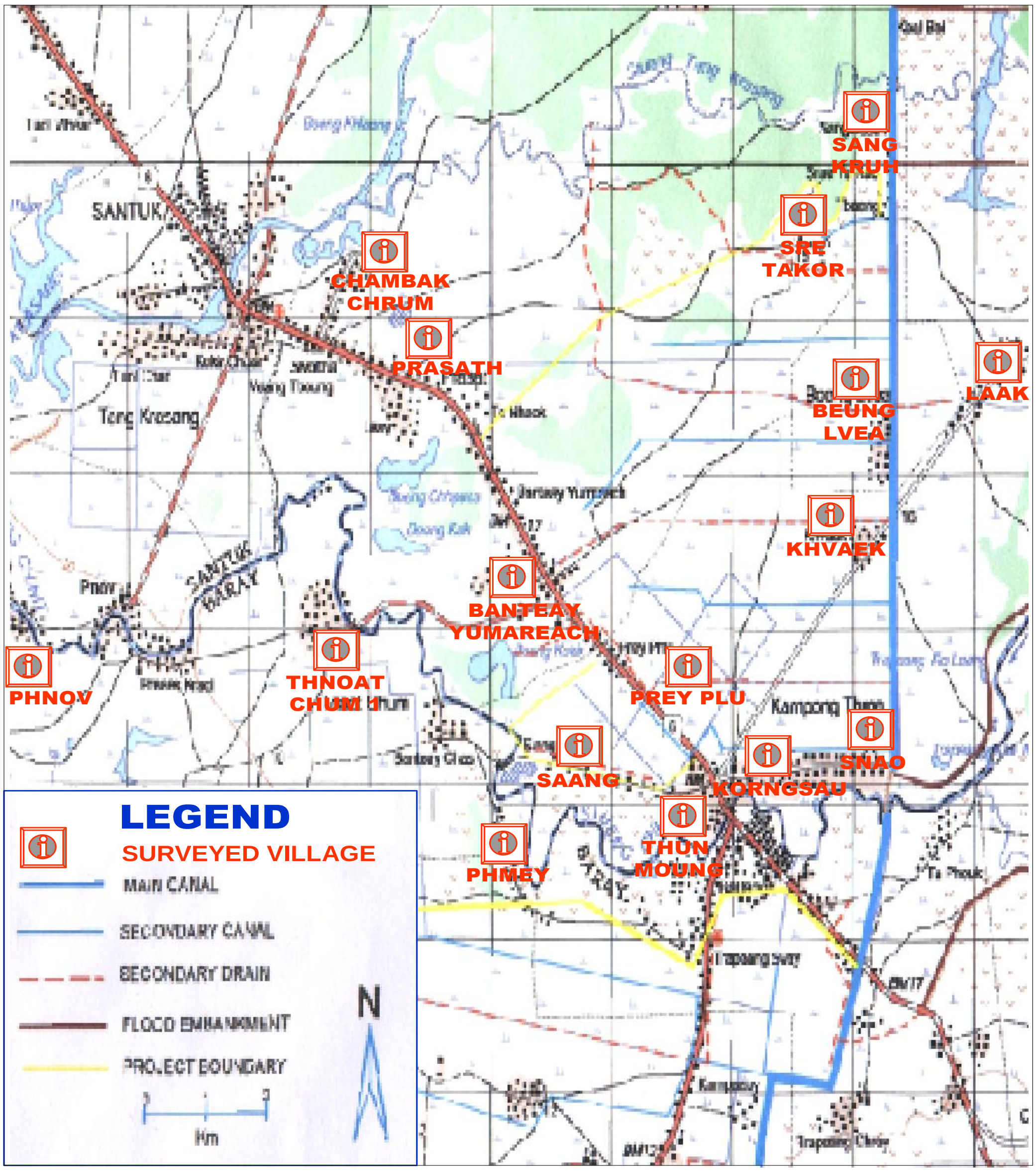
CARDI's Research Project Report
Volume 1, 2004

The **S**tung **C**hinit **I**rrigation and **R**ural **I**nfrastructure **P**roject (SCIRIP)



EXECUTIVE SUMMARY

The Stung Chinit Irrigation and Rural Infrastructure Project (SCIRIP) is located in Santuk and Baray districts, Kampong Thom province. The project is a major irrigation development designed to increase agricultural productivities and stimulate the rural economy growth. At the first stage, the project targets 3,000 ha for the supplementary irrigation in the wet season and 1,800 ha for fully irrigation in the dry season for rice crop (1,500 ha) and for non-rice crops (300 ha). The project expects to increase agricultural incomes by 10-40% depending on access to water in the dry season, and to increase rice yield from 1.3 t/ha to 2.5 t/ha in the wet season in year 2007.

In order to lead for planning the agricultural applied research to support the extension program in the fields of rice production, SCIRIP has requested for the study on “Rice Cropping System”. The Cambodian Agricultural Research and Development Institute (CARDI) won the biding for this study. Four researchers were assigned by CARDI to take responsibility for the study. The study’s period is four months started from November 29th 2003.

The main objectives of the study are (i) to characterize the different local technical itineraries of rice cropping system in the 3,000 ha command area, and the constraints, in order to obtain a detail diagnosis of each rice cropping system, (ii) characterize the local varieties of rice currently produced in terms of length of cycle, straw height, yield potential, pest sensitivity, taste quality, etc., according to the farmer’s knowledge and available documentations, in order to implement variety tests and provide support to the project team in advising farmers, (iii) to characterize the local varieties of rice lost and varieties introduced in the last 30 years, not anymore cultivated, and to describe their potentials for re-introduction under irrigation and drainage conditions, and (iv) based on the survey findings, develop a program for the agricultural applied research of the project, which would take four consecutive years.

The study composed of (i) general field observation, (ii) farmer survey, (iii) data analysis, and (iv) report writing. The study was conducted in three areas classified by GRET/CEDAC (command for 11 villages, upstream for two villages and downstream for three villages).

This report composes of (i) introduction, (ii) objectives of the study, (iii) materials and methodologies, (iv) results and discussion, and (v) conclusion and implication opportunities.

There was a good gender balance among respondents for interview. The average family size was calculated to be six members with two dependents on average. Cattle were the main source of power for crop cultivation. Rice production was a main family income. Some farmers cultivated non-rice crops after the rice. Beside that, other activities such as fishing, wood logging, sugar palm production and off-farm jobs were also practiced.

Rice production depended mainly on rainfall. Rainfed lowland rice was dominant in the command and upstream areas and covered 54% of the total area in the downstream area. In 2003, rain ceased at the end of October and caused late season drought.

Most of rice soils are generally infertile. Cow manure was used mainly for the seedbeds and chemical fertilizer for the main-fields, but their management was relatively poor.

The average land holding per family in the command area was 1.4 ha which composed of small fields located in different direction of households with distant locations. Rice fields are mainly uneven and separated by small levees, leading to difficult water and crop management.

There were a large number of rice varieties cultivated. These varieties have different maturity, plant type, grain and eating quality but most of them are low yield potential. Seed impurity and low viability were also complained by the farmers.

Most farmers are poor in assets and cash, consequently, their limited access to credit facilities hinders the hiring of labour, resulting in longer period of their farm activities such as pulling and transplanting the seedlings and harvesting. They also limit to purchase of farm power and chemical fertilizer. Even though, the practices of exchanged labour were not popular.

With the establishment of irrigation scheme in the command area, the crop cultivation will not depend on rainfall alone. For the better water control systems, the opportunities for improving rice production of the SCIRIP focused on (i) developing cropping calendar for different cropping systems, (ii) the selection of appropriate rice/non-rice varieties for the dry and wet season (including upper, medium and lower fields) areas. This selection involves of replicated trial, on-farm trial and field demonstration as well. Farmer participatory in the selection will be implemented through farmer field day at different growing stages, (iii) identification of type and rate of fertilizer and variety response to fertilizer by conducting replicated and on-farm trials as well as field demonstration with the farmer participatory approach, (iv) farmer field school on land preparation, field management, timing of each activity, fertilizer management, water management, integrated pest management, and harvest and post-harvest operations, (v) seed production system particularly for the early maturity varieties growing in the dry season area, (vi) seed purification technique for the wet season rice varieties, and (vii) developing rice-check list including all important activities for each or group of varieties.

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1. Introduction

The Stung Chinit Irrigation and Rural Infrastructure Project (SCIRIP) is located in the districts of Santuk and Baray in the Province of Kompong Thom, Cambodia. The project is designed to increase agricultural productivity and stimulate the rural economy in the Province of Kompong Thom.

Currently, rice is the sole crop produced during the wet season. During the dry season other crops cultivated in the command area are mainly watermelon, cucumber and tomato and some sweet potatoes (Term of Reference, Appendix 1). The project will provide supplementary irrigation on 3,000 ha starting in June 2003 during the wet season, and irrigation of 1,800 ha during the dry season. It is expected that rice will remain the only crop produced from 3,000 ha during the wet season and from 1,500 ha during the dry season (Term of Reference). The project expects to benefit diversified production of non-rice crops on the remaining 300 ha during the dry season and early wet season.

The main purpose of the project is to improve agricultural production, and to consequently increase farmer's revenues from agricultural production. The 2007 targets are to increase agricultural incomes by 10 % to 40 % depending on access to water during the dry season, and to increase the wet season rice production from 1.3 to 2.5 tons/ha (Term of Reference). In December 2002, the project team conducted a survey on rice production in the command area (Term of Reference). Yields were measured from 150 farm plots, and farmers were questioned on reasons for the low yield potential.

The Cambodian Agricultural Research and Development Institute (CARDI) is engaged by GRET/CEDAC to conduct a Rice Cropping Systems Study (RCSS).

The RCSS (proposed here) reported here will serve as a baseline of agricultural data and agronomic information and will guide the development of an agricultural applied research program that will run during the next four years. This project aims at supporting the extension program in the field of rice production and diversified agriculture.

2. Objectives of the study

The main objectives of the study are:

- To characterize the different local technical itineraries of rice cropping system in the 3,000 ha command area, and the constraints, in order to obtain a detail diagnosis of each rice cropping system.

- To characterize the local varieties of rice currently produced in terms of length of cycle, straw height, yield potential, pest sensitivity, taste quality, etc., according to the farmer's knowledge and available documentations, in order to implement variety tests and provide support to the project team in advising farmers.

- To characterize the local varieties of rice lost to farming communities over the last 30 years to describe their potentials for re-introduction under irrigation and drainage conditions.

- Based on the survey findings, develop a program for the agricultural applied research of the project, which would take four consecutive years.

3. Materials and Methodologies

The methodologies developed and used by CARDI for the RCSS are generally as outlined in GRET's Term of Reference.

In brief:

- GRET has a command area covering large areas within districts of Santuk and Baray in the Province of Kompong Thom.
- CARDI undertook field visits at specific sites where the CARDI team made detailed observations of rice cropping areas and reported on science and technical issues.
- CARDI conducted detailed one-on-one interviews with farmers from representative villages within the command area and both upstream and downstream of the command area.
- At selected villages, CARDI conducted focus group discussions to confirm and expand on material gained from the farmer interviews.
- A second round of farmer interviews occurred approximately mid-way through the RCSS.

During the initial stage of the RCSS project, CARDI staff visited 13 sites to undertake general scientific and technical observations of rice fields. This occurred in the command, upstream and downstream areas. The detail information obtained from the field observation is shown in Appendix 2. The results from the field observation will be used in the discussion parts of all sections.

CARDI staff conducted a series of farmer's interviews and group discussions. The number and location of farmers discussed with GRET were of 66 farmers from 11 villages (Sre Takao, Boeung Lvea, Kvaek, Korng Sao, Snao, Prey Phlou, Thon Morng, Sa-ang, Chambak Chrum, Prasat and Banteay Yumreach) in the command area, 12 farmers from 2 villages (Sangkrus and La-ak) in the upstream area and 18 farmers from 3 villages (Phnov, Thnaot Chum 1 and Thmey) in the downstream area (Figure 1).

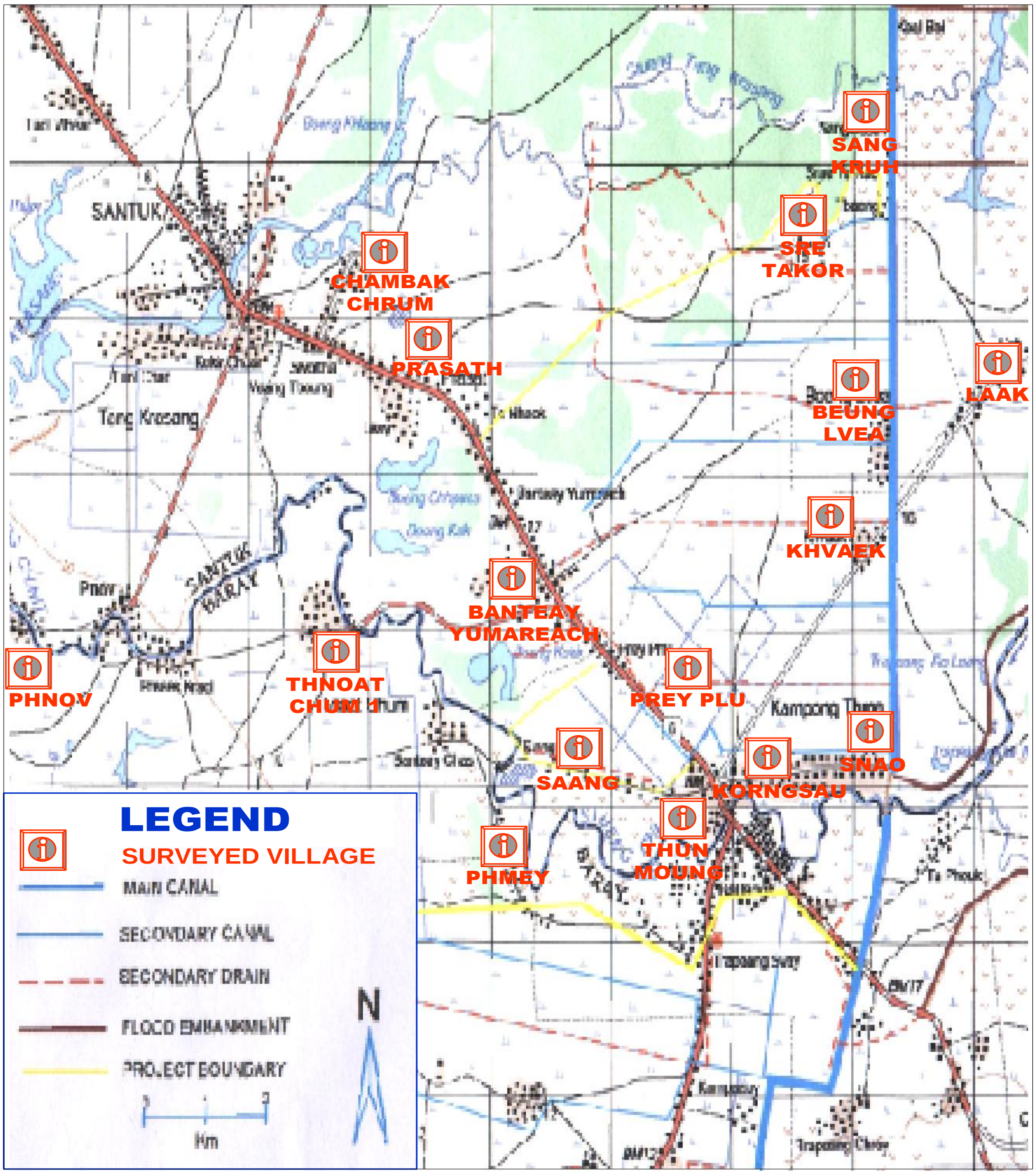
The interviews and discussions were based on the information in a questionnaire (Appendix 3) and checklist (Appendix 4).

A CARDI-team of 2 persons firstly visited each village. A typical daily schedule consisted of each CARDI staff interviewing 3 farmers; each interview took up to 90 minutes. The interviewees were sampled by chance, approaching of interviewers without prearranging.

The records from the interviews describe in detail the farming practices of those farmers interviewed and of farmers in the nearby areas.

