0.15					1.19	3.2
26-end	0.21	0.21	0.34	0.28	0.23	0.14				1.41	3.8
May 1-5	0.14	0.17	0.17	0.31	0.27	0.19	0.14			1.39	3.7
6-10	0.14	0.14	0.17	0.17	0.34	0.25	0.19	0.14		1.52	4.1
11-15	0.14	0.14	0.14	0.17	0.18	0.31	0.25	0.19	0.14	1.64	4.4
16-20	0.22	0.14	0.14	0.14	0.18	0.17	0.31	0.25	0.19	1.73	4.7
21-25	0.22	0.22	0.14	0.14	0.15	0.17	0.17	0.31	0.25	1.76	4.7
26-end	0.17	0.23	0.23	0.14	0.16	0.14	0.17	0.17	0.31	1.74	4.7
Jun 1-5	0.17	0.17	0.23	0.23	0.15	0.14	0.14	0.17	0.17	1.57	4.2
6-10	0.17	0.17	0.17	0.23	0.25	0.14	0.14	0.14	0.17	1.57	4.2
11-15	0.17	0.17	0.17	0.17	0.25	0.23	0.14	0.14	0.14	1.56	4.2
16-20	0.23	0.17	0.17	0.17	0.18	0.23	0.23	0.14	0.14	1.65	4.4
21-25	0.22	0.23	0.17	0.17	0.18	0.17	0.23	0.23	0.14	1.72	4.7
26-end	0.16	0.22	0.23	0.17	0.18	0.17	0.17	0.23	0.23	1.74	4.7
Jul 1-5	0.14	0.14	0.20	0.21	0.16	0.15	0.15	0.15	0.21	1.51	4.1
6-10		0.14	0.14	0.20	0.23	0.15	0.15	0.15	0.15	1.30	3.5
11-15			0.14	0.14	0.22	0.21	0.15	0.15	0.15	1.15	3.1
16-20				0.14	0.15	0.20	0.21	0.15	0.15	1.00	2.7
21-25					0.15	0.14	0.20	0.21	0.15	0.85	2.3
26-end						0.15	0.15	0.21	0.22	0.71	1.9
Aug 1-5							0.14	0.14	0.20	0.48	1.3
6-10								0.14	0.14	0.28	0.8
11-15									0.14	0.14	0.4
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Sep 1-5										0.00	0.0
6-10										0.00	0.0
11-15										0.00	0.0
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Oct 1-5										0.00	0.0
6-10										0.00	0.0
11-15										0.00	0.0
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Nov 1-5										0.00	0.0
6-10										0.00	0.0
11-15										0.00	0.0
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Dec 1-5										0.00	0.0
6-10										0.00	0.0
11-15										0.00	0.0
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Max										1.76	4.7

Upland crops (April to July)

Cropping Area (ha)= 0

Month/5-da	Area factor															1.00	m3/sec
Jan 1-5																0.00	0.0
6-10																0.00	0.0
11-15																0.00	0.0
16-20																0.00	0.0
21-25																0.00	0.0
26-end																0.00	0.0
Feb 1-5																0.00	0.0
6-10																0.00	0.0
11-15																0.00	0.0
16-20																0.00	0.0
21-25																0.00	0.0
26-end																0.00	0.0
Mar 1-5																0.00	0.0
6-10																0.00	0.0
11-15																0.00	0.0
16-20																0.00	0.0
21-25																0.00	0.0
26-end																0.00	0.0
Apr 1-5																0.00	0.0
6-10																0.00	0.0
11-15																0.00	0.0
16-20																0.00	0.0
21-25																0.00	0.0
26-end																0.00	0.0
May 1-5	0.04															0.04	0.0
6-10		0.04														0.04	0.0
11-15	0.00		0.04													0.04	0.0
16-20	0.00	0.00		0.04												0.04	0.0
21-25	0.00	0.00	0.00		0.04											0.04	0.0
26-end	0.00	0.00	0.00	0.00		0.04										0.05	0.0
Jun 1-5	0.04	0.02	0.02	0.02	0.03	0.02	0.06									0.22	0.0
6-10	0.04	0.04	0.02	0.02	0.03	0.03	0.02	0.06								0.26	0.0
11-15	0.04	0.04	0.04	0.02	0.03	0.03	0.03	0.02	0.06							0.29	0.0
16-20	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.02	0.06						0.34	0.0
21-25	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.06					0.39	0.0
26-end	0.05	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.06				0.44	0.0
Jul 1-5	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.00					0.16	0.0
6-10	0.03	0.03	0.02	0.02	0.03	0.02	0.02	0.02	0.00	0.00	0.00	0.00				0.19	0.0
11-15	0.03	0.03	0.03	0.02	0.03	0.03	0.02	0.02	0.01	0.00	0.00	0.00	0.00			0.22	0.0
16-20		0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00		0.22	0.0
21-25			0.03	0.03	0.04	0.03	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00		0.22	0.0
26-end				0.03	0.04	0.04	0.03	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.22	0.0
Aug 1-5					0.05	0.05	0.04	0.03	0.03	0.03	0.02	0.01	0.01	0.01	0.00	0.30	0.0
6-10						0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.27	0.0
11-15							0.05	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.24	0.0
16-20								0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.20	0.0
21-25									0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.16	0.0
26-end										0.04	0.04	0.04	0.03	0.03	0.03	0.13	0.0
Sep 1-5											0.01	0.01	0.01	0.01	0.01	0.03	0.0
6-10												0.01	0.01	0.01	0.01	0.01	0.0
11-15																0.00	0.0
16-20																0.00	0.0
21-25																0.00	0.0
26-end																0.00	0.0
Oct 1-5																0.00	0.0
6-10																0.00	0.0
11-15																0.00	0.0
16-20																0.00	0.0
21-25																0.00	0.0
26-end																0.00	0.0
Nov 1-5																0.00	0.0
6-10																0.00	0.0
11-15																0.00	0.0
16-20																0.00	0.0
21-25																0.00	0.0
26-end																0.00	0.0
Dec 1-5																0.00	0.0
6-10																0.00	0.0
11-15																0.00	0.0
16-20																0.00	0.0
21-25																0.00	0.0
26-end																0.00	0.0
Max																0.44	0.0

Medium paddy (Agust - December)

Cropping Area (ha)= 7,500

Month/5-da	Area factor									1.00	m3/sec
Jan 1-5										0.00	0.0
6-10										0.00	0.0
11-15										0.00	0.0
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Feb 1-5										0.00	0.0
6-10										0.00	0.0
11-15										0.00	0.0
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Mar 1-5										0.00	0.0
6-10										0.00	0.0
11-15										0.00	0.0
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Apr 1-5										0.00	0.0
6-10										0.00	0.0
11-15										0.00	0.0
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
May 1-5										0.00	0.0
6-10										0.00	0.0
11-15										0.00	0.0
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Jun 1-5										0.00	0.0
6-10										0.00	0.0
11-15										0.00	0.0
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Jul 1-5	0.14									0.14	1.0
6-10	0.19	0.14								0.32	2.4
11-15	0.24	0.19	0.14							0.57	4.3
16-20	0.30	0.24	0.19	0.14						0.85	6.5
21-25	0.15	0.30	0.24	0.19	0.15					1.03	7.7
26-end	0.16	0.15	0.30	0.25	0.21	0.14				1.21	9.1
Aug 1-5	0.12	0.15	0.15	0.30	0.26	0.19	0.14			1.31	9.8
6-10	0.12	0.12	0.15	0.15	0.32	0.24	0.19	0.14		1.44	10.8
11-15	0.12	0.12	0.12	0.15	0.17	0.30	0.24	0.19	0.14	1.55	11.6
16-20	0.12	0.12	0.12	0.12	0.17	0.15	0.30	0.24	0.19	1.53	11.5
21-25	0.12	0.12	0.12	0.12	0.13	0.15	0.15	0.30	0.24	1.47	11.0
26-end	0.13	0.13	0.13	0.14	0.13	0.16	0.16	0.30	0.24	1.40	10.5
Sep 1-5	0.08	0.08	0.08	0.08	0.09	0.08	0.08	0.11	0.11	0.89	8.0
6-10	0.08	0.08	0.08	0.08	0.09	0.08	0.08	0.08	0.11	0.77	5.8
11-15	0.08	0.08	0.08	0.08	0.09	0.08	0.08	0.08	0.08	0.74	5.5
16-20	0.17	0.08	0.08	0.08	0.09	0.08	0.08	0.08	0.08	0.82	6.2
21-25	0.17	0.17	0.08	0.08	0.09	0.08	0.08	0.08	0.08	0.91	6.8
26-end	0.11	0.17	0.17	0.08	0.08	0.08	0.08	0.08	0.08	0.94	7.0
Oct 1-5	0.10	0.10	0.16	0.16	0.07	0.07	0.07	0.07	0.07	0.87	6.5
6-10	0.10	0.10	0.10	0.16	0.17	0.07	0.07	0.07	0.07	0.91	6.8
11-15	0.10	0.10	0.10	0.10	0.17	0.16	0.07	0.07	0.07	0.93	7.0
16-20	0.16	0.10	0.10	0.10	0.11	0.16	0.16	0.07	0.07	1.02	7.6
21-25	0.15	0.16	0.10	0.10	0.11	0.10	0.16	0.16	0.07	1.10	8.3
26-end	0.10	0.16	0.17	0.11	0.12	0.11	0.11	0.17	0.17	1.24	9.3
Nov 1-5	0.15	0.15	0.21	0.22	0.17	0.16	0.16	0.16	0.22	1.60	12.0
6-10		0.15	0.15	0.21	0.24	0.16	0.16	0.16	0.16	1.39	10.4
11-15			0.15	0.15	0.23	0.22	0.16	0.16	0.16	1.23	9.2
16-20				0.15	0.16	0.21	0.22	0.16	0.16	1.06	8.0
21-25					0.16	0.15	0.21	0.22	0.16	0.91	6.8
26-end						0.15	0.15	0.21	0.22	0.73	5.5
Dec 1-5							0.17	0.17	0.24	0.58	4.4
6-10								0.17	0.17	0.35	2.6
11-15									0.17	0.17	1.3
16-20										0.00	0.0
21-25										0.00	0.0
26-end										0.00	0.0
Max										1.60	12.0

Early paddy (2)