The interview covered general information on the location and characteristics of the farm, and the farmer's family situation. It looked at specific cropping information, e.g. crop types and their characteristics, calendar of planting, and focused in-depth information on cultural practices for the cropping systems and related marketing practices. In addition, the interview also questioned about information on previously known and now become "lost" varieties. This information on "lost" varieties was tested in the group discussions in order to check accuracy and reliability.

Figure 1. Distribution of the interviewed villages in the command, upstream and downstream areas.



In each village, CARDI staff conducted a group discussion focusing on information related to common rice varieties recently (2003) cultivated, the preferred characteristics for rice for different ecosystems and the lost rice varieties. The group-discussion scheduled for each village was conducted for 90 minutes in the afternoon after the farmer one-on-one interviews. Two group-discussions were conducted per day. In order to address gender issues, the two groups were divided by gender. Each group-discussion consisted of 8-10 members. The interviewees were not included in the group-discussions.

CARDI worked closely with GRET to identify the most suitable itineraries having regard to GRET's experience and knowledge of the location and their desire that a link exist between the topographical situation of the fields and the influence of the leveled water of Tonle Sap lake.

The first round interview focused on data collection on farming practices of a general nature, and on other activities completed at the particular stage of the growing season at the time of interviewing. A second round interview was conducted to gather the remaining data to complete the whole farming system.

CARDI produced a synthesis of the data collected in both interviews and of group-discussions as well as from the field observation, and provided a comprehensive report on all varieties, their characteristics and suitability, and also provided possible research programs for future rice cropping systems with supplementary irrigation in the command area.

4. Results and Discussion

4.1. Profile of respondents

Since the RCSS project was to assess both the constraints to rice production and the potential of natural and household resources for improving rice production in the Stung Chinit area, it was critical to analyze and discuss the characteristics of respondents in the areas. Because the studied villages covered were as many as 18 villages, the analysis was done based on areas classified by the SCIRIP project, for example, command, upstream and downstream areas, and furthermore, field conditions and farmers' characteristics of each area were pretty similar in which a comparison of the three areas can be made.

Table 1 summarizes the characteristics of respondents from the command, upstream and downstream areas.

In the command area, the age of respondents varied from 19 to 73 years with an average of 45 years of age (Table 1). The proportion of female respondents (52%) was slightly higher than the male proportion. A respondent had completed high school and many others studied beyond primary school. The average time at school of education was three years.

A couple of households had just two members but between 5 and 10 family members were the majority of respondents. All respondents of the command area reported in average of 5.5 (range of 5 to 10) family members with 1.6 dependents.

No farmer owned machinery such as tractor, hand tractor or harvester. A few households reported to have mechanical thresher engine for hiring. Draught power, cart, plough and harrow were necessary farming equipments for the farmers though 15% of respondents had to hire or borrow draught powers (Table 1). Out of the total respondents, five (7.5%) of them owned water pump.

Concerning rice crop, only one respondent in the Snao village was found growing two rice crops (dry and wet season rice). Off-farm jobs, including waged labour, workers and other trading, accounted for 50% of the total respondents. After the off-farm jobs, non-rice crops (17%), fishing (17%), palm sugar production (15%) and wood logging (6%) were also practiced.

Table 1: Characteristics of survey respondents in Upstream, Command and Downstream areas

Characteristic	Command area (n=66)	Upstream area (n=12)	Downstream area (n=18)	Total sample (n=96)
Average age (yrs)	45.1	44.1	50.9	46.1
Female respondents (%)	51.5	42.0	50.0	50.0
Average education (yrs)	2.9	1.8	3.7	2.9
No. in household (avg)	5.5	6.4	5.9	5.6
No. of dependants (avg)	1.6	1.2	2.1	1.6
% with no draught power	15.1	8.3	22.2	15.6
% with spray unit	0.0	0.0	11.1	0.2
% with pump	7.5	8.3	0.0	6.2
% with fishing	16.6	0.0	11.1	13.5
% with palm sugar productio	15.1	33.3	5.5	15.6
% with non-rice crops	16.6	16.6	33.3	19.8
% with wood logging	6.0	25.0	0.0	7.2
% with off-farm jobs	50.0	58.3	61.1	53.1

Note: n: number of sample; yrs: year at school; avg: average

In the upstream area, all twelve households sampled by chance for interviewing practiced a single cropping of rice, that is, only one wet season rice crop per annum. There was a wide range in age of respondents varying from 30 to 60 years with an average of 44 years of age. Though the interview was conducted by chance, 42% of respondents were female indicating that the number of male and female in this zone comparably participated in the interviews.

The average of level of education was less than 2 years at school - no respondent in the upstream area was able to finish primary school. Size of family ranged from 5 up to 11 with an average of more than six persons. One household had 3 members. On average just more than one dependant compared to 6.4 total family members.

Data from the interviews indicated that the farmers used only traditional farming tools. The main capital assets for rice cultivation were draught power, cart, plough and harrow. A single respondent had no cow or buffalo. Of the interviewees, one respondent could afford a pump to extract water from nearby sources to rice fields as supplementary irrigation to reduce risk of frequent drought. Beside rice production, farmers also practiced fishing, palm sugar production, wood logging and off-farm jobs (Table 1). Off-farm jobs accounted for 58% of the interviewed farmers and ranks first followed by palm sugar production (33%), wood logging (25%) and 17% of non-rice crop production.

In the downstream area, 18 households of three villages were interviewed. The ages of respondents varied from 23 to 71 years with an average of 51 years of age. The ratio of female and male respondents was 1:1. Though no one in this area had completed high school, the average time at school was a bit high compared to the two other areas, almost four years at school. The average size of the households was six members with two dependents.

Draught power, plough, harrow and cart were also the only traditional farming tools in the downstream area but around 11% of respondents reported to have pesticide spray unit. The off-farm jobs remained more popular than other non-rice activities for the farmers in which up to 61% of respondents involved the jobs. Non-rice crops, fishing and palm sugar production were other extra sources of income. No single respondent reported cutting wood.

From the above analyses the general observations can be drawn as the following.

A single rice crop of the wet season was commonly practiced across the three areas due to water constraint.

It is observed that the younger respondents seemed to do a better job in answering the questions than the older respondents, indicating that the former were more confident in farming activities and hence better communicators. This suggests that young farmers would be a better cooperator with researchers or extension workers when new technologies will be introduced.

There was a good gender balance among respondents across the three areas with strong involvement of female farmers who could answer most of questions in the interviewed questionnaire. This implies that females are not just involved but also share responsibilities in farming indicating that both female and male play the same role in farming.

Given that the average level of education of all respondents was very low this might be a constraint in current rice production, and may have a significant impact in developing better production, especially an introduction of new technology.

The number of dependents member in the households was estimated to be 1/3 of the total members on average. This suggests that there is a chance to increase income when the family improves the working activities by doing more jobs.

Pump was critical for watering when drought occurs, and moreover it could also supply for non-rice cultivation.

Concerning non-rice sources of incomes, all three areas shared very similar activities even though the percentage of each activity was different. Additional jobs were necessary since rice crop alone could not feed their family the whole year round

4.2. Characteristics of the rice fields

As elsewhere in Cambodia, rice in the study areas was grown in three ecosystems: upland, lowland and deepwater (Table 2). Table 2a shows that out of the 209 rice fields (rice parcels) reported by the farmers in the command area, the upland ecosystem captured 2%, the rainfed lowland ecosystem captured 93% and the remaining (5%) was under deepwater ecosystem. In the upstream and downstream areas there was no farmer reported to have upland fields. Deepwater rice fields were reported in very close proportion (46%) to the rainfed lowland fields (54%) in the downstream area. However, there were only 11% of deepwater rice fields in the upstream area.

Table 2: Percentages of rice ecosystems (a), number of rice fields cultivated by farmers (b), rice field sizes (c), the distance between rice fields and household (d) and rice land holding (f) reported by 66 farmers in the command area, 12 farmers in the upstream area and 18 farmers in the downstream area, wet season 2003-2004.

a) Rice ecosystem/topography distribution					
	Upland	**Lowland fileds**			**Deepwater**
		Upper	**Medium**	**Lower**	
Command (209)	2	15	47	31	5
Upstream (36)	0	19	42	28	11
Downstream (56)	0	9	23	21	46
b) Number of rice fields cultivated by farmers					
	1 to 2	**3**	**4**	**5**	**6 to 8**
Command (66)	33	30	26	8	6
Upstream (12)	42	25	25	8	0
Downstream (18)	33	33	17	11	0
c) Rice field sizes (ha)					
	< 0.26	**0.26 to 0.50**	**0.51 to 1.00**	**1.01 to 2.00**	**> 2.00**
Command (209)	40	34	22	3	1
Upstream (36)	22	31	22	22	3
Downstream (56)	31	26	21	14	9
d) Distance from the household (km)					
	< 1	**1 to 3**	**4 to 6**	**7 to 10**	**> 10**
Command (209)	44	45	3	5	3
Upstream (36)	33	44	11	11	0
Downstream (56)	38	41	3	3	14
f) Rice land holding per family (ha)					
	<= 1.00	**1.01-2.00**	**2.01-3.00**	**3.01-4.00**	**> 4.00**
Command (66)	45	32	15	5	3
Upstream (12)	17	34	17	17	15
Downstream (18)	23	12	34	20	11

Number in parenthesis indicates number of total rice fields and total farmers interviewed.

In the rainfed lowland ecosystem, farmers classified rice fields into higher, medium and lower fields. The medium fields were dominant in both command and upstream areas and followed by the lower fields. In the downstream area, the proportions of medium and lower fields were similar.

The number of rice fields cultivated by the farmers varied greatly from one to eight in the command area and from one to five in the upstream and downstream areas (Table 2b). In all areas, about 1/3 of farmers cultivated on one to two different rice fields. About 2/3 of farmers cultivated on more than three different rice fields.

The rice field sizes varied greatly from smaller than 0.25 ha to bigger than 2 ha (Table 2c). In the command area, 40% of rice fields were smaller than 0.26 ha, while 1/3 was in between 0.26 ha and 0.50 ha and only 4% of rice fields were larger than 1 ha in size. In the upstream area, 31% rice fields sized between 0.26 ha and 0.50 ha and only 3% were larger than 2 ha. The remaining rice field size categories were in similar proportion (22%). In the downstream area, 31% and 26% of rice fields were reported to be smaller than 0.26 ha and in between 0.26-0.50 ha in size, respectively.

Around 80% of rice fields located up to 3 km in distance from the households in all areas (Table 2d). The remaining rice fields locate farther than 4 km in distance from the households. However, in the downstream area, 14% of rice fields are farther than 10 km.

Rice land holding per family varied from less than 1.0 ha to more than 4 ha in the three areas (Table 2f). In the command area, most farmers (77%) owned rice land not bigger than 2 ha in size, while only 3% of farmers owned rice land larger than 4 ha in size. In the upstream area, 34% of farmers reported to have rice land from 1-2 ha in size, while the other size categories had an equal proportion of farmers (17%). In contrast, the downstream's farmers with larger deepwater rice fields owned larger rice land. For example, 34% farmers reported to have rice land from 2-3 ha in zise, while 20% and 11% of them owned rice land from 3-4 ha and bigger than 4 ha in size, respectively.

Rainfed lowland rice was predominant in the command and upstream areas and in this ecosystem rice was grown mainly in the medium fields. In this ecosystem, most of farmers cultivated rice in more than two small rice fields located in different directions and a bit far from their household. In general observation, rainfed lowland rice fields were unleveled and most of them were separated by a very small levee. In contrast, deepwater rice was predominant in the downstream area. Deepwater rice fields were generally larger and located very far from the households.

4.3. Rice varieties lost or currently used, and their characteristics

4.3.1. Rice varieties lost and their characteristics

The lost rice varieties were recorded based on the individual respondent and group discussion. In each village, certain farmer reported some varieties as lost but the varieties were in use by the other farmers, thus, these varieties are not considered here as lost varieties. Details of characteristics of the lost varieties are recorded in Table 3.

There were 34 rice varieties were reported to be lost in 11 villages in the command area. These varieties were rainfed lowland rice, except two varieties were rainfed upland rice. The remaining 32 rainfed lowland rice varieties were grown in upper, medium and lower fields with harvesting time varied from mid November to late December. Most of them were intermediate plant height with lodging and shattering score ranged from 1 to 3. Most of varieties were reported to have translucent grain with medium to high market price, but low yield potential. Low yield potential and Pol Pot's regime were reported to be a major reason for the loss of these varieties. However, farmers prefer to re-cultivate seven rice varieties (Chha-eung Moan, Chunteos Pluk, Knheng, Kong Kranhol, Koun Trey, Minh Ton and Neang Raech) as they had a good market price.

In the upstream area, farmers reported 10 rice varieties were lost due to low yield potential and uncertain reason after the Pol Pot's regime (Table 4). Among them two were upland rice, five were rainfed lowland rice and the remaining three were not clear. Details of these varieties are given in Table 4. Farmers prefer to re-cultivate two varieties (Phka Knhey and Neang Ty), because they had a good market price.

Table 3: List of the lost rice varieties and their characteristics reported by the farmers in the command area.

No.	Variety	Ecos-ystem	Har. period (w = week)	PH (m)	LSc	ShS	G. appearance Shape	Transl.	Tolerance to Drought	Flood	Resist. to pest	Cexp	Eating quality	Market price	Reason for loss	Desire to recall
1	Chha-eung Moan	M	Nov 4th w	1.5	2	1	LS	1	Mod	Mod	-	H	Hard	M	Pol Pot time	Y
2	Chunteos Pluk	M	-	0.8-1.0	3	1	M	1	Severe	Susc	Susc	H	Hard	H	Pot Pot time	Y
3	Knheng	M	Dec 1st w	1.3	1	2	B	1	Mod	Mod	-	L	Soft	H	-	Y
4	Kong Kranhol	L	-	1.0-4.0	2	1	M	1	Severe	Severe	Susc	M	M	H	Pot Pot time	Y
5	Koun Trey	U	-	Short	1	1	B	1	-	-	-	M	M	M	-	Y
6	Minh Ton	L	Dec 3rd w	1.2	2	3	LS	1	Mod	Mod	-	M	Soft	H	Late season drought	Y
7	Neang Raech	U-M	-	-	1	1	B	3	-	-	-	H	Hard	M	Pol Pot time	Y
8	Angka Veng	M	Nov 4th w	1.5	1	2	LS	1	Mod	Mod	-	L	Soft	H	Low yield	N
9	Battambang	L	Dec	1.0-1.5	2	2	LS	1	Mod	Susc	Susc	H	Hard	L	Low yield	N
10	Chhuttana	M	Dec 2nd w	1.0-1.5	2	2	LS	1	-	-	-	M	M	M	Low yield	N
11	Damneub Smach	M	Dec 3rd w	0.8-1.2	3	3	LS	1	Mod	-	-	L	Soft	M	Low yield	N
12	Dorng Dav	Up	Nov 3rd w	0.8-1.1	1	3	M	1	Susc	Susc	Susc	L	Soft	H	Pol Pot time	N
13	Kandol	Up	Nov 4th w	0.8-1.2	3	3	B	1	-	-	-	H	M	-	Pol Pot time	N
14	Khlem Romeath	L	-	1.3	2	1	LS	1	Severe	Susc	Susc	M	Soft	M	Pot Pot time	N
15	Koun Kranh	M	Dec 2nd w	1.3	1	1	LS	1	Mod	Mod	-	H	M	M	-	N
16	Krachork Chab	U	Dec 1st w	1.2	1	2	M	1	-	-	-	M	M	H	Low yield	N
17	Kraham	M	-	1.0-1.2	1	1	LS	1	Severe	Susc	Susc	M	M	L	Pot Pot time	N
18	Kranhanh	M	Dec 3rd w	1.3	-	1	-	1	Mod	Mod	-	-	-	-	-	N
19	Kul Pha-av	L	Nov 4th w	1.4-1.8	1	1	LS	3	-	-	-	M	M	M	Low yield	N
20	Kul Prolit	L	-	1.3	1	2	B	1	Severe	Susc	Susc	H	Hard	L	Pot Pot time	N
21	Neang Chek	U	Nov 4th w	0.8-1.0	1	1	LS	2	Mod	Mod	-	M	M	M	Low yield	N
22	Neang Chen	M	Nov 4th w	-	1	-	LS	3	-	-	-	H	Hard	L	Low yield	N
23	Neang Pres	U	-	1.5	2	1	B	1	Severe	Susc	Susc	H	Hard	L	Low yield	N
24	Phirum	U	Nov 2 nd w	0.8-1.2	3	3	LS	1	-	-	-	L	Soft	-	Low yield	N
25	Phkar Sla	M	Nov 4th w	1.2-1.4	1	3	B	1	Mod	Mod	-	M	Hard	H	Low yield	N
26	Raech Angkrorng	M	Nov 4th w	1.5-2.0	1	3	B	1	Susc	Susc	Susc	L	Soft	H	Pol Pot time	N
27	Srau Khmao	U	-	1.2	3	1	LS	1	Mod	Susc	Susc	M	Soft	L	Pot Pot time	N
28	Theang Chek	U	Nov 4th w	0.8-1.2	3	2	LS	1	Mod	Susc	Susc	M	M	M	Low yield	N
29	Banla Phdau	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	Chenhcheum Pravek	M	-	1-1.2	3	1	LS	-	Susc	Susc	Susc	M	M	M	Pol Pot time	-
31	Chnoat Kra-ob	M	-	0.8-1.0	3	1	LS	-	Susc	Susc	Susc	M	Soft	H	Pol Pot time	-
32	Neang Ty	M	Dec 3rd w	0.8-1.2	3	1	M	1	Susc	Susc	Susc	M	M	H	Late season drought	-
33	Srov Lab	M	-	1.0-1.2	3	1	B	-	Susc	Susc	Susc	M	M	M	Pol Pot time	-
34	Thnaot	M	Nov 4th w	1.3	1	1	LS	3	Mod	Mod	-	M	M	M	Charkiness	-

Ecosystem: M=medium, U=upper and L=lower rice field level; LSc=lodging score and ShS=shattering score (1=low, 2=intermediate and 3=high), Grain shape: B=bold, M=medium, LS=long slender; Transl.=translucence: 1=translucent, 2=small chalkiness and 3=large chalkiness; Tolerance and Resistance: Mod=moderate, Susc=susceptible; Cexp=cooking expansion and market price: L=low, M=medium and H=high; Shading indicates varieties that farmers prefer to re-grow, “-“=unknown.