Cropping Area (ha)= 2,700

Month/5-da	Area factor						1.00	m3/sec
Jan 1-5							0.00	0.0
6-10							0.00	0.0
11-15							0.00	0.0
16-20							0.00	0.0
21-25							0.00	0.0
26-end							0.00	0.0
Feb 1-5							0.00	0.0
6-10							0.00	0.0
11-15							0.00	0.0
16-20							0.00	0.0
21-25							0.00	0.0
26-end							0.00	0.0
Mar 1-5							0.00	0.0
6-10							0.00	0.0
11-15							0.00	0.0
16-20							0.00	0.0
21-25							0.00	0.0
26-end							0.00	0.0
Apr 1-5							0.00	0.0
6-10							0.00	0.0
11-15							0.00	0.0
16-20							0.00	0.0
21-25							0.00	0.0
26-end							0.00	0.0
May 1-5							0.00	0.0
6-10							0.00	0.0
11-15							0.00	0.0
16-20							0.00	0.0
21-25							0.00	0.0
26-end							0.00	0.0
Jun 1-5							0.00	0.0
6-10							0.00	0.0
11-15							0.00	0.0
16-20							0.00	0.0
21-25							0.00	0.0
26-end							0.00	0.0
Jul 1-5							0.00	0.0
6-10							0.00	0.0
11-15							0.00	0.0
16-20							0.00	0.0
21-25							0.00	0.0
26-end							0.00	0.0
Aug 1-5	0.21						0.21	0.8
6-10	0.29	0.21					0.50	1.4
11-15	0.37	0.29	0.21				0.88	2.4
16-20	0.46	0.37	0.29	0.21			1.33	3.8
21-25	0.24	0.46	0.37	0.29	0.20		1.56	4.2
26-end	0.25	0.25	0.47	0.38	0.28	0.20	1.82	4.9
Sep 1-5	0.13	0.17	0.17	0.40	0.32	0.25	1.44	3.9
6-10	0.13	0.13	0.17	0.17	0.38	0.32	1.30	3.5
11-15	0.13	0.13	0.13	0.17	0.16	0.38	1.10	3.0
16-20	0.25	0.13	0.13	0.13	0.16	0.16	0.97	2.6
21-25	0.26	0.26	0.13	0.13	0.12	0.16	1.06	2.9
26-end	0.17	0.26	0.26	0.13	0.12	0.12	1.06	2.9
Oct 1-5	0.15	0.15	0.25	0.25	0.10	0.10	1.00	2.7
6-10	0.15	0.15	0.15	0.25	0.23	0.10	1.04	2.8
11-15	0.15	0.15	0.15	0.15	0.23	0.23	1.07	2.9
16-20	0.25	0.15	0.15	0.15	0.14	0.23	1.08	2.9
21-25	0.24	0.25	0.15	0.15	0.14	0.14	1.07	2.9
26-end	0.16	0.25	0.27	0.17	0.16	0.16	1.17	3.2
Nov 1-5	0.23	0.23	0.33	0.34	0.23	0.23	1.60	4.3
6-10		0.23	0.23	0.33	0.32	0.23	1.34	3.6
11-15			0.23	0.23	0.31	0.32	1.09	3.0
16-20				0.23	0.22	0.31	0.76	2.1
21-25					0.22	0.22	0.44	1.2
26-end						0.22	0.22	0.6
Dec 1-5							0.00	0.0
6-10							0.00	0.0
11-15							0.00	0.0
16-20							0.00	0.0
21-25							0.00	0.0
26-end							0.00	0.0
Max							1.82	4.9

Total Div. Req. m3/sec
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.4
0.9
1.7
2.6
3.2
3.8
3.7
4.1
4.4
4.7
4.7
4.7
4.2
4.2
4.4
4.7
4.7
5.1
5.9
7.4
9.2
10.0
11.0
11.7
12.9
14.4
15.1
15.2
15.4
9.9
9.3
9.5
9.8
9.7
9.9
9.2
9.8
9.9
10.5
11.1
12.4
16.3
14.0
12.2
10.0
8.0
6.1
4.4
2.6
1.3
0.0
0.0
0.0
16.3

Table F2.4.4 Dependable Monthly Rainfall and Effective Rainfall

To paddy field

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
80 % Dependable Monthly Rainfall (mm)	0.0	0.0	0.3	26.0	95.8	64.7	80.5	85.0	147.7	158.2	45.1	0.0
Monthly effective rainfall to paddy field=0.75×Monthly rainfall -0.4 (mm)	0.0	0.0	0.0	19.1	71.4	48.1	60.0	63.4	110.4	118.3	33.4	0.0
Daily effective rainfall to paddy field (mm/day)	0.00	0.00	0.00	0.64	2.30	1.60	1.93	2.04	3.68	3.82	1.11	0.00

To upland crop field

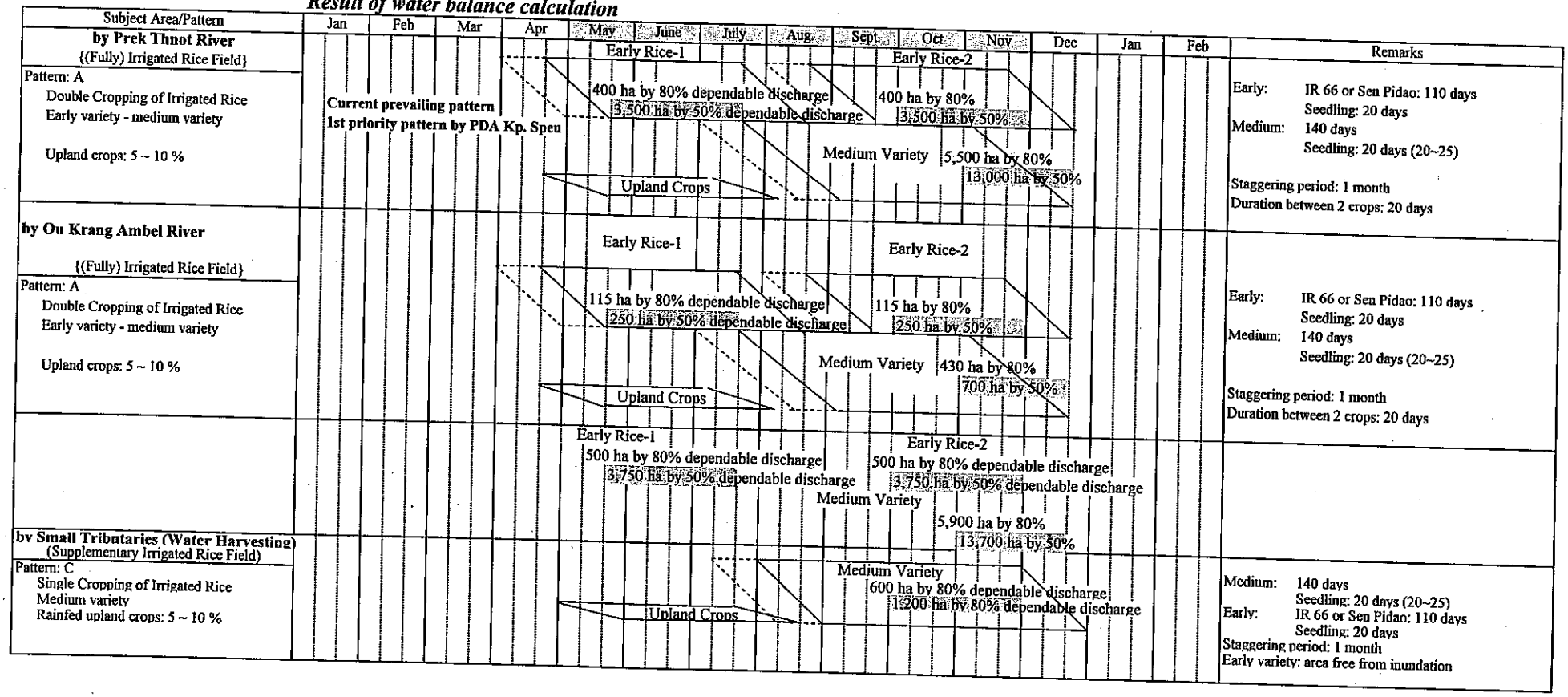
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly effective rainfall (mm)	0	0	0	21.0	91.2	45.9	74.4	57.8	91.6	94.7	32.0	0
Daily effective rainfall (mm/day)	0	0	0	0.70	2.94	1.53	2.40	1.86	3.05	3.06	1.07	0

Average Monthly Effective Rainfall as Related to Average Monthly Etcrop and Mean Monthly Rainfall (USDA(SCA),1969)

Monthly rainfall in mm		12.5	25	37.5	50	62.5	75	87.5	100	112.5	125	137.5	150	162.5	175	187.5	200
		Average monthly effective rainfall in mm															
Average monthly ETcrop in mm	25	8	16	24	*30*												
	50	8	17	25	32	39	46										
	75	9	18	27	34	41	48	56	62	69							
	100	9	19	28	35	43	52	59	66	73	80	87	94	100			
	125	10	20	30	37	46	54	62	70	76	85	92	98	107	116	120	
	150	10	21	31	39	49	57	66	74	81	89	97	104	112	119	127	133
	175	11	23	32	42	52	61	69	78	86	95	103	111	118	126	134	141
	200	11	24	33	44	54	64	73	82	91	100	109	117	125	134	142	150
	225	12	25	35	47	57	68	78	87	96	106	115	124	132	141	150	159
	250	13	25	38	50	61	72	84	92	102	112	121	132	140	150	158	167

Table F2.5.1 Proposed Cropping Calendar by Different Water Source

Result of water balance calculation



Figures

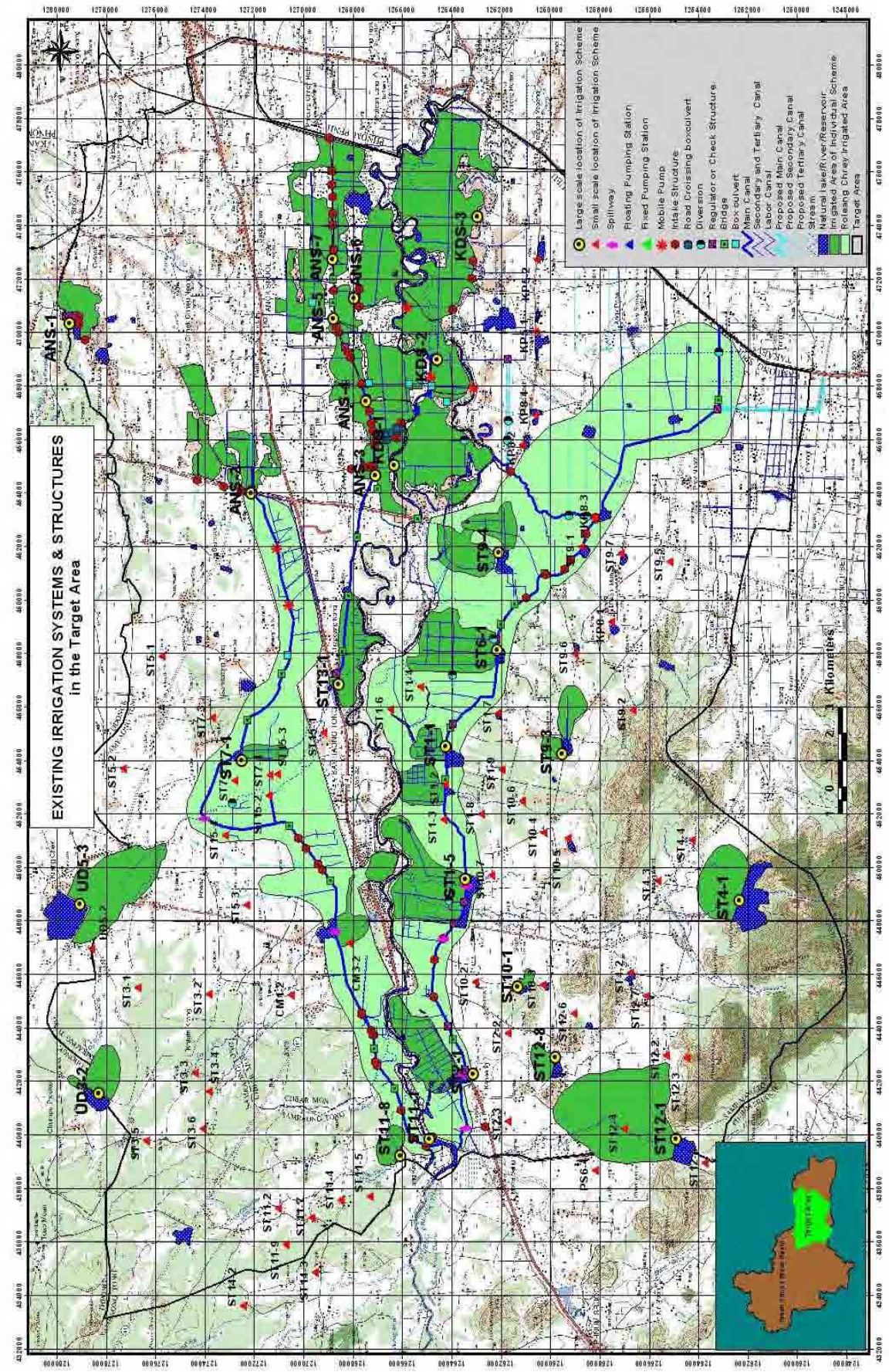


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Figure F1.1.1 Existing Irrigation Systems & Structures in Target Area

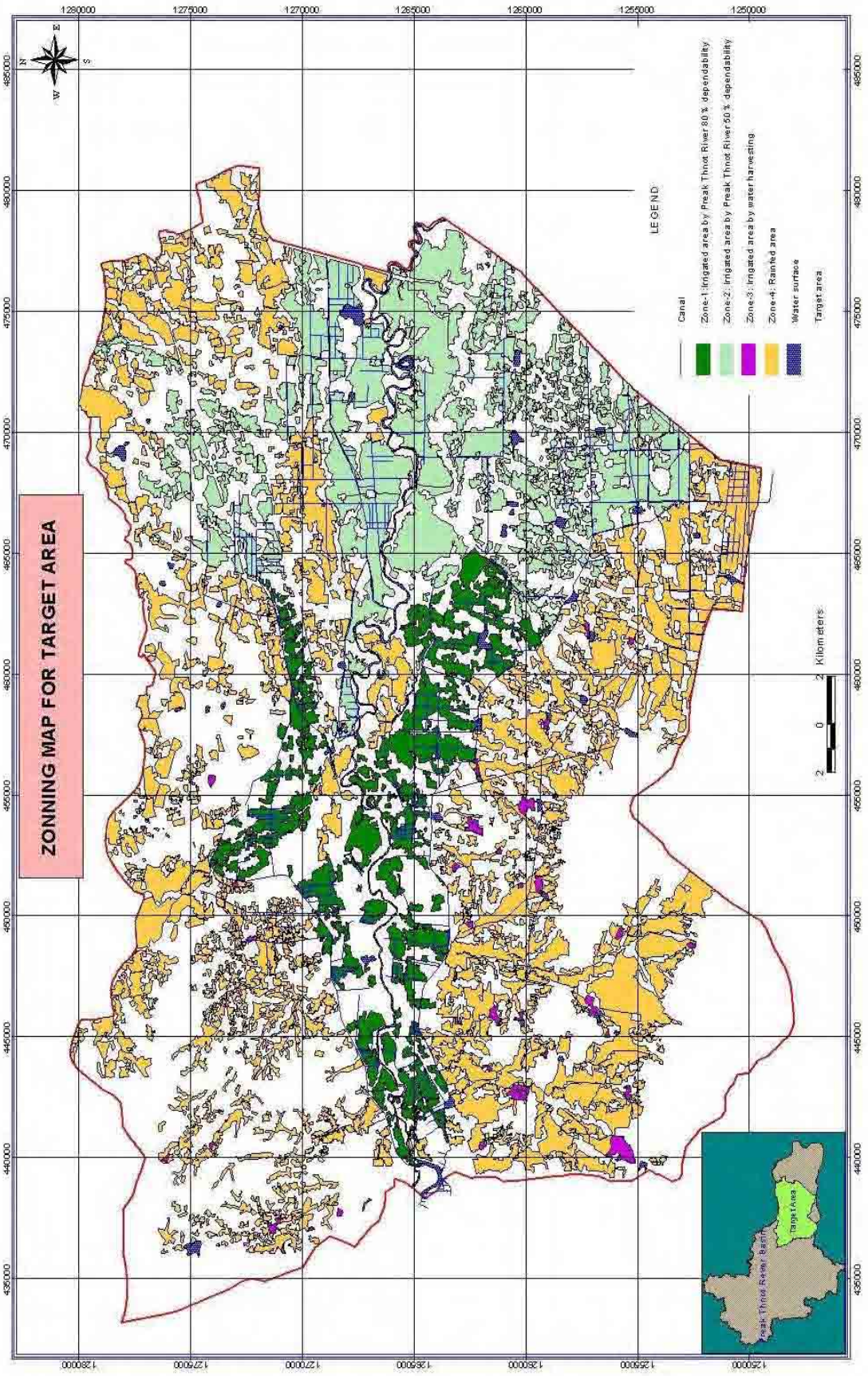

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Figure F2.6.1 Zoning Map for Target Area

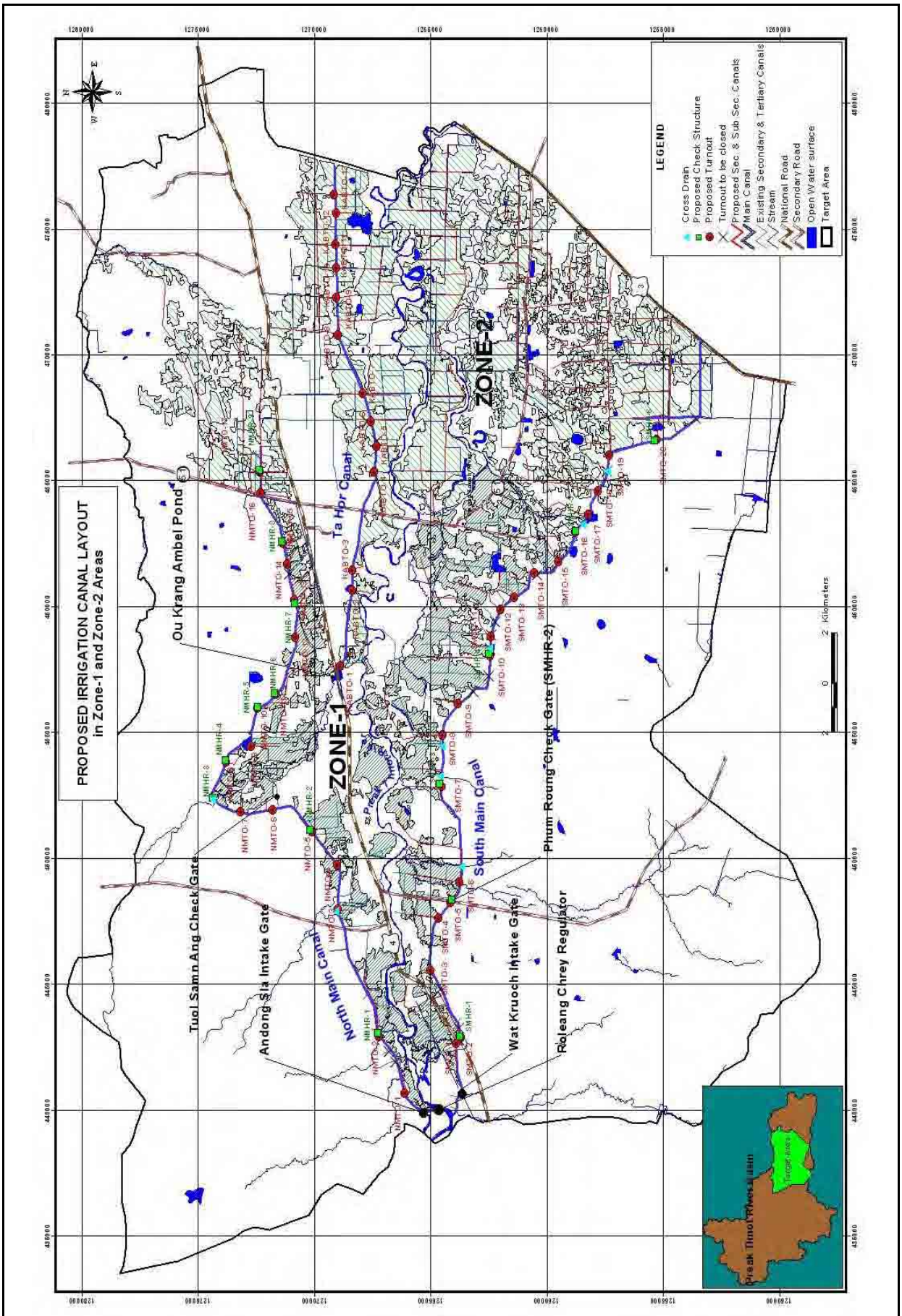

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Figure F3.1.1 Proposed Irrigation Canal Layout in Zone-1 and Zone-2 Areas

Appendix-G

INSTITUTION

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

FINAL REPORT
Volume-VI: Appendixes for Master Plan
Appendix-G
Institution

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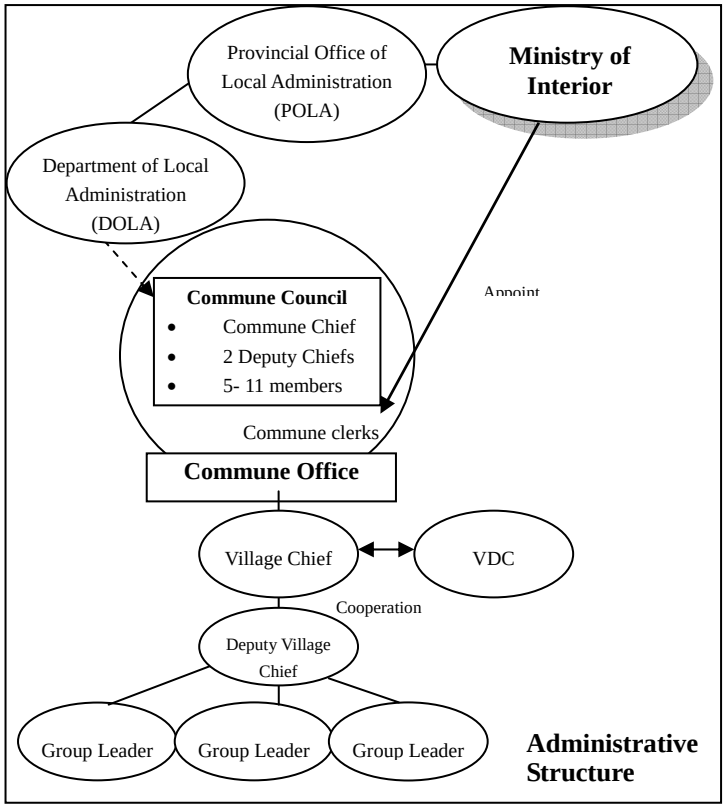
APPENDIX-G: INSTITUTION

G-1 Commune Council (CC)

Commune is the smallest administrative unit under Ministry of Interior. Commune is governed by Commune Council (CC). Commune Council is headed by Commune Chief, who is selected by Commune Council Election every 5 years. The members of Commune Council are also elected at the same time. Commune Council consists of 5-11 members based on demographics and geography. The roles, duties and functions determined in "Low on the Administration and Management of the Commune" are as follows;



Administrative Structure

i) To maintain security and public order,
ii) To arrange necessary public services and be responsible for the good functioning of these affairs,
iii) To encourage the creation of contentment and well-being of the citizens,
iv) To promote social and economic development and upgrade the living standards of the citizens,
v) To protect and conserve the environment, natural resources and national cultural heritage,
vi) To encourage mutual understanding and tolerance among citizens,
vii) To perform general affairs to meet the needs of citizens,
viii) To promote and facilitate the development of the commune by invoking assistance and mobilizing capacities, and
ix) To promote and coordinate the process of democracy in the commune.

G-2 Village Development Committee (VDC)

VDC (Village Development Committee) is established according to the guideline approved by RGC in 1999. VDC members are elected through secret ballot by villagers, and thus the villagers rely on VDC and regard it as their representatives. MRD has been supporting to strengthen or organize VDC, but VDC is independent organization. Therefore, VDC does not have any political, religious, and racial influences. Usually, VDC cooperates with Village Chief when the donors come to the village for development or/ and support. It is remarkable that VDC members do not receive any salary and allowance, but continue their activities. Their incentives can be said that they have the better opportunities to join the training course and the study tour than the ordinal villagers, and reliance from the villagers. Currently, 70% of the villages have established and the rests are preparing to establish VDC in the Target Area. As for the organizational structure, see attached Figure G.1.1 Organizational Structure of VDC. Attached Figure G.1.2 shows

the structure of VDC. In addition, MRD is preparing a draft for VDC circular. Some differences of the present circular and the draft are indicated in the table below.