Table 4: List of lost rice varieties and their characteristics reported by the farmer in upstream (1) and downstream (2) area.

No.	Variety	Ecos-ystem	Har. period (w = week)	PH (m)	LSc	ShS	G. appearance		Tolerance to		Resist. to pest	Cexp	Eating quality	Market price	Reason for loss	Desire to recall
							Shape	Transl.	Drought	Flood						
1) Upstream villages																
1	Phka Knhey	U, M	Nov 3rd w	1.0-1.5	3	2	M	1	Mild	-	-	L	M	H	After Pol Pot	Y
2	Neang Ty	L	Dec 3rd w	1.0-1.5	2	2	B	1	Mild	-	-	L	M	H	After Pol Pot	Y
3	Yeay Sar	Up	Nov 4th w	1.5	3	3	LS	1	Mod	Mild	Susc	L	Soft	H	Low yield	N
4	Srov Phnorng	Up	Nov 4th w	1.0-1.2	3	3	LS	1	Mod	Mild	Susc	L	M	M	Low yield & Pol Pot time	N
5	Neang Ourk	L	Dec 4th w	0.8-1.0	2	3	LS	1	Mod	Mild	Susc	H	M	M	Low yield	N
6	Neang Noy	M	Dec 2nd w	1.0-1.2	3	1	M	1	Mod	-	-	H	Hard	M	After Pol Pot	N
7	Neang Chen	L	Dec 3rd w	0.8-1.0	1	3	B	1	Mod	Mild	Susc	H	Hard	L	-	N
8	Ronuk Chma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Phka Kabas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	Neang Rith	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2) Downstream villages																
1	Changvay Phdau	M	Nov 3rd w	1.0	3	3	LS	1	Mod	Susc	Susc	M	Soft	H	3-year flood	Y
2	Neang Changkoam	M	Nov 3rd w	1.5	3	3	LS	1	Susc	Susc	Susc	L	soft	H	3-year flood	Y
3	Neang Rith	U	Nov 3rd w	1.0	2	3	B	1	Mod	Susc	Susc	H	Hard	L	3-year flood	Y
4	Phally	L	Dec 1st w	1.8-2.0	1	1	LS	1	Susc	Mod	-	L	soft	H	-	Y
5	Sambok Angkrorng	U	Nov 2nd w	1.3	3	3	LS	1	-	-	-	M	M	-	High shatering	N
6	Dorng Dav	U	Nov 2nd w	0.7-1.2	2	1	LS	1	-	-	-	M	M	-	Pol Pot time	N
7	Neang Kong Leung Teuk	De	Dec	> 2.0	3	3	B	1	Susc	Susc	-	M	M	M	Low yield	N
8	Neang Rith	U	Nov 2nd w	0.7-1.2	1	2	B	1	-	-	-	H	Hard	-	Low yield	N
9	Por Sla	U	Nov	1.2	1	1	B	1	Susc	Susc	-	H	Hard	L	Hard cooking rice	N
10	Porng Chab	L	Insensitive	0.7	1	3	B	1	Susc	Susc	-	H	Hard	L	Hard cooking rice	N
11	Neang Pres	U	Nov	1.0-1.2	1	1	B	1	Susc	Susc	-	H	Hard	L	Hard cooking rice	N

Ecosystem: M=medium, U=upper and L=lower rice field level; LSc=lodging score and ShS=shattering score (1=low, 2=intermediate and 3=high), Grain shape: B=bold, M=medium, LS=long slender; Transl.=translucence: 1=translucent, 2=small chalkiness and 3=large chalkiness; Tolerance and Resistance: Mod=moderate, Susc=susceptible; Cexp=cooking expansion and market price: L=low, M=medium and H=high; Shading indicates varieties that farmers prefer to re-grow, "-"=unknown.

Eleven rice varieties were reported to be lost in the downstream area and their details are shown in Table 4. There were several main reasons for being lost of these varieties. Some varieties were lost due to continued 3-year flooding, others were due to hard cooked rice and low yield potential. Among these varieties, one was deepwater rice and the others were rainfed lowland rice. If the seeds were available farmers would preferred to re-cultivate Changvay Phdau, Neang Changkoam, Neang Rith and Phally.

Low yield potential was one of the main reasons for loss of rice varieties in the three areas, indicating that the farmers have adopted the selection for grain yield.

4.3.2. Current (2003) and future rice varieties and their characteristics

Cultivated rice varieties in 2003 and their characteristics were recorded base on individual farmers, while the group discussion focused on the common rice varieties and the preferred characteristics for the further introduced rice varieties in the command, upstream and downstream area. The maturity groups of rice varieties are classified based on Ouk *et al*. (2001) (for the photoperiod sensitive varieties, early maturity group flowers before mid October, intermediate maturity group flowers between mid October and mid November, and late maturity group flowers after mid November). In the rainfed lowland ecosystem, the field levels are classified according to Javier (1997) to upper, medium and lower fields.

Command area

Interview. There were 37 rice varieties cultivating in the command area and their detail characteristics are shown in Table 5. Two varieties were upland rice, four were deepwater rice and the remaining varieties were rainfed lowland rice.

The upland varieties are photoperiod sensitive with intermediate maturity duration, harvesting at the end of November (flowering at the end of October). These varieties are intermediate tall (1.0-1.5m) with harvested yield around 1.0t/ha. Base on the total number of rice fields (209), Por Sla was cultivated in proportion of 1% and Phka Ampil 0.5%.

Rainfed lowland rice varieties with photoperiod sensitivity were widely cultivated in upper to lower fields. Krem and Kratie were reported to be early varieties and CAR6 was late variety. Intermediate maturity varieties were commonly cultivated in all field levels. Krem was commonly cultivated in the upper fields and accounted for 9.4% of the total rice fields. In the medium and lower fields, the popular rice varieties were Leak Sleuk (12.8%), Neang Morn (12.8%) and Riang Chey (11.3%). Harvested yields were greatly varied. However, some farmers reported more than 4 t/ha for Riang Chey, CAR6 and Krem.

Four deepwater rice varieties were cultivated and Kranhol was the most popular variety (4.4%). Some farmers also cultivated Kranhol in the lower fields of rainfed lowland ecosystem. The deepwater rice varieties are photoperiod sensitivity with intermediate to late maturity duration and can elongate up to 3m water depths.

Table 5: List of rice varieties cultivated by the farmers in the command area and their characteristics.

No.	Variety name	Prop (%)	Ecos-ystem	Harvesting period (w = week)	Yield (t/ha)	Phot	PH (m)	LSc	Grain type	Cexp	Eating quality	Tolerance to Drought	Tolerance to Flood	Resistance to Weed	Resistance to Insect	Resistance to Disease
1	Por Sla	1.0	Up	Nov 4th w	0.9-1.0	Y	1.2-1.5	1	B	H	Hard	Mod	-		-	-
2	Phka Ampil	0.5	Up	Nov 4th w	0.9	Y	1.0-1.3	1	M	L	Soft	Mod	-	Susc	-	-
3	IR 66	1.0	Dry	115 days	2.9-5.1	N	0.8-1.0	1	M	M	M	-	-		-	-
4	Neang Rith	1.5	U, L	Nov	1.8-1.9	Y	0.5-0.7	1	B	H	Hard	Mild	Susc	Susc	Susc	Susc
5	Changkong Khsach	2.0	U, M	Dec 2nd w	0.0-0.6	Y	1.5-2.0	3	LS	H	Hard	Mild	Severe			
6	Changvay Phdau	2.0	U, M	Dec 1st w	0.9-1.4	Y	1.0-1.3	1-2	LS	M	M	Mild	Susc	Susc	Susc	Susc
7	Damneub	3.0	U, M	Nov 1st-Dec 2nd w	0.3-1.6	Y	0.8-1.5	1-2	B-M	L	Soft	Mild	Mild	-	-	-
8	Kratie	2.0	U, M	Nov 2nd-4th w	1.0-3.0	Y	1.8-2.0	3	LS	L	Soft	-	-	-	-	-
9	Krem	9.4	U, M	Nov 1st-4th w	0.3-4.0	Y	0.8-1.2	1-2	M	L-M	M-Soft	Mild	Mild	-	-	-
10	Neang Sar	1.5	U, M	Dec 1st-3rd w	0.3-0.6	Y	0.8-1.0	2	M	L-H	Soft-Hard	Mild	Mod	-	-	-
11	Phka Khney	4.4	U, M	Nov 4th-Dec 3rd w	0.8-2.2	Y	1.2-1.3	1-2	LS	L-M	Soft	Mild	Susc	-	-	-
12	Somaly	2.5	U, M	Nov 4th-Dec 3rd w	1.2-3.6	Y	1.3-1.5	1-2	LS	L	Soft	Mild	Susc	Susc	Susc	Susc
13	CAR 3	0.5	M	Dec 1st w	1.5	Y	1-1.5	2	B	M	M	-	-	-	-	-
14	Chraleung	1.5	M	Dec 1st-2nd w	2.1-2.4	Y	1.0-1.2	1	M-LS	H	Hard	-	-	-	-	-
15	Kranhanh	0.5	M	Dec 2nd w	0	Y	1.5-2.0	3	B	H	Hard	Mild	Mild	-	-	-
16	Neang La-eth	1.0	M	Dec 2nd-3rd w	0.5-0.6	Y	0.8-1.2	1	LS	M	M	Mild		-	-	-
17	Neang Sral	2.5	M	Nov 3rd w	2.2	Y	-	-	-	-	-	-	-	-	-	-
18	Neang Storng	0.5	M	Dec 2nd w	1.9	Y	1.8	2	LS	M	M	N	Mild	-	-	-
19	Phka Kabas	3.0	M	Dec 1st-4th w	0.9-1.6	Y	0.7-1.6	1-2	B	H	Hard	Susc-Mild		-	-	-
20	Sambok Angkrorng	3.0	M	Dec 2nd-3rd w	0.8-2.0	Y	0.8-1.6	1	LS	L-H	Soft-Hard	Mod	Mild	-	-	-
21	Sar Changkoam	0.5	M	Nov 4th w	0.4	Y	1.2-1.5	3	M	M	Soft	-	-	-	-	-
22	Sar Kranhanh	1.0	M	Nov 3rd w	0.1-0.7	Y	1.0-1.3	2	M	H	M	-	-	-	-	-
23	Mlis	0.5	M	Nov 3rd w	1.9	Y	1.0-1.5	2	LS	L	Soft	Susc	Mod	Susc	Susc	Susc
24	CAR 6	4.9	M, L	Dec 3rd-4th w	0.6-4.8	Y	1-1.6	2-3	M-LS	L-M	Soft	Susc				
25	Chhma Changkoam	2.0	M, L	Nov 3rd-Dec 1st w	0.8-2.0	Y	1.0-1.7	1-2	M-LS	H	Hard	Mild	Susc	Susc	Susc	Susc
26	Leak Sleuk	12.8	M, L	Nov 4th-Dec 3rd w	0.3-2.4	Y	1.0-1.5	1-2	B-LS	L-H	Hard-Soft	Mild	-	-	-	-
27	Neang Morn	12.8	M, L	Dec 1st-4th w	0.5-2.6	Y	0.8-1.8	1-3	M	M-H	Soft-Hard	Mod	Mod	-	-	-
28	Riang Chey	11.3	M, L	Dec 1st-3rd w	0.6-4.2	Y	0.8-1.8	1-2	M-LS	L-H	Soft-Hard	Mod	-	-	-	-
29	Chhma Santoung	1.5	L	Dec 1st-3rd w	0.3-1.3	Y	1.0-1.5	1-2	M-LS	M	M	Mild	-	-	-	-
30	Kngork Pong	0.5	L	Dec 1st w	2.4	Y	1.2	1	LS	L	Hard	-	-	-	-	-
31	Neang Chhma	0.5	L	Dec 2nd w	0.8	Y	1.5-2.0	2	B	H	Hard	-	-	-	-	-
32	Neang Minh	1.0	L	Dec	1.8	Y	0.8-1.0	3	M	L	M	Susc	Susc	Susc	Susc	Susc
33	Srov Bour	1.0	L	Dec 2nd w	0.3-0.8	Y	1.5-2.0	3	B	H	Hard	-	-	-	-	-
34	Angka	0.5	De	Dec 4th w	0.7	Y	>2	3	LS	H	Hard	Mild	Severe	-	-	-
35	Kanlorng Phnom	0.5	De	Dec 1st w	0.5	Y	>2.0	3	M	H	Hard	-	-	-	-	-
36	Boeung Kak	1.5	De, L	Dec 3rd-4th w	0.6-1.4	Y	1-3	3	B-LS	H	Hard	-	-	-	-	-
37	Kranhol	4.4	De, L	Dec 1st-4th w	0.0-3.4	Y	1.0-3.0	3	B	H	Hard	Mild	Mild	-	-	-

Prop=proportion of total fields, Ecosystem: M=medium, U=upper and L=lower rice field level; LSc=lodging score and ShS=shattering score (1=low, 2=intermediate and 3=high), Grain shape: B=bold, M=medium, LS=long slender; Transl.=translucence: 1=translucent, 2=small chalkiness and 3=large chalkiness; Tolerance and Resistance: Mod=moderate, Susc=susceptible; Cexp=cooking expansion and market price:L=low, M=medium and H=high, "-"=unknown

Most of farmers have similar perception in grain type and cooking quality of particular varieties. About half of the rice varieties across all ecosystems were reported to be tolerance to mild and moderate drought stress. Farmers also reported that nine rice varieties are tolerant to mild and moderate submergence stress. In contrast, farmers have no idea about the resistance level of most varieties against weed, insect pest and disease.

Group discussion. The results of the 11 group discussions on the common rice varieties cultivated in 11 villages are shown in Table 6. There were six rice varieties (including Krem) commonly cultivated in the upper fields of rainfed lowland ecosystem. The six varieties are early to medium maturity duration with harvesting time varied from early to late November. Neang Rith was reported to be tolerant to severe drought and submergence and also resistance strongly to insect pest. Earlier harvest coping with water conditions in the upper fields are the main factor for being cultivate of these varieties. Some farmers also prefer rice with high cooking expansion to feed their family demand.