Differences of the Present Circular and the Draft

Description	Present Circular	Draft
# of member	5-11 persons	5-7 persons
VDC as the assistant of CC*	No	Yes
Budget for VDC activities	No	Yes
Meeting with CC monthly	No	Yes
Mandate	3 years	4 years

Note: CC* = Commune Council

Source:Guideline on Implementation of Decision # 02 Dated on 11 April 1999of RGC about Establishment of Provincial/ City Rural Development Committee (June 1999 MRD)

G-3 Farmers Water Users Community (FWUC)

Forming of Farmers Water Users Community (FWUC) and its subordinate organization, Farmers Water Users Group (FWUG) has been promoted by MOWRAM. They have been established based on the statute of the FWUC issued in June 2000. Main objectives of FWUC are to supply adequate water for irrigation to the members, and to acquire the knowledge of management, maintenance and operation of the irrigation system as well as financial affairs. The table below mentions the inventory data on FWUC in the Target Area. As shown in the table, 25 FWUCs have established in the Target Area but none of them are officially registered. Most of FWUCs are generally inactive mainly due to improper irrigation system.

Inventory Data on FWUC

Name of Irrigation System	Area		
	Commune	District	Province
Ou Kam Pis	Roka Thum	Chbar Mon	Kampong Speu
Roleang Chrey Tboung	Roleang Chak	Samraong Tong	Kampong Speu
Prey Sya	Roleang Chak	Samraong Tong	Kampong Speu
Prey Svay	Roleang Chak	Samraong Tong	Kampong Speu
Prey Robang	Roleang Chak	Samraong Tong	Kampong Speu
Prey Rongeang	Skuh	Samraong Tong	Kampong Speu
Anlong Por	Roleang Chak	Samraong Tong	Kampong Speu
Bak Thmenh	Roleang Chak	Samraong Tong	Kampong Speu
Ou Veaeng	Kahaeng	Samraong Tong	Kampong Speu
Daun Try	Roleang Kreul	Samraong Tong	Kampong Speu
Rong Kor	Rong Kor	Samraong Tong	Kampong Speu
Prey Rumduol	Saen Dei	Samraong Tong	Kampong Speu
Roleang Chrey	Tang Krouch	Samraong Tong	Kampong Speu
Thmor Pouk	Thommada Ar	Samraong Tong	Kampong Speu
Ou Krang Ambel	Trapeang Kong	Samraong Tong	Kampong Speu
Sala Kruos	Preah Nipean	Kong Pisei	Kampong Speu
Boeng Chram Khang Cheung	Preah Nipean	Kong Pisei	Kampong Speu
Pring Tuek	Roka Kaoh	Kong Pisei	Kampong Speu
O Ta Pung	Roka Kaoh	Kong Pisei	Kampong Speu
Day Krohorm	Roka Kaoh	Kong Pisei	Kampong Speu
Samdech Sang Choun Nath	Roka Kaoh	Kong Pisei	Kampong Speu
Domnak Ampil main canal	Damnak Ampil	Angk Snuol	Kandal
Ta Hor Canal	Prey Puok Krang Mkaka Boeng Thum	Angk Snuol	Kandal

Source: Inventory List of FWUCs of Cambodia of MOWRAM, Socioeconomic Survey conducted by the Study Team

G-4 Farmers Organization (FO)

Farmers Organization (FO) is defined as; "An organization which is a collective entry of farmers in a village or in a number of contiguous villages who have come together for an economic activity related to agriculture" in Status of Farmer Organizations in Cambodia, MAFF 1999. This definition includes all organizations whose members are farmers formed by MAFF, NGOs, and the other donors. In a strict meaning; however, Farmers Organization can be defined as the organization registered in or supported by MAFF. Under the coordination of MAFF, there are 4 Farmers Organizations; Agricultural Cooperatives, Community Forestry Communities, Fishery Communities, and Village Animal Health Worker Associations (VAHW). According to the hearing from PDA Kampong Speu and Kandal Provinces, there are 3 agricultural cooperatives in the Target Area. One is in Preah Nipean Commune, one is Prey Nheat Commune, and the rest one is in Roleang Kruel Commune of Kampong Speu Province.

G-5 SWOT for Institutional Analysis

G-5.1 Background

Participatory workshops applying SWOT (Abbreviation of Strengthens, Weaknesses, Opportunities and Threats) analysis were held to understand the present condition of the governmental agencies concerned with the Study; MOWRAM, MAFF, PDOWRAMs and PDAs in Kandal and Kampong Speu Provinces. The final goal of the workshops was to formulate the strategies for strengthening and developing the agencies from the viewpoint of officers working for the agencies, respectively. The workshop also aimed at seeking the way of cooperation and collaboration between the governmental agencies mentioned above and the Study Team.

G-5.2 SWOT Analysis Method

SWOT is one of the popular methods for institutional/ organizational analysis. It consists of mainly 2 steps;

(i) Identifying internal factors (strengths and weaknesses) and external factors (opportunities and threats) of the organization, and
(ii) Combing/Matching the internal factors with the external factors identified in Step (i) to formulate organizational strengthening strategies.

In more details, "Internal factors" and "External factors" are classified into 5 and 6, respectively. In more strict meaning, "External factors" is the external influencing factors to complete the daily works/ to achieve "Mission" of the organization. "Mission" is the overall objective or the reason for the existence of the organization. The table below explains the details of each factor.

Internal and External Factors

Internal Factors	External Factors
1) Management style (ex. Participatory? Exclusive?)	1) Political/ Legal (ex. Related government regulation?)
2) Staff (ex. Punctuality? Motivation?)	2) Physical/ Natural (ex. Drought, flood risks?)
3) Knowledge/ Expertise (ex. Enough for completing the works?)	3) Infrastructural (ex. Roads? Power supply?)
4) Physical resources (ex. Transportation means, office equipment)	4) Technological (ex. Available new technology?)
5) Link (ex. Regular meetings/ workshops?)	5) Economic/ Financial (ex. Budget for the project conducted?)
	6) Physiological/ Socio-cultural (ex. Gender issue? Religious issue?)

Based on the identified SWOT, four types of the strategies can be formulated; (i) Growth

Strategy, (ii) Improvement Strategy, (iii) Avoidance Strategy, and (iv) Withdrawal Strategy. SWOT Matrix describes the entering areas of each strategy and their characteristic.

SWOT Matrix

	Opportunities	**Threats**
Strengths	Using Strengths to seize Opportunities (**Growth Strategy**)	Using Strengths to avoid Threats (**Avoidance Strategy**)
Weaknesses	Removing weaknesses to seize Opportunities (I**mprovement Strategy**)	Removing weaknesses to s avoid Threats (**Withdrawal Strategy**)

In the workshops, the identified Strengths, Weaknesses, Opportunities, and Threats were prioritized to formulate 4 types of strategies to achieve the "Mission" of each agency. Three or Four by factor enter in the SWOT matrix according to the order of high priority.

G-5.3 Workshop Schedule, Participants and Venues

Workshop schedule, participants and venues are summarized in the table below. Qualification of the participants was department chief or deputy department chief of MOWRAM and MAFF, office chief or deputy office chief. It meant that the participants should have been those who can make decision to strengthen/ develop the agencies. The participants were selected covering the departments of the ministries and offices of provincial departments concerned with the Study.

SWOT Workshop Schedule, Participants and Venues

Schedule	Participant	# of Participant	Venue
17 Jan, 2006	Officers of PDOWRAM Kampong Speu Province	16 (M:F= 16:0)	PDOWRAM Kampong Speu Province office
18 Jan, 2006	Officers of PDOWRAM Kandal Province	15 (M:F= 13:2)	PDOWRAM Kandal Province office
19 Jan, 2006	Officers of PDA Kampong Speu	14 (M:F= 12:2)	PDA Kampong Speu office
20 Jan,, 2006	Officers of PDA Kandal Province	15 (M:F= 13:2)	PDA Kandal office
24 Jan,, 2006	Officers of MOWRAM	18 (M:F=16:2)	MOWRAM, Phnom Penh
31 Jan, 2006	Officers of MAFF	12 (M:F=10:2)	MAFF, Phnom Penh

Note: M = male participants and F = female participants

G-5.4 Results of SWOT Workshops and Findings

G-5.4.1 MOWRAM

"Managing and developing the water resources and taking the data on meteorology constantly" is regarded as the "Mission" of MOWRAM among the participants. SWOT and 4 types of the strategies to achieve the mission mentioned above are as follows.

SWOT Matrix for MOWRAM

	Opportunities **1st:** RGC is interested in irrigation systems. **2nd:** There is the water management policy. **3rd:** There is the support from JICA. **4th:** Farmers cooperate with MOWRAM in repairing irrigation systems.	**Threats** **1st:** Cambodian people face flood and drought almost every year. **2nd:** The budget to develop water resources is not sufficient. **3rd:** MOWRAM doesn't receive enough budgets for constructing irrigation facilities.
Strengths **1st:** MOWRAM has a good planning skill. **2nd:** Managers have	**Growth Strategy** • Submitting plans and projects to the National Assembly and requesting support from JICA for	**Avoidance Strategy** • Requesting enough budgets to the National Assembly or other organizations for construction of

leadership ability and manage the works properly based on the technical skills. **3rd:** Most staffs are capable.	the development. • Making a good master plan about the irrigation system that would last for long time with the support from JICA. • Controlling of information on hydrology and meteorology. • Controlling and developing the water resources. • Requesting the farmers' participation in maintaining the irrigation systems. • Establishing laws and regulations about sustainable water use and practicing them.	irrigation systems in order to fight against drought. • Establishing flood control plans. • Building the levees to prevent from flood and the reservoir to store water to fight against drought. • Preparing the request to propose for the budget in order to improve and build more sufficient irrigation system led by the capable officers.
Weaknesses **1st:** Staffs' salary is low. **2nd:** Distribution of the work assignment is not proper. **3rd:** There is no training program to modernize the knowledge within MOWRAM.	**Improvement Strategy** • Improving the management and the administration to develop the human resource through requesting the help from RGC. • Requesting higher allowances, bonuses, and salary. • Requesting more cooperation from the officers of the other organizations. • Improving the human resource through asking to help from JICA. • Creating more training programs for officers and farmers. • Increasing the salary and allowances of the staffs who perform well. • Improving technical skills to work more effectively and to receive more payment. • Improving the staffs' capacity to apply for the jobs on natural disaster. (The job assignments are not based on the hierarchy status, and staffs' salary is low. Is this the reason that we cannot cooperate and work properly?)	**Withdrawal Strategy** • Expecting more state budget allocation to MOWRAM.

Sad to say, recognition of the Study Team and JICA was quite low among the participants. Most of them stated they did not know the activities of the Study Team until the workshop day and recognized JICA as a NGO. One fourth of the participants disappeared during the workshop. Moreover, a chief of a department sent a cleaning lady to the workshop in stead of him. As just described, the motivation to join the workshop/ to improve their working environment and performance was weak at the beginning; however, the discussion heated up gradually. They became enthusiastic to learn the strategic orientation based on SWOT.

G-5.4.2 MAFF

"Improving agricultural productivity for enhancing food security and promoting export to boost national economy" was regarded as the "Mission" of MAFF among the participants. The participants believed this mission plays an important role to reduce poverty. SWOT and 4 types of the strategies to achieve the mission mentioned above are as follows.

SWOT Matrix for MAFF

	Opportunities	**Threats**
	1st: MAFF can get the support from RGC to build irrigation systems. **2nd:** MAFF can get the support from	**1st:** Due to low salary, the experts cannot help the farmers. **2nd:** There is corruption.

	donors in agricultural development. **3rd:** MAFF can get the participation from farmers, who consist of 80% of population.	**3rd:** Forests are destroyed everyday and fish are endangered.
Strengths **1st:** Some departments of MAFF have enough expertise. **2nd:** Some staffs have strong motivation to work. **3rd:** All departments have the action plan for development.	**Growth Strategy** • Encouraging farmers to increase their agricultural production through training, providing production means, and guaranteeing the market for their products. • Providing new technologies to the farmers to promote intensive agriculture and grow more varieties of crops. • Strengthening the monitoring system on agricultural land, and promoting the reclamation of cultivatable land. • Increasing agricultural production yield. • With the encouragement and support of RGC and available MAFF development action plans, improving agricultural productivity through farmers' participation promoted by the motivated experts of MAFF.	**Avoidance Strategy** • Reducing corruption • Improving the national resource management (by using the staffs who have strong motivation).
Weaknesses **1st:** There are no incentives in the departments. **2nd:** MAFF lacks physical and financial resources to implement its good plans and law. **3rd:** Level of staffs' expertise is still low.	**Improvement Strategy** • Encouraging the staffs, who perform the works well. • Providing more new technology and skills to the staffs through training. • Encouraging the staffs to go for the training of new technology, and in the meantime, asking the support from the foreign countries. • Encouraging farmers to grow crops, and raise animals in the uncultivated land. • Encouraging the experts through giving them the opportunities to work in their specialized fields by using their expertise. • Increasing the salary of the staffs • Prioritizing the staffs' capacity building and taking care of their living standard. • Dispatching the agricultural experts throughout the country.	**Withdrawal Strategy** • Reducing the number of staffs who do not have the educational background related to agriculture, and encouraging the agriculture experts.

The workshop was conducted with a small number of highly efficient and selected staffs. The discussion during the workshop did not limit in SWOT and expanded to the framework of Japanese ODA as a whole. More specifically, the discussion on the structure of MAFF and the relation between MAFF and the National Assembly was remarkably interesting. The participants had a deep interest in the activities of the Study Team and JICA. They were seeking/ seizing the "Opportunities" provided through the Study Team and JICA. This is a good sign to promote cooperation with MAFF and the Study Team.

G-5.4.3 PDOWRAM Kampong Speu

"To supply enough water for agricultural and industrial uses and also for the daily living

to people" is regarded as the "Mission" of PDOWRAM Kampong Speu among the participants. SWOT and 4 types of the strategies to achieve the mission mentioned above are as follows.

SWOT Matrix for PDOWRAM Kampong Speu

	Opportunities **1st:** PDOWRAM Kampong Speu can get the support form JICA. **2nd:** RGC is interested in water resources. **3rd:** PDOWRAM Kampong Speu can get the participation from farmers.	**Threats** **1st:** Staffs' salary is low. **2nd:** PDOWRAM Kampong Speu lacks the budget for rehabilitation works. **3rd:** Existing irrigation systems do not guarantee water for farmers.
Strengths **1st:** Leaders are capable. **2nd:** PDOWRAM Kampong Speu can make plans. **3rd:** PDOWRAM Kampong Speu has good relation with farmers.	**Growth Strategy** • Utilizing the good relation with farmers and proposing the rehabilitation projects of irrigation systems through seeking support from RGC and fund from JICA.	**Avoidance Strategy** • Leaders' creating of the jobs such as the programs and the projects prepared by IOs or NGOs and RGC. • Making the program for repairing the irrigation system step by step, and at the same time trying to seek the supports from donors.
Weaknesses **1st:** The capacity of accounting, administration, and planning is limited. **2nd:** Study tours to foreign countries and in Cambodia are not enough. **3rd:** PDOWRAM Kampong Speu lacks the means to work.	**Improvement Strategy** • Making the training program and planning a long-term study tour in the country or foreign countries through seeking the support from RGC and fund from JICA. • Asking for the help and the fund from JICA and RGC in order to purchase the working means and equipments such as cars, and motorcycles.	**Withdrawal Strategy** N.A.

The staffs of PDOWRAM were competent enough to identify SWOT and to classify them into internal and external factors. They see the problems in their working environment and performance. It took time for them to understand the way of formulating the strategies, but they were eager to conceive the strategies. The director also had a keen interest in a participatory SWOT analysis and joined the discussion enthusiastically. It observed that they have high motivation for their works but face the financial and physical difficulties.

G-5.4.4 PDOWRAM Kandal

"To supply enough water for agricultural, industrial and daily/ domestic uses and to tell the people how to maintain the irrigation systems by themselves" is regarded as the "Mission" of PDOWRAM Kandal among the participants. SWOT and 4 types of the strategies to achieve the mission mentioned above are as follows.

SWOT Matrix for PDOWRAM Kandal

	Opportunities **1st:** Cambodia is politically stable. **2nd:** RGC named it "Irrigation Government." **3rd:** JICA helped PDOWRAM Kandal to study the irrigation facilities.	**Threats** **1st:** Natural disasters have struck Kandal Province. **2nd:** PDOWRAM Kandal lacks the budget for construction works. **3rd:** Water Law doesn't exist.
Strengths **1st:** Officers enjoy good health condition. **2nd:** PDOWRAM Kandal has good management. **3rd:** PDOWRAM Kandal can get active participation in the works of the	**Growth Strategy** • Seeking help from JICA in order to study the development project about the irrigation systems. • Making the good relation and information exchange with JICA. • Collecting the data on the water shortage area and proposing the projects to JICA for help	**Avoidance Strategy** • Creating water using law for farmers. • Encouraging farmers to join together in order to search for help.

PDOWRAM.		
Weaknesses **1st:** The officers' salary is low. **2nd:** PDOWRAM Kandal lacks transportation means. **3rd:** The office is too small. **4th:** PDOWRAM Kandal lacks the funds to study projects.	**Improvement Strategy** • Contacting NGOs and JICA for the support of the salary. • Requesting JICA for help with transportation means. • Requesting the budget from JICA in order to study and improve the irrigation systems. • Requesting JICA for help with constructing the office. • Requesting JICA with the budget to study the projects. • Requesting JICA with the budget to construct the irrigation systems. • Renting a truck for study tours in the areas with developed irrigation systems.	**Withdrawal Strategy** • Renting the transportation means in order to search for the budgetary assistance of the projects. • Seeking for kind people or supporting agencies in the country or abroad. • Seeking for the partners to construct the irrigation system.

At the beginning of the workshop, its proceeding method provoked the big discussion among the participants. It was the proof that they had the interest in SWOT analysis. It was a little hard for them to classify the factors into external and internal ones respectively, but the classification became smooth gradually. They thoroughly understood how to formulate "Growth" and "Improvement" strategies. The director organized the workshop very well. This proved the high capability in management of PDOWRAM Kandal.

G-5.4.5 PDA Kampong Speu

"To increase farmers' income by improving agricultural production activities" is regarded as the "Mission" of PDA Kampong Speu among the participants. SWOT and 4 types of the strategies to achieve the mission mentioned above are as follows.

SWOT Matrix for PDA Kampong Speu

	Opportunities **1st:** JICA implements the project in Kampong Speu Province. **2nd:** RGC puts the 1st priority on agriculture. **3rd:** There is farmers' participation.	**Threats** **1st:** There are not enough irrigation systems in Kampong Speu Province. **2nd:** PDA Kampong Speu lacks the budget for development. **3rd:** Technical knowledge of farmers is still low.
Strengths **1st:** There are capable leaders. **2nd:** Knowledge, the number and capability of the staffs are medium. **3rd:** There is a clear plan. **4th:** There are enough experienced staffs to apply for the project.	**Growth Strategy** • Managing of the planning activities and proposing the projects to JICA for the budgetary assistance for the agricultural works. • Assigning the skillful staffs to cooperate with the farmers. • Seeking for the support from JICA and providing the training program to the farmers.	**Avoidance Strategy** • Trying to repair the irrigation systems through requesting the supporting projects of JICA. • Increasing the relationship with PDOWRAM in order to construct the irrigation system and control the water resources effectively and efficiently.
Weaknesses **1st:** Skills of some staffs are limited. **2nd:** Allowance for the staffs is limited. **3rd:** PDA Kampong Speu staffs lack transportation means.	**Improvement Strategy** • Trying to find documents or books in libraries related to agriculture. • Strengthening the abilities of the staffs and farmers through training programs and study tours.	**Withdrawal Strategy** • Expecting the investment of private companies in agriculture. • Giving the permission to the private companies to develop water resources.

The participants said they had the knowledge of SWOT and experienced the other SWOT workshops. Nevertheless, it was tough for them to classify the factors into external and internal ones respectively. Most of them lacked the motivation to participate in the

workshop. This might be because there have been so many opportunities to attend the workshops organized by various types of donors, and the donors have not required their involvement much in the discussion. The participants did not intend to see any problems with their performance and focused on the general but not the specific issues to them. Moreover, one third of the participants escaped from the workshop after the break in the morning because of joining the wedding ceremony. A ray of this agency is the existence of a few qualified and eager chief class staff.

G-5.4.6 PDA Kandal

"To enhance the agricultural development in order to guarantee food security and increase the income of the farmers" is regarded as the "Mission" of PDA Kandal among the participants. SWOT and 4 types of the strategies to achieve the mission mentioned above are as follows.

SWOT Matrix for PDA Kandal

	Opportunities **1st:** PDA Kandal can get the support from JICA. **2nd:** PDA Kandal can expect the participation from the farmers. **3rd:** RGC has clear and good policy.	**Threats** **1st:** Kandal Province has faced drought and flood. **2nd:** Farmers do not incorporate the new technique. **3rd:** Irrigation systems are insufficient and improper.
Strengths **1st:** Staffs are highly responsible. **2nd:** Organizational structure of PDA Kandal is proper. **3rd:** Chiefs have good management and leading skill.	**Growth Strategy** • Trying to make the farmers understand farming knowledge by themselves. • Extending the knowledge to the farmers through the staffs who had received technical training. • Organizing farmers' associations. • Giving TOT (Training of Trainers). • Providing the extension service to leader farmers. • Transferring the crop planting technique to the farmers. • Sending the staffs to study appropriate technologies. • Providing more knowledge to the farmers for agricultural development. • Training the staffs in order to extend the knowledge to the farmers. • Making good relation with JICA in order to ask for help to manage irrigation systems and to fight against drought.	**Avoidance Strategy** • Managing and controlling the existing or new irrigation systems for proper water use and distribution. • Trying to forecast the natural disaster and to make a good plan for preparing drought/ flood. • Dispatching the experienced officers to train the farmers.
Weaknesses **1st:** Staffs' salary is low **2nd:** Working means are insufficient. **3rd:** There are not enough human resources in rural areas.	**Improvement Strategy** • Proposing the specific project on supporting the insufficient part of PDA Kandal • Proposing the project to seek support from JICA in order to organize the village livestock agency (VLA). • Improving the capacity of the staffs in order to get the support from IOs and NGOs • Creating the seeds providing program to the farmers in the rural areas through proposing the project to JICA. • Requesting the help of NGOs or	**Withdrawal Strategy** • Stopping some activities which cannot avoid the effects of natural disasters and/or which require high technique.

	the other donors in order to construct reservoirs and to repair irrigation systems. • Requesting the budget for the study tour on the farmers. • Searching for the help from the donors in order to act on time. • Requesting the help of JICA to establish "Animal Bank." • Requesting the help of JICA for emergency assistance of animal foods in preparation for flood/ drought. • Proposing the project to JICA for rehabilitating the small irrigation system. • Extending the technique to the farmers through rural development groups. • Trying to extend and introduce the new seeds suitable for each area. • Organizing and strengthening the FWUC in each area. • Seeking for the help from donor agencies in order to make the extension program to the farmers for early rice planting.	

The participants said they had the knowledge of SWOT and experienced the other SWOT workshops. Except a few participants, they lacked the motivation to participate in the workshop. Two third of the participants walked out and the remains abandoned themselves to chatting or reading the documents not related with the workshop. This meant most of the participants did not have any interests in improving their working environment or/ and performance. A ray of this agency is that a senior officer has the opinion; it is ashamed of depending on the donors everything of PDA works.