Ten varieties were widely cultivated in the medium fields, except two (Leak Sleuk and Riang Chey) were cultivated in both medium and lower fields. These varieties are intermediate maturity with plant height ranged from 0.8 to 2.0m. Six varieties (including Neang Morn), maturity in December, were commonly cultivated in the lower fields. Most of varieties cultivated in medium and lower fields were reported to be tolerant to mild and moderate drought and submergence stress. High yield potential, suited to the water conditions, good quality and high market price are the main factors for being widely cultivated of these varieties.

For deepwater ecosystem, Boeung Kak and Kranhol were very popular. Both are late maturity duration, harvesting in late December to early January, and can elongate up to 3m tall for Kranhol and 4m tall for Boeung Kak.

During discussion, farmers were asked to list down the characteristics for further introduced/new varieties in the rainfed upper, medium and lower fileds; and deepwater ecosystem. The upland rice was not considered due to its small proportion and its fields are not located in the target area. The preferred characteristics of the new varieties are listed in Table 7.

In rainfed lowland where the field level is in the upper position, farmers prefer to have new varieties with higher yield than Krem and Ronuk, but earlier than Krem for about two weeks. The new varieties should grow between 0.8m and 1.1m tall and tolerate to severe drought and moderate submergence. These varieties also should expanse well while cooking with medium or soft cooked rice and have medium to high market price.

For medium fields in the rainfed lowland ecosystem, the new varieties should yield higher than Somaly, Phka Knhey and Leak Sleuk with intermediate plant height (1.0-1.3m) and do not lodge. The new varieties also should mature about one week earlier than Kong Khsach and tolerant to drought and submergence. Grains should be long slender and translucent with soft or hard cooked rice and high market price.

Table 6: List of common rice varieties cultivated in the command area and their characteristics.

No.	Variety	Ecos-ystem	Harvested period (w = week)	PH (m)	LSc	ShS	Grain appearance		Tolerance to		Resist. to pest	Cexp	Eating quality	Market price	Reason for cultivating
							Shape	Transl.	Drought	Flood					
1	Chhma Changkoam	U	Nov 4th w	0.7-1.0	3	2	M	2	Mod	-	-	M	M	M	Well adapted & high cooking expansion
2	Krem	U	Nov 4th w	0.7-1.2	2	2	M	1	Mod	Mod	-	M	M	M	Early maturity, high yied and suited to shallow water depth
3	Neang Rith	U	Nov 2nd w	1.5-2.0	1	1	B	3	Severe	Severe	Severe	L	Soft	L	Early maturity
4	Phka Kabas	U	Nov 1st w	1.3-1.5	3	1	LS	3	-	-	-	H	Hard	M	High cooking expansion
5	Ronuk	U	Nov 2nd w	1.0	3	3	LS	1	Severe	Mild	Mild	H	Hard	M	Early maturity
6	Sambok Angkrorng	U	Nov 4th w	1.2	2	1	LS	1	Mod	Mod	Mod	H	Hard	M	Custom
7	Changvay Phdau	M	Nov 4th w	1-1.2	2	2	M	1	Mild	Severe	Mod	L	Soft	M	Early maturity
8	Chanlong	M	Nov 4th w	1.8-2.0	2	1	LS	3	Mild	Mild	Mod	L	Soft	H	High yield & high price
9	Kantuy Damrey	M	Nov 4th w	1.4	3	1	B	1	Mod	Mod	Mod	L	M	M	Custom
10	Kong Khsach	M	Dec 2nd w	1.0-1.5	3	1	M	2	Susc	Mod	-	H	Hard	M	Suited to the water level
11	Kratie	M	Nov 4th w	1.0-1.2	1	1	LS	3	Mod	Mod	Mod	M	Soft	H	Early maturity, good quality & high price
12	Mlis	M	Nov 4th w	1.0-1.6	2	2	LS	1	Mild	-	-	L	Soft	H	High price & reserved variety
13	Phka Knhey	M	Dec 1st w	1.0-1.6	2	1	LS	1	Mod	Susc	-	L	Soft	H	High yield & high price
14	Somaly	M	Nov 3rd w	1.0-1.5	2	2	LS	1	Mild	-	-	L	Soft	H	High yield, good quality with aroma & high price
15	Leak Sleuk	M, L	Dec 1st-3rd w	0.8-1.5	2	2	LS	1	Mod	Mild	Mod	M	M	M	High yield, translucent & suited to lower lowland fields
16	Riang Chey	M-L	Nov 3rd w	1.0-1.6	2	2	LS	1	Mod	Mild	Mod	M	M	M	High yield, good quality & price
17	CAR 6	L	Dec 2nd w	1.5	2	2	B	1	Severe	Severe	Severe	L	Soft	H	Test new variety
18	CAR11	L	Dec 3rd w	1.5-1.7	1	2	LS	1	Severe	Severe	Mod	M	Soft	M	Test new variety
19	Changkoam	L	Nov 4th w	1.5-1.8	1	1	M	1	Mild	Severe	Severe	L	Soft	M	New varieties
20	Chma Santorng	L	Dec 3rd w	1.2	3	3	LS	1	Mod	Mild	-	H	Hard	M	High yield
21	Neang Morn	L	Dec 1st-2nd w	0.9-2.0	3	3	B	1	Mod	Susc	Mod	M	M	M	High yield & drought tolerance
22	Sar Kranhanh	L	Dec 3rd w	1.0-1.5	2	1	B	1	Susc	Mod	-	H	M	H	High yield
23	Boeung Kak	De	Dec 3rd-Jan 1st w	1.5-4.0	3	2	B	2	Mild	Mod	Susc	H	Hard	L	High yield & suited for deepwater
24	Kranhol	De	Dec 3rd w	1.5-3.0	3	2	M	1	Susc	Mod	-	H	Hard	L	No variety choice

Ecosystem: M=medium, U=upper and L=lower rice field level; LSc=lodging score and ShS=shattering score (1=low, 2=intermediate and 3=high), Grain shape: B=bold, M=medium, LS=long slender; Transl.=translucence: 1=translucent, 2=small chalkiness and 3=large chalkiness; Tolerance and Resistance: Mod=moderate, Susc=susceptible; Cexp=cooking expansion and market price:L=low, M=medium and H=high "-"=unknown

Table 7: List of the characteristics of the new varieties preferred by farmers in command area.

Character	Rainfed lowland ecosystem			Deepwater ecosystem
	Upper field	Medium field	Lower field	
Higher yield than	Krem and Ronuk	Somaly, Phka Knhey and (Leak Sleuk)	Riang Chey, Neang Morn, Leak Sleuk and Chhma Santorng	Yes
Maturity earlier than	Krem for about two weeks	Kong Khsach for about one week	Sar Kranhanh about for one week	Kranhol for about one week
Plant height (m)/elongation ability	0.8-1.1	1.0-1.3	-	Similar to Boeung Kak
Lodging score/kneeing ability (1-3)	1	1	1	3
Shatering score (1-3)	-	-	-	-
Grain shape	-	LS	LS	Better than Boeung Kak
Grain translucence (1-3)	-	1	1	1
Tolerance to	Severe drought and moderate submergence	Severe drought and moderate submergence	Severe drought and submergence	Severe drought and submergence
Resistance to insect pest/disease	-	Rice bug and grass hopper	-	-
Cooking expansion	Medium to high	-	High	High
Eating quality	Medium to soft	Soft and hard	Soft and hard	Soft and hard
Market price	Medium to high	High	High	-

Shattering score: 1=low, 2=medium and 3=high shattering, Grain translucence: 1=translucent, 2=small chalkiness and 3=large chalkiness, LS=long slender.

For lower fields in the rainfed lowland ecosystem, the new varieties should yield higher than Riang Chey, Neang Morn, Leak Sleuk or Chhma Santorng with maturity duration for about one week earlier than Sar Kranhan and do not lodge. Grains should be long slender and translucent with soft or hard cooked rice and high market price. The new varieties also should tolerance to drought and submergence.

The new varieties for deepwater ecosystem should yield higher than the existing varieties, mature for about one week earlier than Kranhol, elongate similar to Boeung Kak, have a good kneeing ability and tolerate to drought and submergence. They also should have translucent grains with high expansion while cooking and soft or hard cooked rice.

Upstream and downstream areas

Interview. The rice varieties cultivated in both upstream and downstream areas and their detail characteristics are listed in Table 8.

In the upstream area, Krem was cultivated in the upper and medium fields and accounted for 24% of the total field number (36) (Table 8a). Neang Chhma, was cultivated in the medium and lower fields, accounted for 21% of the total field number. In the lower fields, Leak Sleuk and Neang Sar were cultivated and each accounted for 3% of the total field number. Kranhol was commonly cultivated (12%) in deepwater ecosystem.

In the downstream area, Chhma Changkoam (in the upper and medium fields), Neang Ty (in the lower fields) and Angka [deepwater rice, farmers received this variety from an immediate assistance from the state in the communist time (1979), so farmers called it Angka] were cultivated on 21%, 11% and 18% of the total field number (56), respectively (Table 8b). In both areas, the harvested yields varied greatly from 0.1 to 2.4t/ha.

Group discussion. The common varieties cultivated in both areas and their characteristics reported by the farmers are shown in Table 9.

In the upstream area, the common cultivated varieties are: Krem for the upper fields; Chhma Changkoam, Sambok Angkrorng and Changkong Khsach for the medium fields; Neang Chhma and Leak Sleuk for the lower fields; and Kranhol for deepwater ecosystem.

In the downstream area, eight varieties were reported to be commonly cultivated. They are: Krem for the upper fields, Chhma Changkoam for the medium fields, Neang Storng and Neang Ty for the lower fields, and Kranhol, Angka, Boeung Kak and Phka Prolit for deepwater ecosystem.

Table 10 shows the characteristics of the new rice varieties preferred by the farmers for both rainfed lowland and deepwater ecosystems in the upstream and downstream areas.

In the upstream area for the upper fields in rainfed lowland ecosystem, farmers prefer new varieties that yield higher than Krem, mature within November 1st week and do not lodge (Table 10a). The new varieties also should have long slender and translucent grains with high cooking expansion and medium or hard cooked rice. The new varieties for the medium fields should yield higher than Riang Chey, mature in between November 3rd and December 1st week, do not lodge and tolerate to severe drought. Grains of the new varieties should be long slender and translucent with well expanse and medium or hard cooked rice. For the lower fields, farmers prefer new varieties that yield higher than Kranhol, mature within December 1st week and do not lodge. The new varieties should have long slender and translucent grains.

In the downstream area under rainfed lowland ecosystem where the fields are in the upper position, farmers prefer new varieties that yield higher than Krem, do not lodge and have soft cooked rice. For the medium fields, the new varieties should yield higher than Chhma Changkoam, mature two weeks earlier than Chhma Changkoam, do not lodge, should have translucent grains with soft cooked rice. For the lower fields, the new varieties should have higher yield than Neang Ty, but mature two weeks earlier and tolerate to submergence. The new deepwater rice varieties should yield higher than Kanlorng Phnom and have an ability to elongate similar to Boeung Kak. Their grains should be long slender and translucent.

Farmers in all areas reported many rice varieties that have been lost and most of them were due to the low yielding and civil war. However, some varieties reported to be lost in one area are cultivated in the other area. For example, Phka Knhey, Phka Kabas and Neang Ty were reported to be lost in the upstream area, but the first two were found in the command area and Neang Ty in the downstream area. The preferred variety for re-cultivation (Changvay Phdau) by the farmers in the downstream area was found in the command area. Thus, at the presence, it is a chance to re-introduce some varieties using the source among the three areas. However, some lost varieties may be found in the germpalsm conservation (CARDI).

In general, rice yields harvested from the command, upstream and downstream areas in wet season 2003 was relatively low and the low yields were also observed during the field observations. Late season drought was reported to be a major factor that affected yield. The rain ceased in late October and affected all maturity groups in the rainfed upland ecosystem. The water shortage was more severe for the medium maturity varieties, which were cultivated in the upper fields. For example, Changkong Khsach and Changvay Phdau, both are medium maturity varieties, were cultivated in the upper fields in the command area (see Table 3). Most of rice fields are separated by very small levees with poor maintenance, so the water could not kept for a long time after rain ceased. Another factor may considered is uneven of the rice fields, in which the crops growing in the upper part suffered earlier and longer period of drought, resulting in lower yield. In contrast, flood affects crops grown in the lower part more severe. The low soil productivity was also contributed to the low yield in these three areas. The rice yields in 2003 were generally lower than in 2002, because of this late season drought (data not show).

Severe drought was developed for deepwater rice, particularly in the downstream area. The water level in the Tonle Sap lake was relatively shallow and receded very fast. This water level, couple with earlier ceased rain and un-levee fields enhanced the timing and severity of drought, which leaded to very low yields (see Table 8). However, in 2003, farmers had better harvests than a previous year. In 2002, crops were almost complete destroyed by flood.

There was a longer period for harvesting certain variety. The longer time from maturity to harvest may contributed to higher yield loss as the matured grains were dropped down and eaten by birds and rats before the harvesting took place.

Table 8: List of rice varieties cultivated by the farmers in the upstream and downstream areas and their characteristics.

No.	Variety name	Prop (%)	Ecos-ystem	Harvesting period (w = week)	Yield (t/ha)	Phot	PH (m)	LSc	Grain type	Cexp	Eating quality	Tolerance to Drought	Tolerance to Flood	Resistance to Weed	Resistance to Insect	Resistance to Disease
a) Upstream area																
1	Kratie	3	U	Nov 2nd w	0.2	Y	0.6-0.7	1	LS	L	Soft	-	-	-	-	-
2	Neang Raech	3	U	Dec 3rd w	0.2	Y	0.6-0.7	1	LS	M	M	-	-	-	-	-
3	Por Sla	3	U	Nov 3rd w	0.3	Y	1.5	2	B	H	Hard	Severe	Mod	Mild	Mild	Mild
4	Krem	24	U, M	Oct 4th-Nov 1st w	0.1-1.2	Y	0.5-1.2	1-2	M-LS	L-H	Soft-M	Severe	Severe	-	-	-
5	Neang Morn	6	M	Dec 1st w	2.3	Y	1.4	2	-	M	M	Mild	Severe	Mild	-	-
6	Changkong Khsach	6	M, L	Nov 3rd w	2.1-2.3	Y	1.0-1.6	1-3	M	H	Hard	Mild	Severe	Mild	-	-
7	Neang Chhma	21	M, L	Dec 2nd-4th w	0.3-2.0	Y	0.8-1.5	1-3	LS	L-H	Soft-Hard	Mild	Mod	Mild	Susc	Mild
8	Sambok Angkrorng	9	M, L	Oct 3rd-Dec2nd w	0.2-0.8	Y	0.8-1.2	1-3	M-LS	M-H	M-Hard	Mild	Mod	-	-	-
9	Leak Sleuk	3	L	Dec 1st w	2.4	Y	1.2	2	LS	H	Hard	Severe	Mod	Mild	Mild	Mild
10	Neang Sar	3	L	Dec 4th w	2.4	Y	1.0-1.6	3	B	H	Hard	Severe	Mod	-	-	-
11	Boeung Kak	6	De	Jan 2nd w	0.9	Y	2.0-3.0	3	B	H	Hard	-	-	-	-	-
12	Srov Bour	3	De	Dec 2nd-4th w	0.6	Y	1.5-2.3	3	B	H	Hard	-	-	-	-	-
13	Kranhol	12	De, L	Dec 3rd w	0.2-2.0	Y	1.0-3.0	3	B	H	Hard	Mild	Severe	Mod	-	-
b) Downstream area																
1	Krem	5	U	Nov 2nd-4th w	0.7-1.0	Y	1.0-1.5	2-3	LS	L, H	Soft, Hard	Susc	Susc	Susc	Susc	Susc
2	Chhma Changkoam	21	U, M	Nov 4th-Dec 2ndw	0.2-2.4	Y	1.0-1.6	3	LS	H	Hard	Mod	-	-	-	-
3	Damneub	4	U, M	Nov 2nd w	0.9-1.7	Y	1.0-1.5	2	B-M	L	Soft	-	-	-	-	-
4	Chong Banla	2	M	Dec 1st w	2.4	Y	1.5	2	M-LS	M	M	Susc	Susc	Susc	Susc	Susc
5	CAR 6	4	L	Dec 3rd w	1.4-2.8	Y	1.0	1	B	M	Soft	-	-	-	-	-
6	Leak Sleuk	4	L	Dec 3rd w	1.7-2.0	Y	1.2-1.5	3	M-LS	H	M	Mod	Mod	-	-	-
7	Neang Ty	11	L	Dec 3rd w	1.0-2.3	Y	1.0-1.5	3	B	H	Hard	-	-	-	-	-
8	Angka	18	De	Dec 1st-3rd w	0.2-1.9	Y	1.4-4.0	3	M-LS	H	Hard	Mod	Severe	-	-	-
9	Boeung Kak	7	De	Dec 1st-4th w	0.2-1.7	Y	>3.0	2-3	LS	H	Hard	Mild	Severe	-	-	-
10	Phka Prolit	9	De	Dec 1st-3rd w	0.3-1.2	Y	>3.0	3	B	H	M	Mild	Mild	Susc	Susc	Susc
11	Srov Bour	4	De	Dec 2nd w	0.7-1.0	Y	1.5-2.0	2	B	H	Hard	Susc	Susc	Susc	Susc	Susc
12	Kranhol	7	De, L	Dec 2nd w	0.2-1.0	Y	1.2-3.0	3	B-M	H	Hard	Mod	Mod	-	-	-
13	Neang Storng	5	De, L	Dec 1st-2nd w	0.1-0.2	Y	>1.5	1	LS	H	Hard	-	-	-	-	-

Prop=proportion of total fields, Ecosystem: M=medium, U=upper and L=lower rice field level; LSc=lodging score and ShS=shattering score (1=low, 2=intermediate and 3=high), Grain shape: B=bold, M=medium, LS=long slender; Transl.=translucence: 1=translucent, 2=small chalkiness and 3=large chalkiness; Tolerance and Resistance: Mod=moderate, Susc=susceptible; Cexp=cooking expansion and market price:L=low, M=medium and H=high "-"=unknown

Table 9: List of common rice varieties cultivated in the upstream and downstream areas and their characteristics.