In conclusion, the motivation/ incentive to work is very crucial to achieve the missions and to cooperate with the other agencies; in more strict sense, MOWRAM and MAFF, and PDOWRAM and PDA in each Province. Improving their motivation surely contributes to executing the pilot projects in the Master Plan for comprehensive agricultural development in the Prek Thnot river basin and the Master Plan itself. It is comprehensible that most of the participants/ the officers lack strong motivation to work due to low salary. Nevertheless, the incentive is not only money. It is noticeable that staff motivation can be boosted by the awareness of necessity for the works or somebody; specially, the bosses. Acknowledgement from them and probably external agencies concerned would be a strong incentive for the officers.

Tables

(1) Mission and SWOT of MOWRAM

Mission

- Managing and developing the water resource and taking the data on meteorology constantly.

Table G.5.1 SWOT of MOWRAM

Strength
1st MOWRAM has a good planning skill **2nd Managers have leadership ability and manage the works properly based on the technical skill** **3rd Most of officers are capable** • There are good and sufficient leaders in MOWRAM. • The manager has strengths. • Rain is gauged regularly. • Data on hydrology, meteorology and irrigation systems are available in MOWRAM. • Good relationship between leaders and staffs. • There are proper tools or materials to use in the office. • There are modern facilities. • Managers or officers have experiences for applying the projects. • There are good management structures. • The institute has sufficient structures. • There are offices in all provinces and cities. • Working group structure of MOWRAM is good and adequate. • Counterparts can participate in the survey of JICA Study Team all the times. • There are FWUCs in some provinces • MOWRAM has many experiences. • MOWRAM has enough staffs to work. • There are plenty of officers. • Officers received many technical training programs. • There are technical staffs with high capacity or skill. • Staffs that have enough technical skill are happy to work. • MOWRAM has good relationship with JICA. • Officers have specific skill. • Most officers are capable. • Technical skills of staffs are good • Strong and capable officers have skills. • MOWRAM has enough human resource to complete the job. • MOWRAM has good communication with line agencies. • MOWRAM has good cooperation with the other ministries and NGOs. • The managers are strong.
Weakness
1st Low salary **2nd Distribution of the work assignment is not proper** **3rd There is no training program to modernize the knowledge within MOWRAM** • Poor living standard of the officers. • Lack of financial support for staffs' tasks. • Some officers escape from the jobs due to low salary. • Officers have many works to do but can receive small allowances. • Many officers do not respect the working time. • Lack of cooperation with staffs. • One person does many tasks. • Limited cooperation within the organization. • There is not enough works for some staffs. • Chances are not provided for some capable officers. • The irrigation system is not controlled properly. • Leaders of MOWRAM did not use the experience staffs. • Most officers do not have much cooperation with the other organizations. • The management of the high ranking officers is not transparent. • Some leaders lack capacity of leading and having relationship with the technical staffs.

- Some high ranking officers do not respect to their obligations and duties.
- There are modern equipments but spare parts are not enough.
- Technical equipments are not so modern.
- There is not enough office equipment including PC.
- Some leaders lack the ability to manage the jobs.
- Some high ranking officers do not listen to the ideas of subordinate staff.
- Some high ranking have temper.
- Some expert staffs are doing the job not based on their own expertise.
- Lack of transportation means to work
- Limited facilities to apply for the projects.
- Experienced staffs do not have many works to do.
- There is no transparency.
- Knowledge of the officers is limited.
- Officers lack the knowledge for skilled works.
- Limited technique.
- Lack of human resource.
- Job assignment is determined based on friendship or kinship.
- Doing the job with wrong technique.
- Some officers are not serious about doing the jobs.
- It takes longer time of unskillful staffs to do the job.

Opportunities

1st RGC is interested in the irrigation system
2nd There is the water management policy
3rd There is support from JICA
4th Farmers cooperate with MOWRAM in repairing irrigation systems

- There are machineries to repair and construct the irrigation systems.
- MOWRAM is the only one agency that has the duty to make laws or regulations related water resource.
- MOWRAM receives high technologies from the JICA experts.
- Cambodia has abundant rainfalls.
- There are supports from international organization: ADB, WB, and JICA.
- MOWRA try to know the natural phenomena first and then to create the measures to fight against flood and drought.
- MOWRAM receives the aid from NGOs for the development.
- There is good policy and law in the country
- JICA has chances to help MOWRAM for construction of irrigation systems.
- MOWRAM are supported by various NGOs for studying and increase the technology.
- Social-cultural condition has improved due to the reduction of the illiterate.
- NGOs support MOWRAM because NGO trusts MOWRAM due to the good polices of RGC.
- There are trainings provided by foreign countries.
- Peace and political stability
- Favorable nature
- Clear seasons: dry and rainy seasons
- There are chances to study in Japan.
- There are many water sources.
- Technical improvement.
- Good relation with neighboring countries and other countries in the world.
- There is proper structure from the central government to local government (Communes and Villages).
- There are needs of the people in the areas.
- Cambodia is lucky because it receives economical and technical aid from international communities and countries.
- There are infrastructures in all fields.
- There is participation from the farmers.
- Infrastructure has improved due to political stability.

Threats

1st Cambodian people face flood and drought almost every year
2nd The budget to develop water resources is not sufficient.
3rd MOWRAM doesn't receive enough budgets for constructing the irrigation facilities.

- There is too much water in the rainy season, but insufficient water in the dry season. This affects on the agriculture.
- Drought
- Flood, the long dry season and other natural disaster.
- Small amount of budget to construct the irrigation system.
- State budgets are not enough for water resource development plans.
- Farmers have many children.
- MOWRAM does not get enough fund (from the cabinet) to develop the country.
- Irregularity rainfall by the season.
- People have low knowledge.
- Lack of measurement to defend from natural disasters.
- Some areas lack electricity power, water supply, and roads.
- Poor technology.
- Lack of markets.
- Dealers/ Middlemen exploit the farmers.
- People busy with the family problems and daily living.
- Dealers buy the lands
- Lack of budget to buy modern equipments for meteorological works.
- Farmers have been cultivating crops based on old practices (not easy to change from the old habits to new one).
- Most farmers suffer from poor health condition.
- Farmers do not participate very much in maintaining the irrigation systems.
- Unfertile soil.
- There is dispute about water use.
- Water Law has not yet adopted.
- There are many landmines that cause the development projects going slow.
- Poor electricity supply (insufficient power supply to meet the need).

(2) Mission and SWOT of MAFF

Mission

- Improving agricultural productivity for enhancing food security and promoting export to increase national economy
- Reduction of poverty
- To increase household income and reducing poverty

Table G.5.2 SWOT of MAFF

Strength
1st Some departments of MAFF have enough expertise **2nd Some staffs have strong motivation to work** **3rd All departments have the action plan for development** • DoF (Department of Fisheries) has enough expertise in agriculture and fisheries • There are good experts on animal health at DAHP (Department of Animal Health & Production) • DAHP has technology of animal health extending to the farmers • DAE (Department of Agricultural Extension) has good cooperation with PDA • Good extension workers work with farmers closely • DoF has a good leader • MAFF staffs have increased their capacity in many fields • MAFF promotes to improve staffs English proficiency • MAFF promotes the farmers to use Biomasses • DAE has the farming system obtained through Agro- Ecosystem analysis to extend to Communes • DoF has its sector development plan for management of fisheries resources • MAFF has promoted agricultural marketing • Belated fisheries law has been revised and now under the approval of NA (National Assembly) • MAFF educates the farmers how to use chemicals (fertilizer, pesticide) • DAHP has many experts to promote animal health at the village level to help the farmers when the animals get sick • MAFF encourages the farmers to produce agricultural product for export to ASEAN countries, South Korea, and

India
- MAFF transfers the knowledge to the farmers
- DALI (Department of Agronomy & Agricultural Land Improvement) promotes HYV rice seed
- MAFF promotes national agricultural production
- MAFF has a mater plan for agriculture research
- MAFF strengthen the implementation of law on animal disease, especially, the imported animals

Weakness

1st There are no incentives in departments
2nd MAFF lacks physical and financial resources to implement its good plans or law
3rd Level of officers' expertise still low

- EIA office does not have enough office equipment
- Staffs cannot respect the time sheet
- EIA office staffs have never got EIA training
- Limit of extension workers at provincial level
- Farmers lack market information
- Lack of equipment to do work
- Lack of human resource management in the staffs who have high capacity, and therefore some of them move to NGOs
- Agricultural extension services on new technology are not sufficient
- Knowledge in animal husbandry of farmers is still in low level
- DAHP lack experimental equipments for animal disease at the laboratory
- MAFF staffs' English capacity and computer skill for office works are still insufficient
- 58% of staffs come late to work and go back home earlier
- Most of MAFF staffs don't know what EIA is
- The relationship between DoF and other line departments in MAFF is weak
- Information is not managed and shared properly within DoF and among the other departments of MAFF
- Participatory management is not fully considered in MAFF
- Structure of each organization to supervise experts is not sufficient in the field
- Process of establishing law for animal veterinarians are not revised
- Tasks on controlling vegetable sanitary and physosanitary were taken away from MAFF, and transferred to MOC (Ministry of Commerce)
- At DAHP, some of staffs still lack the knowledge on animal husbandry technology
- Some staffs work in the different department from their experience and expertise
- Most of specialized staffs are working (gathering) only in the central office or organization
- Lack of TIP (technical implementation procedures)
- EIA office has established but not implemented yet

Opportunities

1st MAFF can get support from FGC to build the irrigation system
2nd MAFF can get support from donors in agricultural development
3rd MAFF can get the participation from farmers, who consist of 80% of population

- DAE has good cooperation with the other external organizations
- MAFF has supported by ADB on gender mainstreaming
- MAFF is supported from RGC to construct the irrigation system and tax exemption on the import of agriculture related machines
- Agriculture is identified as the first angle of rectangle policy of RGC
- MAFF is supported by international organizations.
- Each department under MAFF has advice from international experts
- Technology transfer from external agencies to government officers and farmers
- MAFF has good relationship with other organizations and countries in the world
- According to fisheries policy reform, fisheries resources are managed by community
- Getting much attention of IOs to environment in Cambodia, especially to deforestation
- Fishes play important role in food security, national economy and culture
- Animals husbandry helps to generate family income and boost up national economy
- Farmers' animal husbandry has been increasing
- High flood leads to high fisheries productivity
- Decentralization for Provincial Department is progressing
- Staffs of DoA (Department of Administration) have been trained by JICA and UNDP…..

- Exchange of experiences between foreign countries and MAFF
- EU has opened the fish market for Cambodia

Threats

1st Due to the salary is low, the experts cannot help the farmers
2nd Corruption
3rd Forest and fish are destroyed everyday

- Limited fund for technology transfer to farmers
- EIA office doesn't have international experts on EIA
- There is no policy to stop agricultural import, especially vegetable, from the other countries
- We do not have enough salary for living
- EIA office doesn't share information on environment assessment in MAFF and EIA offices in the other institutions
- Research activities regarding fisheries are not fully encouraged by the government
- There is no international market for Cambodian agricultural products
- Opportunity of utilizing water resources from the Mekong river for agriculture is still low
- Market for agriculture production of the farmers is not guarantee by RGC
- Low incentive from government to keep quality staff to serve for DoF
- Farmers lack general education, which is influencing to agriculture
- MAFF does not receive fund and technical support for EIA from donors
- There are not so much investment on agriculture sector
- Farmers still use traditional variety, and it results in low rice yield
- Business animal husbandry is still limited
- Lack of irrigation systems is the obstacle for agricultural development
- Limited internet access
- Farmers didn't join in
- There is no control system along the road on the transportation of meats and animal throughout the country
- Price of land increase, and therefore that of farmland is increasing
- Large parts of land have landmines and the land where the landmines have already cleared is occupied by the rich
- Some types of pesticides is stopped using in the world but they are still in the markets of Cambodia

(3) Mission and SWOT of PDOWRAM Kampong Speu

Mission

- To supply enough water for agricultural purpose an industrial use and also for the daily living to people

Table G.5.3 SWOT of PDOWRAM Kampong Speu

Strength

1st Leader are capable
2nd PDOWRAM Kampong Speu can make good plans
3rd PDOWRAM Kampong Speu has good relation with farmers

- Data collections at rural areas
- Good management at data control
- Good relation/good communication
- Good behavior during the work time
- Managers are skillful at staff control
- Good staff management
- Staffs are highly responsible for their jobs
- Staffs obey the job regulations
- Good relation with the farmers
- PDOWRAM Kampong Spue provides technical support to the farmers
- PDOWRAM Kampong Spue receives good support from the farmers
- Clear responsibility by manager
- Rice rescue intervention on time
- Enough office stationeries
- The Director of PDOWRAM Kampong Spue leads the people to repair the canals
- The are sufficient irrigation systems
- The are FWUCs

- The guaranteed irrigation systems had been constructed
- PDOWRAM Kampong Spue knows how to make plans
- There are accurate maps
- PDOWRAM Kampong Spue has experiences
- There are staffs
- There are capable officers
- PDOWRAM Kampong Spue has extension programs to the farmers
- Bookkeeping
- There are specific offices
- There is solidarity among staffs
- There are irrigation system
- There are maintained levees

Weakness

1st The capacity of accounting, administration, and planning is limited
2nd Study tours to foreign countries and in Cambodia are not enough
3rd Lack of means to work

- Small # of staffs in the department
- Limited experience
- Lack of understanding capacity
- Office lacks space, materials, and staffs
- Lack of experts (hydrology, meteorology, and engineering)
- Unclear information
- Insufficient # of staffs to apply to he job
- Materials, tools and equipment are insufficient
- Obsolete tools and equipments
- Some data collection is not proper
- Lack of technical standard
- Lack of understanding of foreign languages
- Lack of study tours within the country or abroad
- Workshop participations are not enough
- Lack of short training programs (administration, planning and accounting)
- Lack of capacity building for applying to the jobs.