No.	Variety	Ecos-ystem	Harvested period (w = week)	PH (m)	LSc	ShS	Grain appearance Shape	Grain appearance Transl.	Tolerance to Drought	Tolerance to Flood	Resist. to pest	Cexp	Eating quality	Market price	Reason for cultivating
a) Upstream villages															
1	Krem	U	Nov 1st w	0.7-1.0	1	3	M	1	Mod	-	-	H	hard	M	Early harvest
2	Chhma Changkoam	M	Dec 1st w	1.0-1.5	2	2	M	1	Mild	-	-	L	M	H	After Pol Pot
3	Sambok Angkrorng	M	Dec 2nd w	0.8	1	3	LS	1	Severe	Mod	Susc	H	soft	M	Well adapted and high fertility
4	Changkong Khsach	M	Nov 3rd w	1.2-1.5	3	1	B	1	Severe	Mod	-	H	soft	M	Well adapted and high fertility
5	Neang Chhma	M, L	Dec 2nd-4th w	1.0-1.5	3	1	B	2	Mild	Mild	Susc	H	M	M	Well adapted and high fertility
6	Leak Sleuk	L	Dec 2nd w	1.0-1.5	3	1	LS	2	Mild	Mild	-	H	Hard	M	High yield
7	Kranhol	De, L	Dec 3rd w	1.3-2.3	3	2	B	2	Mild	Mod	-	H	Hard	L	Suited for water depth up to 1.5 m
b) Downstream villages															
1	Krem	U	Nov 2nd w	1.1	1	1	B	1	Mild	Mild	-	L	Soft	H	High yield and soft cooked rice
2	Chhma Changkoam	M	Nov 4th w	0.8-1.5	3	2	M	1	Mild	Mild	-	M	M	M	Well adapted
3	Neang Storng	L	Dec 1st w	2.0	1	3	LS	1	Susc	Mild	-	H	M	M	No new variety
4	Neang Ty	L	Dec 3rd w	1.0-1.6	3	2	LS	1	Susc	Mild	-	H	Hard	M	Well adapted
5	Kranhol	De	Dec 1st w	2.0	3	3	B	1	Mild	Mild	Susc	H	Hard	L	Appropriate for shalow deepwater fields.
6	Angka	De	Dec 1st w	2.0	3	3	LS	1	Susc	Susc	Susc	H	Hard	M	No new variety
7	Beung Kak	De	Dec 4th-Jan 1st w	3.0-4.0	3	3	B	3	Susc	Severe	-	H	Hard	L	Good elongated ability
8	Phka Prolit	De	Jan 1st w	> 5.0	1	1	B	1	Mild	Mild	-	M	Hard	L	Appropriate for very low fields

Ecosystem: M=medium, U=upper and L=lower rice field level; LSc=lodging score and ShS=shattering score (1=low, 2=intermediate and 3=high), Grain shape: B=bold, M=medium, LS=long slender; Transl.=translucence: 1=translucent, 2=small chalkiness and 3=large chalkiness; Tolerance and Resistance: Mod=moderate, Susc=susceptible; Cexp=cooking expansion and market price:L=low, M=medium and H=high "-"=unknown

Table 10: List of the characteristics of the new varieties preferred by farmers in the upstream and downstream areas.

Character	Rainfed lowland ecosystem			Deepwater ecosystem
	Upper fields	Medium fields	Lower fields	
a) Upstream villages				
Higher yield than	Krem	Riang Chey	Kranhol	
Maturity time	Nov 1st w	Nov 3rd-Dec 1st w	Dec 1st w	
Plant height (m)	-	-	1.2-1.3	
Lodging score (1-3)	1	1	1	
Shatering score (1-3)	-	-	-	
Grain shape	LS	LS	LS	
Grain translucence	1	1	1	
Tolerance to	-	Severe drought	-	
Resistance to insect pest/disease	-	-	-	
Cooking expansion	High	High	-	
Eating quality	Medium to hard	Medium to hard	-	
Market price	-	-		
b) Downstream villages				
Higher yield than	Krem	Chhma Changkoam	Neang Ty	Kanlorng Phnom
Maturity earlier than	-	Chhma Changkoam for about two weeks	Neang Ty for about two weeks	-
Plant height (m)/elongation ability	-	-	-	Similar to Boeung Kak
Lodging score/kneeing ability (1-3)	1	1	-	-
Shatering score (1-3)	-	-	-	-
Grain shape	-	-	-	LS
Grain translucence (1-3)	-	1	-	1
Tolerance to	-	-	Severe submergence	-
Resistance to insect pest/disease	-	-	-	-
Cooking expansion	-	-	-	-
Eating quality	Soft	Soft	-	-
Market price	-	-	-	-

Shattering score: 1=low, 2=medium and 3=high shattering, Grain translucence: 1=translucent, 2=small chalkiness and 3=large chalkiness, LS=long slender.

4.4. Cultural practices

4.4.1. Land preparation

The period of land preparation for wet season rice crop in the Stung Chinit area as well as in the other rainfed lowland areas across Cambodia varied according to rainfall distribution. Since most land preparation in Stung Chinit depends mainly on draught power with traditional farming tools, the tillage could be carried out only after the soil was wet by a couple of rains. Several soakings by early rainfall are necessary before the soil is soft enough to be ploughed by cattle because the topsoil is baked so hard by sun hit during May (Nesbitt, 1997). The lower field is likely to be ploughed earlier than the upper field because the top layer of the former is likely to be softer than the latter.

According to the record, two times of plowing followed by one harrowing were more commonly practiced in the command area for both deepwater and rainfed lowland ecosystems. Up to 70% against 30% between plowings two times and one time was practiced of all fields under deepwater ecosystem (Table 11a). Concerning the period of performing, the fields were plowed between April and June but the first plowing was majority in May (40%) and the second plowing was in June (40%). The standing water in the fields was critical for the second plowing since the harrowing was conducted as soon as possible for transplanting. The one time plowing practice was mostly done in late May.

In all field levels in rainfed lowland, more or less 90% practiced two plowings. For the two times plowing, the first plowing was done mostly in May for the upper (45%), medium (63%) and lower (71%) fields. Second plowing was mainly done in June for the upper fields (62%), and in July for the medium (51%) and lower (48%) fields.

The upstream area's practice of land preparation was comparable to the command area. Of the deepwater fields, 75% were ploughed two times with the same percentage between the first and second plowing in April (25%) and between the first and second plowing June (50%) (Table 11b). All the one time plowing completed in April. All rainfed lowland fields were ploughed twice except medium fields. The first plowing was generally conducted in May and June for the upper and medium fields and in April for the lower fields. The second plowing was mainly took place in June for the upper fields, in June and July for the medium fields and in May for the lower fields.

A single plowing was largely practiced in the downstream area compared to the previous two areas. Around 50% of deepwater fields was plowed only one time and completed mainly in May (Table 11b). The first plowing of double plowing was mainly in April and the second plowing was in May. Interestingly, 80% of the rainfed upper fields were plowed one time. April and May were the peak periods for either one or two times plowing for the rainfed upper fields. Thirty to 35% of rainfed medium and lower fields was plowed once, respectively. In the medium fields, the first plowing was usually in May (36%) and the second plowing was frequently in June (36%) but it was also fairly percentage in July (21%) while the single plow was only in May and June and this schedule was pretty similar to the rainfed lower fields.

Though it has been observed that the number of land preparation was different from area to area and field to field, farmers in all three areas would prefer to plow their rice fields two times if it was affordable. Draught power would be the main constraint but rainfall and available labour could not be a deniable factor caused reducing the number of plowing or delaying land preparation which in some fields in the command and upstream areas was as late as August.

The ability of farmers to use an appropriate method of land preparation to better manage both organic materials and soil structure of their rice fields was limited by a lack of draught power or machinery, and unreliable source of irrigation.

Table 11: Proportion of number of plowing in the main-fields for different months in different ecosystems in the command, upstream and downstream areas.

	Deepwater			Rainfed upper fields			Rainfed medium fields			Rainfed lower fields		
	Two times		One	Two times		One	Two times		One	Two times		One
	First	Second	time	First	Second	time	First	Second	time	First	Second	time
a) Command villages												
Proportion (%)	70		30	82		18	95		5	95		5
Proportion (%) in												
April	30	20	-	10	-	-	6	2	-	6	5	-
May	40	10	20	45	-	6	63	1	3	71	3	1
June	-	40	10	26	62	6	22	39	-	15	25	4
July	-	-	-	-	20	6	4	51	2	8	48	-
August	-	-	-	-	-	-	-	2	-	-	14	-
b) Upstream villages												
Proportion (%)	75		25	100		0	93		7	100		0
Proportion (%) in												
April	25	25	25	-	-	-	-	-	-	80	10	-
May	-	-	-	57	-	-	47	-	-	20	50	-
June	50	50	-	43	57	-	46	40	7	-	30	-
July	-	-	-	-	29	-	-	40	-	-	10	-
August	-	-	-	-	14	-	-	13	-	-		-
c) Downstream villages												
Proportion (%)	52		48	20		80	64		36	67		33
Proportion (%) in												
April	36	4	4	20	-	40	-	-	-	42	-	-
May	8	36	44	-	20	40	36	8	21	16	51	16
June	8	12	-	-	-	-	29	36	14	8	17	16
July	-	-	-	-	-	-	-	21	-	-	-	-
August	-	-	-	-	-	-	-	-	-	-	-	-

Shading indicates the highest percentage. The proportions were calculated based on the number of main-fields (Deepwater: 11, 4 and 27 fields for command, upstream and downstream area, respectively; Upper fields: 32, 7, 5 fields for command, upstream and downstream area, respectively; Medium fields: 98, 15 and 13 fields for command, upstream and downstream area, respectively; and Lower fields: 66, 10 and 12 fields for command, upstream and downstream area, respectively.

In common practices, seedbed preparation started immediately after the first main-field plowing with two times of plowing within 2-3 weeks interval. Then the seedbed was harrowed and leveled. All seedbeds were typically rainfed lowland type without raising the bed. Pre-germinated seeds were used.

Timing and intensity of land preparation were mainly depended on available water, which was erratic and unpredictable. Farmers started plowing after several times of rainfall for the first plowing and when there is standing water in the fields for the last plowing and harrowing.

4.4.2. Planting methods

In all areas, farmers practiced both transplanting and direct seeding methods. All deepwater rice fields were direct seeded and consisted of 5% for the command area, 11% for the upstream area and 46% for the downstream area (Table 12). Direct seeding was also practiced for rainfed lowland rice and accounted for 20% in the command, 42% in the upstream and 5% in the downstream area. Most of rice cultivated in the upper fields in the upstream area was direct seeded. Therefore, the proportion of direct seeding practice is relatively high in this area.

Seed rate for direct seeding varied greatly (45-160kg/ha) for all areas with the mean value around 110 kg/ha. There was not much difference in mean values of seed rate between the deepwater and rainfed lowland rice.

Transplanting method accounts 72% in the command area, 47% in the upstream area and 49% in the downstream area. The mean values of seed rate ranged from 88±38 kg/ha in the command to 99±14 kg/ha in the downstream area for the local varieties with the range from 45-150 kg/ha. For the introduced varieties, mean value of seed rate was about half of the local varieties (53±17 kg/ha) and seed rate ranged from 30-95 kg/ha.

The mean values of sowing rate ranged from 1.0±0.6 kg/10m^2 in the downstream area to 1.9±1.4 kg/10m^2 in the command area. Number seedlings per hill varied from 3-5 for local varieties in the three areas and 2-4 for the introduced varieties in the command area. Spacing between hills varied from 20x20 cm to 30x30cm in the command and downstream areas, and 10x10 cm to 30x30 cm in the upstream area.

Table 12: Proportion (%) of direct seeding for deepwater (D) and rainfed lowland (R) rice and transplanting, seed rate±standard deviation (SD), seed rate range, sowing rate, minimum and maximum seedlings per hill and spacing between hills for the introduced (InV) and local (LV) varieties and labour requirement for pulling and transplanting the seedlings in the command, upstream and downstream areas, wet season 2003.

	Command (209)		Upstream (36)	Downstream (57)
a) Direct seeding	*(D=5%)*	*(R=20%)*	*(D=11%, R=42%)*	*(D=46%, R=5%)*
Seed rate±SE (kg/ha)	112±21	109±14	103±21	112±23
Range (kg/ha)	72 - 160	96 - 133	45 - 129	54 - 144
b) Transplanting	*(InV=18%)*	*(LV=54%)*	*(LV=47%)*	*(LV=49%)*
Seed rate±SD (kg/ha)	53±17	88±38	97±24	99±14
Range (kg/ha)	30 - 95	45 -150	60 - 108	79 -125
Sowing rate±SD (kg/10m^2)	1.6±0.8	1.9±1.4	1.3±1.1	1.0±0.6
Min. seedlings/hill (no.)	2.2±1.1	3.1±1.0	3.9±1.4	3.4±0.9
Max. seedlings/hill (no.)	3.4±1.3	4.4±1.2	4.8±1.5	4.5±0.9
Spacing (cm x cm)	20x20 - 30x30	20x20 - 30x30	10x10 - 30x30	20x20 - 30x30
Labour (person-days/ha)	22-94 (45)		18-80 (43)	20-90 (49)

Seedling ages for the upper, medium and lower fields in the three areas are shown in Table 13. The seedling ages varied from 2 week-old to 10 week-old in the command area. However, the 6 week-old seedlings accounted for 33% followed by the 5 week-old seedlings (24%) and 4 week-old seedlings (19%) of the total transplanted fields (150). In the upstream area, the oldest seedlings were 6 week (31%) followed by 5 week-old and 4 week-old (each, 25%). In the downstream area, the common seedling age was 4 week-old. The 5 week-old and 6 week-old accounted for 31% and 12%, respectively.

Labour requirement for pulling and transplanting the seedlings was estimated from about 20 to 90 per hectare with average from 43 to 49 per hectare for the command, upstream and downstream areas.

Table 13: Percentage of seedling ages for the upper, medium and lower fields and the total in the command, upstream and downstream areas, wet season 2003.