Opportunities

1st There is the support from JICA
2nd Government is interested in water resources
3rd Participation from the farmers

- Peace
- Political and social stability.
- Government is interested in irrigation systems
- FWUCs are organized
- Farmers could have enough water to use
- RGC tries to take over the developing method of developed countries
- There are many NGOs to help
- Support from NGOs in repairing the irrigation systems
- More people are happy in irrigated areas
- Large cultivation land
- There is a measure to prevent from deforestation
- There are lands for watering
- There are natural water sources
- Rural development is promoted
- Election registration increases
- Cooperation for local authorities
- There are levees, lakes, and ponds…
- Repairing of the irrigation systems
- Participation of farmers in maintaining the irrigation systems
- 85% of the people are farmers.

Cooperation with related institutions.

Threats
1st Officers' salary is low **2nd PDOWRAM Kampong Speu lacks the budget for rehabilitation works** **3rd Existing irrigation systems do not guarantee water for farmers** • Anarchy on the irrigation systems. • Anarchy on the water distributions. • Technique of the irrigation system management is limited. • Deforestation. • Lack of wells. • Boundary of the basin, levee, and canals is not clearly fixed by the law. • The irrigation system is not guaranteed the farmers' need of water. • Lack of formal law and formal documents. • Natural disasters • Lack of dams • People are facing droughts. • Farmers built houses in the basin. • Water sources are destructed. • Low salary • Lack of water irrigation canals • Living standard of farmers is low. • Lack of rural roads • Water pumping stations are not sufficient. • Climatic change (frequent drought) • Lack of food • Sick people increases. • Small # of farmers does not participate in. • Lack of budget • Unfertile paddy fields • Lack of agricultural markets • Allocated budget is not arrived on time. • Lack of machinery • Lack of partnership in development of water resources • Illegal fishing with electric equipment in the basin. • Anarchy of fishing in the irrigation systems. • Small # of farmers has not yet joined FWUCs. • Farmers grow rice in ponds. • Most of the irrigation systems are not fully constructed. • The private property of the farmers is affected.

(4) Mission and SWOT of PDOWRAM Kandal

Mission

- To supply enough water for agricultural, industrial and daily/ domestic uses and to tell the people how to maintain the irrigation systems by themselves

Table G.5.4 SWOT of PDOWRAM Kandal

Strength
1st Officers enjoy good health condition **2nd PDOWRAM Kandal has good management** **3rd PDOWRAM Kandal get active participation in the woks of the PDOWRAM** • Moral in working. • Good leadership to do the jobs. • Officers have high education. • Farmers participate in DOWRAM/ PDOWRAM • Intervention during drought • Irrigation systems exist. • The office of PDOWRAM Kandal is located near the Phnom Penh city, and near the big river • Some staffs are capable

- Some staffs had been studying abroad.
- There are canals for water distribution for farming.
- There are FWUCs.
- Good discipline in PDOWRAM Kandal
- The department assigns the job on time.
- The department has some officers who have enough skill to do the job.
- Good relationship with farmers and the other institutions
- The department has good managements.
- The officers of the department have high technique.

Weakness

1st The officers' salary is low
2nd PDOWRAM Kandal lacks transportation means
3rd PDOWRAM Kandal lacks the funds to study projects

- Officers lack foreign languages proficiency.
- Insufficient irrigation systems.
- Irrigation systems do not guarantee sufficient water
- Shortages of fund to operate the missions
- Some officers resign the department.
- The officers' techniques are still limited.
- Workplaces for the officers are not proper (the provincial office and district office).
- The workforces and the materials of the department are not sufficient.
- Lack of rainfall gauge
- Lack of stationeries at the district offices
- A few number of watering systems
- Some irrigation systems are damaged.
- Lack of maintenances of the irrigation systems
- Lack of fund to open the training programs to the members of the associations that had been already formed
- There is no supplementary training program to increase the knowledge of the officers.
- Lack of the fund for forming FWUCs
- Lack of study tour in the country and overseas.
- Lack of transportation means to come to work
- Rice rescue operations were not done on time.
- Lack of surveying instrument for measuring the land level
- Drought intervention work is not insufficient.
- Staff capacity has not fully improved.
- FWUCs have not existed yet in all areas.
- The members of FWUCs do not understand well about their own duties.

Opportunities

1st Political stability
2nd RGC named it "Irrigation Government"
3rd JICA helped to study the irrigation facilities

- PDOWRAM Kandal is supported by JICA.
- NGOs are interested in and support PDOWRAM Kandal
- There are enough water sources.
- JICA opens training programs to the government officers of the PDOWRAM in the province.
- Political stability
- RGC supports and join PDOWRAM Kandal works
- JICA helps to study the infrastructure such as roads and irrigation systems.
- There are markets for exporting products.
- The geographical location of Kandal Province is good.
- Government is interested in irrigation systems.
- Good cooperation with the local authorities
- WFP help to repair the canals.
- Security
- Solidarity
- Japanese government helps PDOWRAM Kandal.
- Farmers have chances to participate in the survey of JICA Study Team.

- Peace in the country
- PDOWRAM Kandal manages and controls water well.
- There is a water source (the Prek Thnot river)
- Food for Work program sponsored by WFP

Threats

1st Natural disaster strikes Kandal Province
2nd PDOWRAM Kandal lacks the budget for construction works
3rd Water Law doesn't exist

- # of dams is insufficient.
- Irrigation systems are old and damaged.
- Climate change
- Some areas are not safe in the country.
- There are not enough budgets for construction.
- Natural disasters (Drought, flood)
- Flood damages dams damaged and brings about shallower canals.
- Overlapped working system.
- No law for water use
- Insects destroy crops.
- People lack understanding capacity.
- Political influences
- Low technology
- Natural condition is not positively influencing.
- Lack of information about hydrology, meteorology, and water requirement
- Lack of technology
- Sufficient infrastructure has not completed to meet the need.
- Lack of pure water
- Unclear information
- Drinking water and agriculture water are contaminated.
- Storms destroy levee under construction.
- The number of helping NGOs is decreasing.

(5) Mission and SWOT of PDA Kampong Speu

Mission

- To increase farmers' income by improving agricultural production activities

Table G.5.5 SWOT of PDA Kampong Speu

Strength

1st There capable leaders
2nd Knowledge, # and capability of the staffs are medium
3rd There is a clear plan
4th There are enough experienced officers to apply for the project

- There are official policies that can be applied.
- There is the medium number of human resources.
- There are offices to work at the province and the district.
- Fairness and justice
- The department has a huge land for many buildings.
- The department has high responsibility.
- Good behavior
- Clear administrative structure.
- Officers are ready for duty at the province and district.
- Good managing ability
- There are salaries for officers.
- Good and proper working place

Weakness

1st Skills of some staffs are limited.
2nd Allowance for the officers is limited
3rd PDA Kampong Speu officers lack transportation means

- Lack of stationeries
- Lack of specialized staffs
- Lack of experimental tools and equipments.
- The offices of some district have not been constructed yet.
- The amount of supporting projects cannot cover whole areas.
- Lack of telephones and radio transmissions
- Lack of information systems (IT, VCR and etc.).
- Applicable policies and laws are limited.
- Existing laws, policies and regulations do not cover all fields.
- Lack of ability to print documents, books, and magazines related to agriculture.
- Some officers live far away from the office.
- Lack of documents, bulletins and books related to agriculture for distributing to farmers
- Capacity building of officers has not been done generally.
- Foreign languages ability is limited.
- Lack of supporting projects for development process

Opportunities

1st JICA implements the project in Kampong Speu Province
2nd RGC put the 1st priority on agriculture
3rd There is farmers' participation

- Government projects construction of a hydroelectric power generation along the Prek Thnot river.
- Varied NGOs come to support the development process.
- NGOs come to contact the office in order to provide the training program.
- There are participations from the private sectors (farms, factories and etc.)
- There are markets.
- Farmers are happy with receiving support projects.
- Geographical location of the irrigation systems is good due to support from JICA.
- There is the Prek Thnot river as the natural resource.
- There is the water resource from Roleang Chrey regulator.
- There are varied supporting projects.
- NGOs cooperate with PDA Kampong Speu.
- There are communication/ transportation roads.
- There are sufficient areas/ fields to apply the projects.
- There are canals.
- Support from the local authorities
- Supplementary training program provided to technicians
- There is MAFF
- The specialized office has technical extension programs for the farmers.
- Officers have received some allowances from the projects.
- There are cooperation from NGOs and other related donors.
- There is water source of the Prek Thnot river.
- There are supports from CAAEP and SEILA.
- Favorable natural resources
- Participation from farmers' association.
- Government has the policy about the development of the weste side of Phnom Penh city.

Threats

1st There are not enough irrigation systems in Kampong Speu Province
2nd Lack of the budget for the development
3rd Technical knowledge of farmers is still low

- Some people are illiterate.
- Farmers have low understanding of new knowledge
- Sick people
- Farmers act according to the old habit.
- Lack of NGO law

- Animal diseases
- Rice diseases
- Small number of irrigation systems
- Climatic change
- Natural disasters
- Low rice yield
- Low price of agricultural products
- Due to low salary, the officers come to work irregularly.
- Low allowance
- Supply of agricultural tools or equipments is not sufficient to meet the needs.
- Unfertile soil.
- Small investment in agriculture
- Construction of some irrigation systems has not completed.
- Insufficient help from the experts for farmers
- Supporting budget from the projects is limited.
- Farmers' production faced many difficulties.
- Lack of agricultural processing
- Insufficient water to use in the dry season
- Improper use of natural resources
- Salary is limited.
- Farmers trust new techniques a little.
- Price of agricultural products is not much competitive at the market.

(6) Mission and SWOT of PDA Kandal

Mission

- To enhance the agricultural development in order to guarantee food security and increase the income of the farmers

Table G.5.6 SWOT of PDA Kandal

Strength
1st Staffs are highly responsible **2nd Structure is proper** **3rd Chiefs have good management skill and leading the staffs** • Most officers have high education (bachelor degree) • The office of the department is located at the population center where the electricity supply system, water supply system and roads exist • Capable officers • Proper office department • Some officers can use PC. • PDA Kandal is divided into structural parts. • Staffs have good knowledge and experiences. • Officers have enough skill in each field. • Good administrative structure extended up to local authority level. • Solidarity • Big department with good management. • Officers have the duty based on the experiences. • Good management in the office • There is a network from the province to the districts • There is enough number of staffs. • Enough skillful officers • Staffs received training program based on their own expertise. • Hardworking staffs
Weakness
1st Staff salary is low **2nd Working means are insufficient** **3rd There are not enough human resources in rural areas**

- Low salary
- Lack of transportation means
- Staffs are busy with the personal business rather than the public works.
- Allowance does not meet the need.
- English proficiency is enough.
- Lack of the condition for using E-mail and seeing Web-sites
- Lack of computers
- Lack of internal solidarity
- Lack of animal breeding
- Lack of pure quality seeds
- Lack of computer skills
- Lack of stationeries
- Lack of the experience to write the proposal
- Lack of the experience to make plans
- Experiences are limited.
- Lack of sharing experience among each other
- There is not sufficient # of highly educated officers.
- Lack of monitoring and evaluating products
- Management job is limited
- Lack of technical documents
- Lack of technique to do the jobs
- Some officers doing jobs is not based on their skill.
- Lack of demonstration farms
- Cultivation area has not jet been determined or specified.

Opportunities

1st PDA Kandal can get support from JICA
2nd PDA Kandal can expect the participation form the farmers
3rd RGC has clear and good policy

- Decentralization policy of the government
- Political stability
- Government has good policies on agriculture
- There are private schools of foreign language schools to improve the proficiency
- Good cooperation with local authorities
- Plenty of time to do the jobs.
- There is good management for leading officers.
- People are happy with the helping program.
- Farmers have lands for cultivation.
- There are officers who can use the computers.
- Government joins WTO (World Trade Organization).
- Most people are farmers.
- Natural potential is high for farming.
- Staffs accept job assignments and do them happily based on their skills.
- Clear division of the seasons: the dry season and the rainy season
- Fine population density compared with the land size.
- Chance to create the market for agricultural products
- Good infrastructure
- There are some technicians that have enough capacity.
- There are enough labors.
- There are enough water sources (from mountains, rivers, and lake)
- There are enough lands to construct the irrigation systems.
- Some districts have the irrigation systems.
- Good geographical location (varied longitudinal land)
- Average infrastructure conditions
- Some districts have water sources.
- There are many water reservoirs.
- There are sufficient water sources.
- There are sufficient investment law, business law and Aid law.
- People love agriculture.

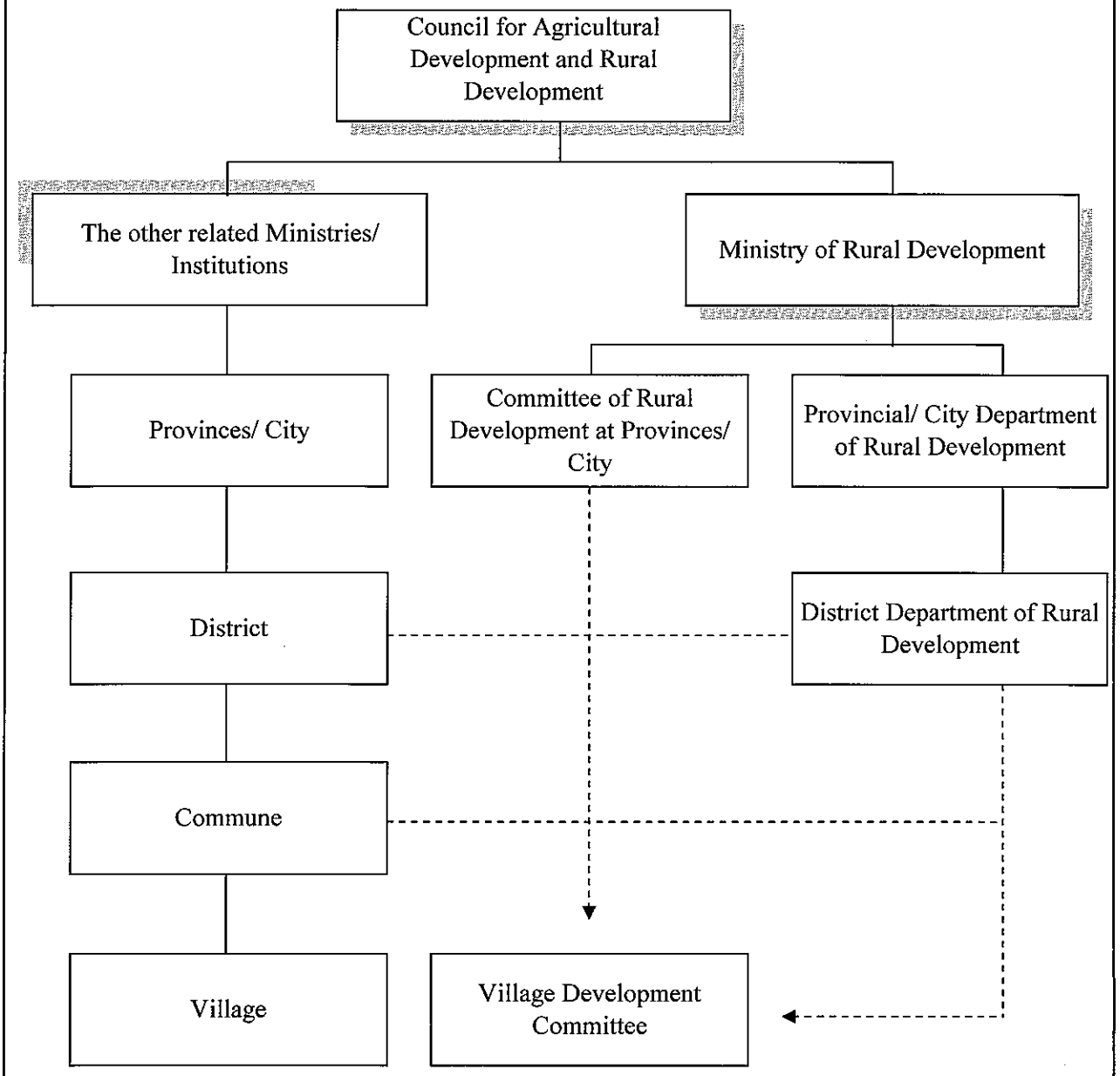
- PDA Kandal can provide easy means for development.

Threats

1st Kandal Province has faced drought and flood
2nd Farmers do not incorporate the new technique
3rd Irrigation systems are insufficient and improper

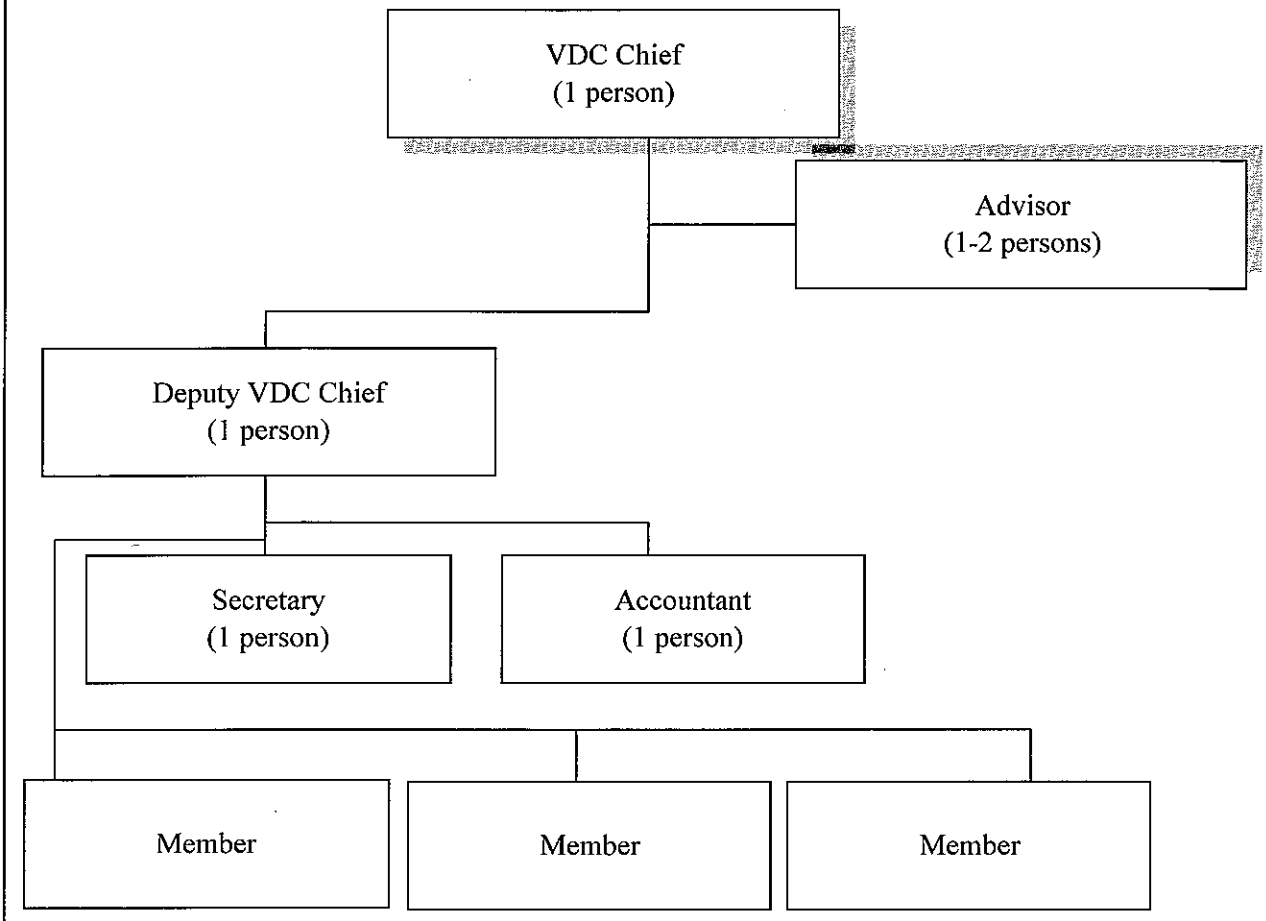
- Climatic change
- Some cultivation lands fully depend on rainfall.
- Goods inflation
- Drought (the long dry season/ insufficient rainfall in the rainy season).
- Lack of irrigation systems
- Infrastructure is not enough.
- Production cost does not balance with income.
- Uneven land
- Animal diseases (bird flu and etc.)
- Farmers lack agricultural technique.
- Insecurity
- Some farmers sell agricultural land.
- Some farmers cannot read and write
- Farmers grow rice based on the old practice.
- Products' price is not stable.
- Lack of the fund to establish animal bank
- Farmers do not like joining the association very much.
- Cost of production is high.
- Most farmers lack draft animals.
- Poor road conditions
- Insects destroy crops.
- Lack of policies on irrigation systems
- Law is not complete.
- The number of "Farmers Association" is not enough.
- Fund does not arrive on time to start the job.
- PDA Kandal doesn't have the full right of decision making to do the job.
- The irrigation systems become shallower and damaged.
- There is no scholarship.
- Import of agricultural products from foreign countries
- Land is not properly classified by the regulations.
- Agricultural products prices fluctuate.
- Unfertile soil
- Poor country (not yet developed)

Figures



Source: Guideline on Implementation of Decision # 02 Dated on 11 April 1999of RGC about Establishment of Provincial/ City Rural Development Committee (June 1999 MRD)

The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, The Kingdom of Cambodia	**Figure G.1.1** Organizational Structure of VDC
Japan International Cooperation Agency	



* Member = 3-5 persons

Source: Guideline on Implementation of Decision # 02 Dated on 11 April 1999of RGC about Establishment of Provincial/ City Rural Development Committee (June 1999 MRD)

The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, The Kingdom of Cambodia	**Figure G.1.2** Structure of VDC (Village Development Committee)
Japan International Cooperation Agency	