Weeks after sowing	Command (150)			Total	Upstream (17)			Total	Downstream (28)			Total
	Upper	Medium	Lower		Upper	Medium	Lower		Upper	Medium	Lower	
2	1	-	-	**1**	-	6	-	**6**	-	4	-	**4**
3	2	8	3	**12**	-	13	-	**13**	-	8	-	**8**
4	2	11	7	**19**	-	19	6	**25**	15	15	8	**38**
5	7	11	6	**24**	-	25	0	**25**	0	31	-	**31**
6	2	22	8	**33**	19	-	13	**31**	8	-	4	**12**
7	1	-	4	**5**	-	-	-	**-**	-	8	-	**8**
8	1	1	2	**3**	-	-	-	**-**	-	-	-	**-**
9	-	-	-	**-**	-	-	-	**-**	-	-	-	**-**
10	2	2	1	**4**	-	-	-	**-**	-	-	-	**-**

Number in parenthesis indicates number of transplanted rice fields.

Transplanting is a common planting method for rainfed lowland rice. Although transplanting requires high labour input compared to direct seeding method, the rainfed lowland farmers are commonly practiced. There are two reasons for an advantage of transplanting method: (i) after the transplanting, the seedlings can survive for longer period of drought or flood than the pre-germinated seeds of direct seeding do, and (ii) transplanted seedlings are better competitive to weeds particularly in uneven fields with poor land preparation and water management.

The use of high seed rate for both direct seeding and transplanting indicates that farmers concern of low germination rate with less vigorous seedlings, seed lost by birds, termites and rats, and as well as natural disaster such as drought and flood. Transplanting with two to four seedlings per hill is the best practice for the rainfed lowland rice particularly in the fields with crab and rat problem. However, to exceed this number is not an economical practice. It is difficult for the rainfed lowland farmers to control seedling age as they could not control the water in the fields. However, if water were available for the transplanting, one month-old seedlings would be recommended to use for the medium and late maturity varieties and 20-25 days-old seedlings for the early maturity varieties.

Transplanting requires high labour input (about 45 persons per hectare) and most farmers used their own labour. Therefore for the medium to large field size (>=0.5 ha), farmers took longer period to complete transplanting and this can lead to different crop performance particularly under the stress conditions, resulting in low grain yield.

4.4.3. Water Management

Water is critical for rice crops. Rice grown in the command, upstream and downstream areas relied mainly on rainfall (Table 14). However in the command area, 33% of interviewed farmers reported they could access water from the Stung Chinit through canals nearby, while 7% of them used underground water for supplementary irrigation. The remaining farmers (60%) relied completely on rainfall.

Table 14: Water usage for rice cropping systems

Source of water	Command area (66)	Upstream area (12)	Downstream area (18)
Rainfall (%)	60	42	83
Rainfall+steung Chinit (%)	33	42	17
Rainfall+partial irrigation (%	7	16	0

Number in parenthesis indicates number of respondents.

In the upstream area, 42% of interviewed farmers reported rainfall was the only source of water for their rice crops. A similar number relied on rainfall and water from the Stung Chinit as their rice fields are close to the main water canal. Some farmers (16%) could supplement their fields from the any source of water nearby by using water pump.

Most of farmers (83%) in the downstream area depended on rainfall as a water source for their rice crops. Beside rainfall, water from the Stung Chinit was also a water source for some farmers (17%), particularly for those who were growing deepwater rice. They reported that the deepwater rice would grow well, first, if the water from the Stung Chinit reaches their fields before the water from the Tonle Sap lake rises up and, second, if water from both of sources reached their fields simultaneously. The first is to push the plants to grow before water rising and the second is to minimize composite level brought by water from the Tonle Sap lake.

From upstream through downstream areas, most rice-growing farmers depended on rainfall, only few farmers were able to access water from the Stung Chinit and underground water using tube-well with motor pumps. In 2003, rice production in these areas was seriously damage by late season drought as the rain ceased in late October. Late season drought coupled with shallow water level in the Tonle Sap lake severely affected deepwater rice grown in the downstream area.

General field observation indicates that most of rice fields in the three areas were uneven and separated by very small levees with bad maintenance. Drainage system is not existed except the topography levels that allow the water flows from the upper to the lower fields. Fortunately with the topography levels, flood water would not stand for a long period, if the water level in the Tonle Sap lake was shallow.

Pheav et al. (2003) suggested that the Prey Khmer soil has poor water holding capacity due to high leaching rate, while the rest of the soils found in the command area have relatively good water holding capacity.

4.4.4. Fertilizer Management

Farmers in the three areas used both cow manure and chemicals as the sources of fertilizer for the seedbeds and main-fields (Table 15).

In the command area, for transplanting, about half of the seedbeds were treated with cow manure and 41% were treated with chemical fertilizer. The range of cow manure incorporated into the seedbeds varied between 1.6-32 t/ha with the mean value of 8.8 t/ha, while the chemical fertilizer varied from 20-400 kg/ha with the mean value of 220 kg/ha. For the main-fields, chemical fertilizer was used for 72% (application varied from 50-400 kg/ha with the mean value of 100 kg/ha) of the total main-fields, while the cow manure accounted for only 17% (application varied from 0.5-13 t/ha with the mean value of 3.5 t/ha).

Table 15: Proportion of seedbeds and main-fields, range and the mean values incorporated by cow manure (CM) and chemical fertilizer (CF) in the command, upstream and downstream areas

Area	Seedbed		Main-field	
	CM (t/ha)	CF (kg/ha)	CM (t/ha)	CF (kg/ha)
Command (150/209)	53%	41%	17%	72%
Range	1.6-32.0	20-400	0.5-13.0	50-400
Mean	8.8	220	3.5	100
Upstream (12/36)	17%	25%	0%	47%
Range	0.5-5.0	40-300	-	50-310
Mean	6.6	130	-	120
Downstream (28/56)	57%	7%	21%	19%
Range	1.6-28.0	30-250	0.5-4.0	25-125
Mean	11.3	100	2.0	60
Source of CF	Philippines (16-16-08-13), DAP (48-16-0), 15-15-15 and Urea			

Number in parenthesis indicates number of transplanted/total fields. The percentages are calculated based on the number of transplanted fields for the seedbeds and the total fields for the main-fields.

In the upstream area, only 17% and 25% of the total seedbeds were treated with cow manure and chemical fertilizer, respectively. The rate of cow manure ranged from 0.5-5.0 t/ha with the mean value of 6.6 t/ha and the rate of chemical fertilizer ranged from 40-300 kg/ha with the mean value of 130 kg/ha. Only the chemical fertilizer was used for the main-fields and the mean value for an application rate was calculated to be 120 kg/ha with the range of 50-310 kg/ha.

Fifty-seven per cent of seedbeds were incorporated by cow manure with the mean value of 11 t/ha and the chemical fertilizer was used only for 7% of the total seedbeds. Cow manure was incorporated into the 21% of the main-fields in the range from 0.5-4.0 t/ha with the mean value of 2.0 t/ha. Nineteen per cent of the main-fields were treated with chemical fertilizer with the mean value of 60 kg/ha (25-125 kg/ha).

In general, farmers applied cow manure earlier, before the first plow begins, for both seedbeds and main-fields. All farmers reported using their own manure collected from the place where they kept their cattle, usually under their houses. The manure was simply collected and kept freely under the house. This method of storage can lead to the losses of some nutrients particularly nitrogen. The common sources of chemical fertilizer farmers bought from the markets (45,000-50,000 Riel per bag) and applied to the fields were 16-16-08-13 (known as the Philippines), Di-ammonium phosphate (known as DAP or the USA), urea and 15-15-15. Most farmers applied chemical fertilizer at two weeks after sowing for the seedlings and as basal for the main-fields.

Effort for topdressing of fertilizer at the right time was not succeeded as farmers could not control water level in the fields that was mainly depended on erratic and unpredictable rains.

The farmers in the interviewed areas are generally poor, and are unable to purchase chemical fertilizers. Some of them who were able to buy lacked the knowledge to use chemical fertilizers properly. Some chemical fertilizers sold on the market are not good quality.

The soils in the command area consisted of Prey Khmer, Prateah Lang Bakan, Krakor and Kampong Siem groups (Pheav *et al*., 2003) and the results for the previous studies indicated that these soil groups are not or have a small deficit in sulfur (Pheav et al., 1996; White et al., 1997a,b and Seng et al., 2001). The use of 16-16-08-13, which contains high proportion of sulfur, may lead to sulfur toxicity for the rice plants. Also, rice production in these areas usually experience many droughts frequently occurring within cropping season, which leads to uneconomical fertilizer use.

4.4.5. Weed, Pest and Diseases Management

Weed problem

Many types of weed were reported by the farmers in the upstream, command, and downstream villages (Appendix 5). Farmers in the command (30%) and upstream (35%) areas controlled weeds by hand only (Table 16). In the downstream area, 19% of interviewed farmers controlled weeds by hand and 16%, particularly for the deepwater rice, used herbicides.

Table 16: Weed management for rice cropping systems

Type of weeding	Command (66)	Upstream (12)	Downstream (18)
Control by			
Hand (%)	30	35	19
Herbicide (%)	0	0	16
Un-control (%)	70	65	65

Number in parenthesis indicates number of interviewed farmers in each area.

Most of weeds identified in these areas are strong competitors for light, water and nutrient with rice crop, leading to significant rice yield reduction if the weed problem is not solved on time. Most farmers in these areas did not control the weeds. Some farmers believe that water management and other cultural practices are not fully effective in controlling weeds, and they tend to rely heavily on hand-weeding which is time and labour consuming method. The lack of labourers for hand-weeding is now alarming due to competition from other industries for available labour (eg. movement of labour into garment industries in the city).

Pest and disease problems

The detailed information about the pest and diseases reported by the interviewed farmers in the villages of the command, upstream and downstream areas are shown in Appendix 6.

Rice crops grown in the three areas were affected by common pests and diseases (Table 17). Rats, crabs and grasshoppers were reported in all areas as the major rice pests, and Kra was reported as a common disease. Fortunately, farmers reported that these common pests and diseases did not seriously affect the crops and this confirm with our field observation. Therefore, only one farmer in the command area used rodenticide to control rats and two farmers in the downstream area used pesticide.

Table 17: Insect and disease management for rice cropping systems

Area	Pest	Disease
Command	Rat, Crab, Grasshopper, Worm, Rice bug, Termite	Kra, Brown spot
Upstream	Rat, Crab, Grasshopper, Worm, Beatle	Kra
Downstream	Rat, Crab, Grasshopper, Stemborrer, Rice bug, Thlom	Kra

Since the problems of pest and disease in the three areas are not regarded as serious, farmers are not aware of pest and disease management. However, the experience from elsewhere indicates that the severity and incidence, as well as new pests and diseases, increase with the increases in cropping intensity in an area.

4.5. Harvesting and Post Harvesting Practices

4.5.1. Harvesting

Harvesting was carried out in a wide range of duration, commencing in the third week October and finishing in December and possibly extending until the second week of January (Table 18).

Across the three areas (command, upstream and downstream) of study, time of harvesting commenced at a very comparable period, that is, late October or early November and finished at the end of December. Harvesting activities took more or less 10 weeks from mid October to late December with the busiest period in between the first and second week of December in the command (49%), upstream (29%) and downstream (59%) areas. Only two harvests of deepwater rice in the upstream area were completed by the second week of January 2004.

Table 18 : Distribution of harvesting period

Period (week)	Command area (209)		Upstream area (36)		Downstream area (56)	
	Number	%	Number	%	Number	%
1st-2nd Oct	0	0	0	0	0	0
3rd-4th Oct	0	0	6	18	0	0
1st-2nd Nov	30	14	5	15	4	7
3rd-4th Nov	31	15	4	9	5	9
1st-2nd Dec	102	49	11	29	33	59
3rd-4th Dec	46	22	8	24	14	25
1st-2nd Jan	0	0	2	6	0	0

Number in parenthesis indicates number of total rice fields in each area. The percentages were calculated based on the number of total rice fields.

Table 19: Distribution harvesting labour per hectare

Labour (person-days/ha)	Command area (209)		Upstream area (36)		Downstream area (56)	
	Number	%	Number	%	Number	%
<10	2	1	1	3	6	11
10 to 19	28	13	8	22	14	25
20 to 29	47	22	7	19	5	9
30 to 39	51	24	9	25	11	20
40 to 49	22	11	6	17	6	11
50 to 59	12	6	0	0	1	2
> 59	47	22	5	14	13	23
Range	4-180		3-161		3-129	
Mean	43		43		36	

Number in parenthesis indicates number of total rice fields in each area. The percentages were calculated based on the number of total rice fields.

Table 20: Total labour inputs and times spent for harvesting rice fields

Area	Labour (person-days)		Time (day)	
	Range	Mean	Range	Mean
Command (209)	1 to 30	7	1 to 19	4
Upstream (36)	3 to 20	6	1 to 15	5
Downstream (56)	1 to 40	5	1 to 25	5

Number in parenthesis indicates number of total rice fields in each area

Labour force played an important role in harvesting in the three areas as the activity was done manually. The crop was cut with hand held sickle and bundled, placed as piles neatly in the field or transported to a central threshing site particularly at home. Labour input in a per hectare basis was broadly different from field to field ranged from 3 to more than 100 labourers to harvest a hectare rice crop (Table 19). In fact, only one respondent reported using three workers per hectare due to a very poor crop performance. Using part-time family or owned labourers led to a high number of person-days on a per hectare basis. Labour rates (Person-days) were highest in the command area, and ranged from 4-180 person-days per hectare, while 3-129 and 3-161 person-days per hectare in the upstream and downstream areas, respectively (Table 19).

Although there was a wide range of labour input for harvesting on a per hectare basis, between 30 and 50 person-days was the most frequent pattern, with an average around 40 person-days. Individual rice fields required different labour inputs, from 1 to 40 person-days to finish one plot (Table 20). The average labourers per day was 6 persons per family. With a small number of labourers, it took up to 25 days to finish harvesting job of a single rice field for a certain farmers. On average, a single rice field in the three areas required around five days of a total harvesting duration.

The sources of harvesting labourers were common across the three areas. There were three alternatives: family or owned labourers, exchanged labourers and hired labourers. Table 21 summarizes the types of harvesting labourers in a rice field basis.

Table 21: Labour source for harvesting

Labour	Command area (209)		Upstream area (36)		Downstream area (56)	
	Number	%	Number	%	Number	%
Owned (O)	114	55	26	72	38	68
Hired (Hi)	1	0	0	0	0	0
O+Exchanged (E)	20	10	3	8	6	11
O+Hi	69	33	5	14	12	21
E+Hi	0	0	0	0	0	0
O+E+Hi	5	2	2	6	0	0

Number in parenthesis indicates number of total rice fields in each area. The percentages were calculated based on the number of total rice fields.

Among the interviewed farmers, only one had no family labourer and he used the owned labourers as the critical source. Most of the farmers in the command (54%), upstream (71%) and downstream (67%) areas used their owned labourers for harvesting rice fields. In addition to the owned labourers, 33% of farmers in the command area practiced labourers hiring as did 14% in the upstream area and 24% in the downstream area. The use of owned and exchanged labourers to harvest the rice fields was relatively low, calculated to be 10% for the three areas. Only a few rice fields in the command and upstream areas were harvested by the three types of labour.

The practice of owned labourers alone was one of the factors caused the lengthy harvesting. Money was the main constraint to farmers from hiring labourers. Furthermore, it was hard for villager to hire extra labourers during peak harvesting period or very costly. According to field observation, farmers used their own labour for harvesting and transporting as well. For example, two little kids (brother and sister), about 11 years old, were spotted harvesting a very poor yielding crop at Saang village. A field nearby, a wife who just gave birth, of a couple managed to harvest the crop and feed the baby. At Boeung Lvea and Snao villages, all family members (parent, daughter and son) harvested from the morning time but at the afternoon time husband or son nor both collected rice bundles and transported home. Beside labour availability, distant fields and access to the field were also contributed to the extension of harvest duration, e.g. two harvests of the upstream farmers delayed until January due to the later constraint.

Though the practice of exchange labourers was adopted by farmers in the three areas, it was low percentage compared to other areas such as Prey Kabas of Takeo province where exchange labour was very popular (Chea, 2002). Some farmers complained about the performance of exchanged labourers irresponsible and poor which caused losses in their harvest. However, if farmers were able to select a good and reliable team, and arrange the date of harvest of each member ahead that the performance would be improved. Therefore, exchanged labourers would be a sound option for farmers to shorten duration of harvest and operate harvesting at the right time of crop maturing which in turn minimizes yield loss at harvesting stage. Delaying harvesting beyond crop maturing contributed to yield loss to birds, to operate cutting and to transporting. The extension of harvesting period could damage grain quality, especially for lodging varieties.

Using owned labour results in delaying harvesting period and labour input as well. The results calculated from this study indicate that with owned labour farmers required about 40 labourers in average to harvest rice in a hectare field size. The study conducted by the agricultural engineering program of CARDI showed that an average labour input for harvesting a hectare rice field ranged from 25-30 labourers for the areas where exchanged labour is practiced. However in our study, if we concentrate on the data range between 9-60 labourers per hectare and eliminate the rest then an averaged labour input per hectare for harvesting rice would ranged from 26 for the downstream area to 29 for the command area (Appendix 7).

4.5.2. Post-harvest

Paddy post-harvest operation in this study includes all activities occurring after the harvesting task was completed. This included activities such as transport, threshing, winnowing, drying and storage.

Post-harvest practice is critical in preventing harvest losses. There is a high risk of crop loss if it is poorly and carelessly managed. The cost to operate post-harvest is considerably high if farmers are shortage of family labour and farming capital assets such as draught animals and ox-cart.

Table 22 shows the proportion of different means for transportation, threshing, drying and storage practiced in the command, upstream and downstream areas in the number of farmer basis.

Following harvesting, most farmers across the three areas transported the crops tied into sheaves to their homes using cattle cart except few farmers who threshed at the fields and carted only grain home.

Ox-cart was the most important transported mean for carrying rice bundle or grain from field to home. The only transport available for farmers in the upstream and downstream areas was a cart pulled by cattle. Of the interviewees in the command area, seven per cent used light machinery, hand tractor and vehicles, as means of transport the sheaves.

Duration of moving rice bundles home depends on distance between the field and house. Most farmers transported the rice bundles at the afternoon.

It has been observed that three types of threshing were generally practiced in the areas: mechanical thresher engine, draught power and manual threshing. Manual threshing was carried out by hitting the sheaves held with two sticks linked by a short string against a wooden board. In the command area, thresher (68%) was most popular compared to two other practiced methods. In contrast, most farmers in the upstream (69%) and downstream (75%) areas used draught power threshing.

Table 22: Post harvest practices

Area	Transport (%)		Threshing (%)			Drying (%)		Storage (%)	
	Cart	Machinery	Thresher	Draught	Manual	Sun	Other	Bag	Granary
Command (66)	93	7	68	30	2	100	0	17	83
Upstream (12)	100	0	11	69	20	100	0	26	74
Downstream (18)	100	0	23	75	2	100	0	23	77

Number in parenthesis indicates number of total farmers in each area. The percentages were calculated based on the number of total farmers.

The practice of hand threshing was low in the command and downstream areas, and 20% in the upstream area, ranking second after draught power. Draught power and hand threshing was mostly undertaken with family labour source as it was costly for farmer to own a thresher. In contrast, it was not difficult to hire thresher within the areas. The cost for thresher ranged from four to seven per cent of total threshed grain depending on peak period of harvesting but five per cent was commonly charged.

Table 23: Duration of threshing and drying process

Day	Command area		Upstream area		Downstream area	
	Threshing (%)	Drying (%)	Threshing (%)	Drying (%)	Threshing (%)	Drying (%)
1	70	55	23	34	43	57
2	14	35	12	54	15	34
3	3	10	23	6	15	9
4	2	0	12	6	9	0
5	0	0	18	0	11	0
>5	11	0	12	0	7	0

The percentages were calculated based on the number of rice fields (command=209, upstream=36, downstream=56) for the threshing and the number of farmers (command=66, upstream=12, downstream=18) for the drying.

Thresher use was the fastest method compared to other traditional practices. Although Table 23 indicates that duration of threshing was up to 5 days or longer, use of a thresher generally required only one day with the current harvest of farmers in the areas.

Other two threshing methods would take as long as one week if they thresh only at leisure especially with manual threshing. Most farmers were able to finish the threshing task within three days with different means of threshing in the three locations (Table 23).

Using mechanical threshers is necessary since it was clean but winnowing was also needed for draught power and hand threshing. Winnowing with natural wind is important for cleaning rice grain.

All farmers in the three areas dried their rice grains under the sun (Table 22). The grain was dried on palm mats or flat surface but the mat is more useful since it can be moved quickly when raining, and grain still kept clean. Drying duration was usually one or two days though Table 23 indicates that some farmers dried their grain up to 4 days. Grain was dried only half day or even no drying if grain dried enough with bundles or the sheaves left for long time before drying. Most farmers properly dried the rice seeds for two to three days (data not shown).

Grain was stored after drying for consumption and other allocations such as feeding or selling. Farmers in the three areas stored rice grains in either bag or granary. Around 75 to 85% farmers stored rice grains in the granary under their house or nearby and the rest was stored in the bag (Table 22). The consumed grains were commonly stored in the granary while the seed and selling grain was kept in the bag, but those who harvested only small quantity did not separate between grain and seed.

Transportation was a major constraint in the three areas as there were a lot of small rice fields scattered in different locations and many were a long distance from home. It took hours to reach the field so it was hard for them to cart sheaves more than once per day. Also there was a risk of losing the sheaves if left overnight at the field. The harvest had to be scheduled by adjusting to the transport ability. Access to those rice fields located in central rice growing area was not easy before surrounding fields harvested.

Threshing seemed not being a problem for the villagers since mechanical thresher engine was available and affordable. Contract threshers were highly capacity threshing designed with good-throwing ability (Rickman et al., 1997). Other farmers could remove grain from panicles with their owned-draught powers but those who were shortage of cattle or could not afford for threshing machine could practice hand threshing. Though the latter practice was not as fast as thresher, the stubble could be easily stacked up and preserved for long time feeding. A long drying in sheaves, particularly, in the fields before threshing would contribute to grain loss when carrying otherwise severe problem was not recorded for drying and storage.

4.6. Calendar of Family Activities

Looking at rice-based farming systems together with non-farm activities in the study areas, the calendar of family activities have been classified into three main activities: rice production, non-rice cropping and non-cropping activities (Figure 2).

Rice production was described from land preparation to harvesting and post-harvest but they were grouped into three-phase activities related to time, land preparation, planting (included direct seeding, sowing and transplanting) and harvesting. *Non-rice cropping* included growing of home vegetables and other field crops such as watermelon, maize, sweet potatoes etc (Pheav et al., 2003). *Non-cropping activities* consisted of sugar palm sugar production, small-scale or household livestock, fishing, wood logging and non-farm jobs such as wage labour, factory worker, porter and small trading.

Figure 2 indicates that rice-cultivating calendar in the three areas was pretty similar except harvesting period would be a couple of weeks different due to varieties, labour availability and field distance.

Land preparation was commenced in April but completed in late July in the downstream area and in mid August in the command and upstream area.

Planting started in the first or second week of May in the three areas and finished before September in the command and upstream areas and before August in the downstream area.

Usually first harvest started in early November, except for the early maturing varieties starting as early as mid October and the harvested product was stored in bags or granaries at the end of December or early January.

Of non-rice cropping, only watermelon and home vegetables were reported by the interviewees. Watermelon was cultivated in the command and upstream areas but not in the downstream area, and was cultivated after the harvest of rice crops in the period between November and February or possibly lasted to April.

Home or garden vegetables could be cultivated all year round of cropping calendar since it was cultivated on non-rice land, required less labour and at leisure time.

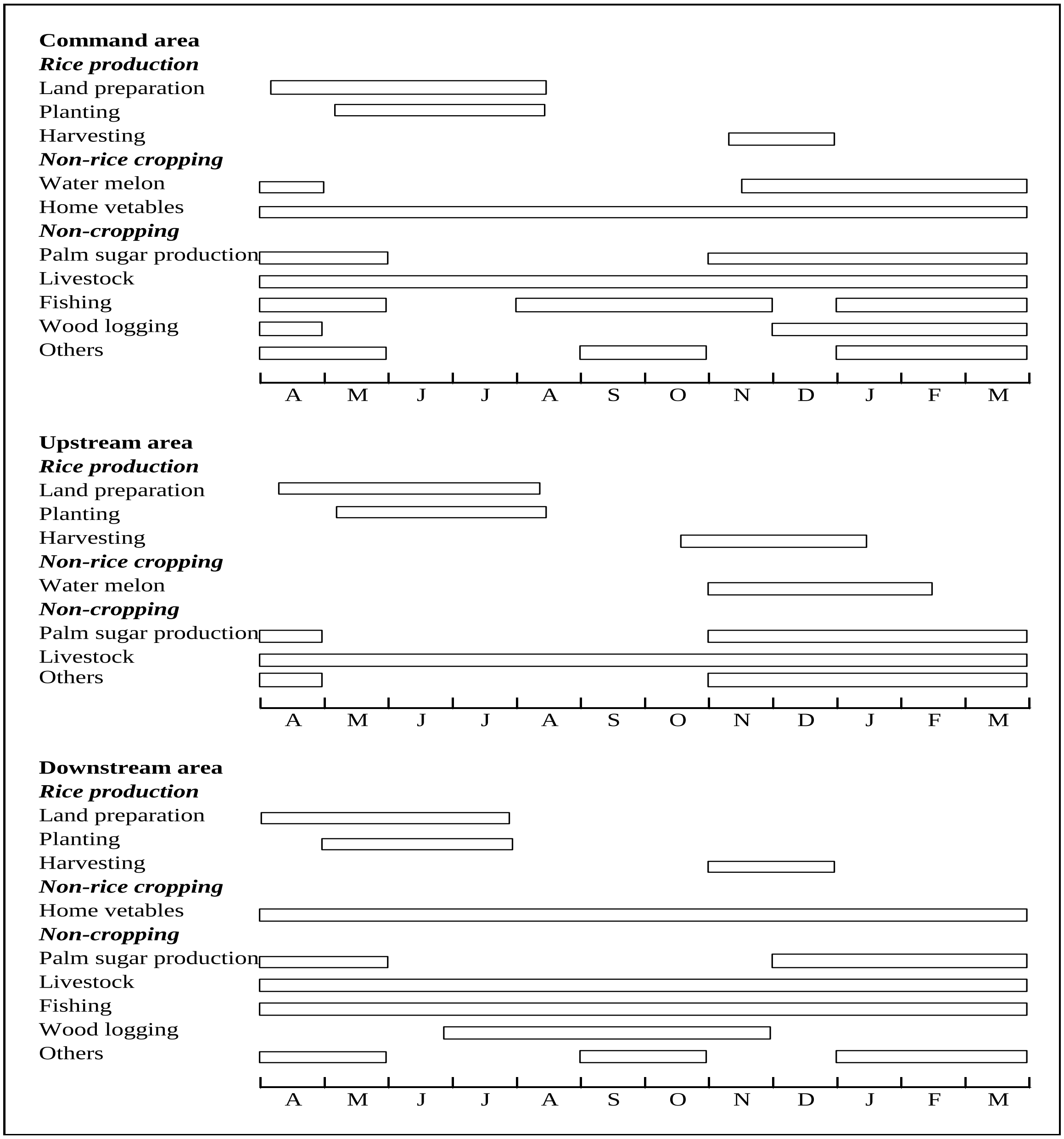
Among the non-cropping activities, poultry and pig raising (or family livestock) could be considered as whole year round practices in all interviewed villages in the three areas.

Palm sugar production was another common source of income in the areas. This production could be carried out only in the dry season between November and April or sometime until May.

Small-scale fishing with traditional tools and used mainly for home consumption (only a small proportion for trading) was done only during off rice production activities in the command area but most interviewees in the downstream area were reported to do fishing for the whole year.

It was noticed during the field observation that most of the farmers in the downstream area, did intensive fishing in the Tonle Sap lake for the period of January to March.

Figure 2: Calendar of family activities



Wood logging (for building houses and fired wood) was also important for the farmers in the command and downstream areas but it was done during free time from rice cultivation, that is, between harvesting and land preparation or between transplanting and harvesting periods. Wage labour and other small trading stopped as well when the farmers were busy with rice crop.

Even though wet season rice cultivation was considered as key production of household incomes from early rainy season to dry season, the farmers did not spend the whole period with their rice crop. Most farmers had single or zero visited field after transplanting. This would contribute to low yielding.

A period between harvesting and land preparation for the following crop, rice fields were left fallow except those who cultivated watermelon. Watermelon was seen as an additional income to rice production but according to field observation, farmers very frequently applied pesticides without concerning their health, e.g., a man with only a pair of shorts was spotted spraying pesticides against wind direction.

Considerable input was spent of building fences surrounding watermelon farms to protect free grazing cattle. Guarding 24 hours was also critical for few weeks before harvesting otherwise fruits were simply stolen. However, cultivation of watermelon was a sound extra income, which could improve the growers' living standard somehow.

From the analysis of family activity calendar, it will be possible for the villagers in the command area to grow an additional rice crop, dry season or early wet season crop, if irrigation is available.

Early wet season crop starts in late April is better option since it may require only supplementary irrigation and slightly affect other activities in particular watermelon cultivation. Palm sugar production is able to cease in April, and wood gathering can start after transplanting wet season crop. Since fishing is not the main source of income and is always possible for the villagers depending on water availability, it could be practiced at leisure time or shift the calendar. The calendar of waged labour and small trading can be shifted otherwise they do not involve rice production.

4.7. Family Labour Input Allocations

Labour is critical for rice-based farming systems, in particular rice production which required substantial labour to operate a particular area of rice cropping. From 160 to 240 person-days is needed to cultivate rice crop on a hectare land in rainfed lowland condition (Chea, 2002). If the labour was hired, it may cheap comparing to other developed countries but it is costly for the Cambodian farmers with very low living standard. Labour input would cost as much as USD 150 per hectare if it was calculated at local market wage rate that is more costly than other input costs in rice production (Chea, 2002).

Across the sixteen villages of the three areas, family size ranged from 4 to 7 in average per village and the number of dependants including children and retired person was normally less than 2 representing interviewed households of a village (Table 24).

Except for dependant members, most full family labour took part in rice production with an average 6 persons of each family. Family labours were differently allocated based on different phases of rice cultivation such as land preparation, pulling and transplanting, crop caring, harvesting and post-harvest.

Farmers prepared the lands of rice fields with traditional way: usually one male labourer plows (by single plow) and harrows (by wooden harrower) rice fields using draught power. A single plow was mainly used for plowing rice fields. All family members, young, old, weak and strong, were required to carry out pulling and transplanting. Those families who had more people were able to finish transplanting in shorter periods. Typical no labour was allocated to the rice field for the period between transplanting and harvesting, with only a few households using one person to monitor field possibly fixing the levees or spot weeding but only for field adjacent to village. Harvesting and post-harvest period could be considered the busiest activities and all family members hectically performed to achieve their long time investment of efforts, in-kind and in-cash inputs.

Results of the study also indicate that only 1/3 of family labour contributed to non-rice cropping such as watermelon or home vegetables, more or less 2 labours in average excluding non-cultivating families (Table 24). Similarly, one of family members was commonly responsible for catching fish nearby or far away from home, e.g., a group of men with simple fishing tools and reserved foods for several days was spotted traveling from another village to fish at the lake located adjacent to Sangkruh Village during second phase of the field trips.

Palm sugar production was a daily activity with usually two persons of the family undertaking the task. A male labourer, normally husband or son, together with wife or mother, was the normal partners for sugar production. The former was responsible for climbing palm tree and tapping palm fruit and latter carried the job of bubbling and stirring palm juice.

In general, a single labourer, husband or son, of a family practiced wood gathering traveled with cattle pulled cart to the forest for several days to log trees and transport home.

Like home vegetables, livestock such as chickens and ducks would not require more labour and time to feed or care them. One labour would be enough for collecting feed, feeding and caring a couple of pigs that the farmers normally owned.

Concerning the number of cattle the villagers kept, not more than one labourer was required. It has been observed that a teenager or even younger one could manage to control a pair of animal or more.

Interestingly, most interviewed households made additional income through other exchanges. One to three persons of family members were allocated to carry out such jobs as wage labour, porter, cyclo, factory worker or small trading within villages or towns (Table 24). This indicates that rice production alone was not enough to feed their family whole year round.

Family or owned labour has an important role to play in the rice-based farming systems like the villagers in the three areas. Beside rice production, other farming activities might not be operated without enough permanent or part time family labour. As mentioned, it was possible to hire labour if it was affordable but it would be economically unjustified to invest highly in labour for a considerably poor yielding production.

Furthermore, it might not be appropriate to employ labour for non-rice cropping activities such as fishing, wood logging or livestock. Though discussed in harvesting section, exchanged labour was the most appropriate option to overcome the constraint of labour shortage, the practices were impossible if there was no single family member who could work in exchange. With an average of four full labours per family, the farmers in the area were fairly good in allocating their members to various activities during the year.

4.8. Harvest Allocation

Averaged rice yield in the 2003 was low across the three areas (Table 25). Yield variation was large in the command area ranging from 0.1 to 6.0 t/ha (for IR66 cultivated in the dry season). Rice yield was estimated to be less than 1.0 t/ha for about 40% of the total rice fields. Ten per cent of the rice fields produced grain yield higher than 2.5 t/ha and the remaining (50%) in between 1.0-2.5 t/ha. An averaged grain yield across the interviewed villages was estimated to be 1.5 t/ha.

In the upstream area, there was a large yield difference among the 36 rice fields, ranging from 0.1 to 2.4 t/ha with an average of 1.1 t/ha. Some farmers harvested almost nothing from the upper fields, which were severely affected by late season drought. Almost 60% of the rice fields produced grain yield less than 1.0 t/ha and of that 35% was below 0.5 t/ha. Twenty-five per cent of the rice fields obtained quite good grain yields ranging between 2.0-2.5 t/ha.

Similar to the upstream area, an averaged grain yield in the downstream area was estimated to be 1.0 t/ha with 45% of rice fields produced grain yield higher than 1.0 t/ha.

In the command area, only a single farmer harvested 70 kg of the whole products while the rest got more than 300 kg of total grain. The majority farmers in this area harvested between 1 and 4 tonnes with an average of 1.7 tonnes. On average, farmers in the upstream area harvested almost 2 tonnes of total grain. However, 3 farmers obtained less than 1.0 tonne but at least 350 kg. Higher percentage (39%) of farmers in the downstream area harvested total grain below 1 tonne compared to the other two areas with an average of 1.8 tonnes.

The harvest on a per hectare basis alone would not enough to measure the quantity of family consumption since each household owned more than one plot of rice field, e.g., some farmers operated as much as 6 rice fields and the low yield figure was probably from smaller field. Table 26 estimates the total grain (output) in the command, upstream and downstream areas.

Table 24: Family labour input allocations

Labour & activities	Upstream		Command area											Downstream		
	Sangkruh	Laak	Sre Takao	Beung Lvea	Snao	Khvaek	Chambak Chrum	Prasath	Prey Plu	Banteay Yumareach	*Saang*	*Korng Sao*	Thun Moung	Phnov	Thnoat Chum I	Thmey
No. in household (avg)	6.7	6.2	5.5	5.8	6.7	5.5	6.7	5.3	4.7	4.5	6.0	5.5	4.3	5.3	5.5	5.8
No. of dependants (avg)	1.8	0.5	1.8	1.0	2.0	2.8	0.7	1.2	1.0	2.2	1.6	2.0	1.5	1.5	1.8	2.0
No. in rice (avg)	3.8	5.7	3.7	3.0	4.5	3.2	5.8	4.2	2.8	2.3	3.5	3.7	2.5	3.7	3.0	3.4
No. in non-rice crops (avg)	1.0	2.0	0.8	0.0	3.0	2.3	0.0	0.0	0.0	1.0	2.0	0.0	1.5	0.0	1.6	3.0
No.in fishing	0.0	0.0	1.5	1.0	1.0	1.0	0.0	1.0	0.0	0.0	1.5	0.0	0.0	1.0	0.0	0.0
No. in palm sugar	2.0	2.0	0.0	0.0	2.0	1.0	0.0	2.0	0.0	0.0	2.0	0.0	0.0	0.0	1.0	0.0
No. in wood logging	1.0	1.5	1.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
No. in livestock	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0
No. of off-farm job	2.0	1.8	1.0	1.2	2.0	2.3	1.0	1.5	1.5	1.5	3.3	1.0	1.3	1.3	1.6	3.0

Table 25: Distribution of rice yield in the command, upstream and downstream areas

Grain yield	Command area (208)		Upstream area (36)		Downstream area (56)	
(t/ha)	Number	%	Number	%	Number	%
<0.5	36	17	13	36	14	25
0.5-0.90	47	22	8	22	17	30
1.0-1.49	42	20	4	11	11	20
1.5-1.99	33	16	2	6	7	13
2.0-2.49	27	13	9	25	6	11
2.5-2.99	9	4	0	0	1	2
3.0-3.99	6	3	0	0	0	0
4.0-4.99	5	2	0	0	0	0
> 4.99	3	1	0	0	0	0
Range (t/ha)	0.12-6.00		0.05-2.40		0.07-2.80	
Mean (t/ha)	1.45		1.06		1.04	

Number in parenthesis indicates number of total rice fields in each area. The percentages were calculated based on the number of total rice fields.

Table 26: Distribution of total grain in the command, upstream and downstream areas

Output	Command area (66)		Upstream area (12)		Downstream area (18)	
(tonne)	Number	%	Number	%	Number	%
<0.5	7	11	1	8	3	17
0.5-0.99	14	21	2	17	4	22
1.0-1.99	25	38	6	50	3	17
2.0-2.99	11	17	2	17	5	28
3.0-3.99	9	14	0	0	2	11
4.0-4.99	0	0	0	0	1	6
> 4.99	0	0	1	8	0	0
Range (tonne)	0.07-3.96		0.34-7.92		0.48-4.44	
Mean (tonne)	1.65		1.95		1.81	

Number in parenthesis indicates number of total interviewed farmers in each area. The percentages were calculated based on the number of total interviewed farmers.

Harvested product was used for home consumption, seeds for next year, feeding and for selling with the former being the priority of all interviewees across the three areas after reserving seeds. The rice shortage estimated by the interviewees based on their harvest in the three areas is figured in Table 27. Though the rice output of interviewed farmers in the upstream area was around 2 tonnes of grain, only 4 out of 12 interviewees would not experience food shortage while the rest reported that they will face a rice shortage. The duration of shortage ranged from 1 to 9 months with an average of a 4 month-period. Family food security in the command area looked better than the upstream area with up to 55% of the interviewees reporting the harvest was sufficient for consuming whole year round. The other would experience food insufficiency ranging from 1 to 9 months as well but duration in short supply was 3 to 4 months. Comparing to the above two areas, the situation for the downstream area's interviewees was more severe as 72% of interviewees estimated that they would suffer inadequate food for 1 to 8 months and mostly a 5 month-period. Poor yielding due to late season drought was the undeniable factor causing family food shortage. Large families owning only a small plot of rice fields was also attributed to food in short supply for as long as a nine-month period.

Table 27: Rice distribution for family consumption

Month	Command area (66)		Upstream area (12)		Downstream area (18)	
	Number	%	Number	%	Number	%
0	36	55	4	33	5	28
1	2	3	1	8	1	6
2	3	5	1	8	3	17
3	8	12	2	17	1	6
4	7	11	2	17	1	6
5	2	3	0	0	6	33
6	3	5	1	8	0	0
7	3	5	0	0	0	0
8	1	2	0	0	1	6
9	1	2	1	8	0	0
10	0	0	0	0	0	0
Range (month)	1 to 9		1 to 9		1 to 8	
Mean (month)	4		3		4	

Number in parenthesis indicates number of total interviewed farmers in each area. The percentages were calculated based on the number of total interviewed farmers.

To deal with food shortage, the villagers normally used incomes from other sources such as watermelon, waged labour, wood logging, palm sugar production, fishing or livestock to buy paddy rice or milled rice. In need, rice was bought usually from their neighbours or other households within the village. Milled rice was mostly available at local or Kampong Thmar markets. Borrowing from relatives, close friends or neighbours (at interest free rates) was also practiced for those who were running out of grain for a few months.

If there were other options, the villagers would not have access to rice lenders with high interest rice loan. Helmers (1997) indicated that informal money lenders dominated in rice markets charged at a very high interest rates of 20-30% per month on cash loans, and 100% on loans of rice in kind over one semester period.

Beside human consumption, the harvest was allocated for feed of chicken, duck and pigs. In general, the villagers did not spend too much grain for chickens since they are small eaters and they are able to roam around the households and in the rice fields. Much more feeds were needed for ducks but they were not commonly raised by the villagers. Pigs which are a big eaters, were raised by many villagers because they would be a reliable source of credits when money is needed urgently. Raising 2 to 3 pigs was commonly practiced by the farmers and around 1 kg of paddy were used daily for feed, mixing with other plants such as banana trunk, convolvulus or watermelon leaves. Therefore, the proportion of harvest for feeding pigs was quite high compared to total family consumption.

Rice selling or in exchange for other products has not been a common practice in subsistence farming condition like in the study areas. Only one interviewee of upstream area used to sell their rice for the same purpose like for land preparation and fertilizer purchase. Around 20% of interviewees in the command area sometimes or seldom sold their rice. Rice income was spent on such typical costs as labour cost, chemical fertilizers, health care, kids’ schooling, clothing, marriage, traditional and religious ceremonies or possibly dishes. This is similar to the study reported by Helmers (1997). The process of selling was gone through different options, for example door to door dealers, their neighbours, rice millers or markets. Price of rice seemed not different among these middlemen within the same period. Normally, the price was very cheap at harvesting months and it slightly increased to the highest price between August and September. However, the villagers were not able to store their rice for sale at a maximum price because they were too poor to keep their rice for that long period. Therefore, it was impossible for farmers to take advantage from price fluctuation since the harvested product would be sold at anytime to meet the immediate needs of their family.

5. Summary and Recommendations

5.1. Constraints to rice production

Poor yields of rice in the study areas have a major impact on food shortages and consequently poverty alleviation. Low rice productivity was attributed to natural abiotic factors and socio-economic constraints such as erratic rainfall (drought and flood), poor soil fertility, low yield potential traditional varieties, small farm size, and inadequate labour and farm power or capital. The same constraints described above are also common in other parts of the country especially where the rainfed lowland conditions exist (Lando and Mak, 1994a).

Water constraints

Inadequate rains in early wet season cropping (May-June) delay seedbed establishment. This leads to difficult land preparation, and poor seedling vigour. Inadequate rains in July and August (mini drought) delay transplanting. This leads to poor transplanting recovery and poor vegetative growth (Ouk *et al.*, 2001). In general, the unfavourable effects of insufficient rains are mostly felt in the upper fields where early-duration varieties are grown; less effect is experienced in the lower fields planted to late-duration varieties. Reduced rains from mid to late cropping season (September- November) can adversely affect the yield of crops during its reproductive stage. The most affected are the late-duration varieties, followed by the medium-duration ones. By contrast, excessive rains from September to October coupled with high floodwater levels in the Tonle Sap lake cause flooding in some parts in the rainfed lowlands or flood-prone areas. Flash floods laden with silt can damage leaves and submerge the crop for several days, and can cause significant plant death. Rains cease earlier resulting in late season drought, particularly for the late maturity group and for the rice growing in the fields with small levees.

Erratic and unpredictable rainfall is only the source of water for rainfed lowland rice. With unreliable water source farmers could not plan their cropping activities. Therefore, most of the cropping activities and timing is depended by rains.

Soil constraints

Soil fertility is one of the most serious constraints to rice yield improvement (White *et al.*, 1997a,b). Rice soils in the command area are generally infertile (Pheav *et al.*, 2003), probably as a result of continuous cultivation without adequate replenishment of nutrient losses by plant uptake in addition to the effects of runoff, erosion and leaching. Previous results from elsewhere on the mostly similar soils in the command area were reported to be deficient in N and P, and some may be K, and Mg-deficient according to both the pot and field experiments (Lor *et al.*, 1996; Pheav *et al.*, 1996). Other macro-and micro-nutrients disorders are also evident when a single of these main fertilizers N, P, K, and Mg are applied. The high fields have the highest sand content, and therefore the poorest water- and nutrient-holding capacities. This is similar to the results reported by White *et al*. (1997a,b). They also found that although the low fields are the most fertile soil, some soils are still poor in terms of N and P contents regardless of the field level. In addition, a number of problem soils exhibit acidity, and/or high salt concentrations in some areas (White et al., 1997a; Pheav et al., 2003).

Rice yield responses to application of commercially available fertilizers is considered by some farmers to be uneconomical, probably due to poor quality fertilizers and/or to their limited first-hand experiences (poor timing of fertilizer application, poor matching of the fertilizer types with each soil group). For example, a case study in Takeo Province of Cambodia by Ieng et al. (2002) indicated that in similar rainfed lowland conditions, farmers generally use either single or combined chemical fertilizers such as nitrogen, phosphorus, potassium and sometime sulfur without concerning of nutrient balance and most often at the lower rates than the recommendation for each soil type (White et al., 1997a; Dobermann and White, 1999; Seng et al., 2001; Pheav et al., 2003). Most of the farmers applied manure in the seedbeds and some in the main-fields. However, the manure was simply collected without any concern of nutrient loss.

Biotic constraints

All the interviewees share common crop protection problems. The incidence of weeds is usually a problem when standing water is not maintained in the fields, and this occurs especially in between early to mid-cropping season. The only wet soil occurs at this time also encourages weed growth and competes with the rice crop. Farmers do not make an adequate response to weed problem. They spot weed by hand.

Rats randomly attack the crop at any stage of growth, but are particularly attracted to the crop during booting stage. Crabs can also damage rice plants by cutting particularly for the younger plants in the flooded fields. Grasshoppers damage leaves and make matured grains dropped down. Fortunately, these diverse pests are generally not considered a major problem in the study areas. Farmers reported no serious pest and disease problems in the rainfed lowland and deepwater rice, but termites were slightly considered for the upland rice.

Genetic constraints

The cultivation of one crop of traditional rice varieties in the wet season is the commonest form in rice farming, and this system normally has low an annual productivity. Results from the group discussions suggested that farmers prefer varieties commonly with higher yield and earlier maturity (to escape late season drought) than the local popular varieties. Every farmer cultivates several varieties but the purity and quality of the seeds may be quite low as well.

Farmers normally produce their own seeds and varietal mixing can take place at any time during the period between transplanting and harvest. Poor on-farm seed storage results in low seed viability, and farmers often have to solve the problem by applying high seeding rates.

Socio-economic constraints

The average farm size varies from <0.5 to 1 ha. Each family farm is composed of small fields distributed in at least two ecosystems and at different directions from their households often at distant locations. Rice fields are mainly uneven and separated by small levees. These constraints lead to difficulty in water and crop management.

Inadequate labour force, farm power, and cash are common socio-economic constraints, which beset rice farmers, and these problems were also found elsewhere in Cambodia by Lando and Mak, 1994a. The competition for labour and farm power is exacerbated when the timing of beginning of farm activities such as land preparation and transplanting and as well as at harvest. Labour exchange is not commonly practiced in the command area. Most farmers use their own labour even for the activities that require large labour input such as transplanting and harvesting. Therefore, they require a longer period to complete such activity for a particular field. For example, an average of 40 labourers are required for pulling and transplanting the seedlings in a hectare field size, a family with four labourers will complete these activities for 10 days. In contrast, they would complete these activities within several days if they exchange their labour with the others.

Most farmers are poor in assets and cash, consequently, their limited access to credit facilities hinders the hiring of labour, resulting in longer period of their farm activities such as pulling and transplanting the seedlings and harvesting. The economic position also limits their ability to purchase farm power and chemical fertilizer.

5.2. Potentials for increasing rice farming system in the command area

Very limited potential exists for increasing the area under rice cultivation in rainfed lowlands, because land distribution to each family is limited which prevents the expansion of rice cultivation. Therefore, farmers need new ways to boost food production for year-round consumption and for market purposes on their existing areas. However, there are several points that need to be considered.

- Firstly, the irrigation scheme is being established in the command area. This irrigation will supply for dry season crops as well as supplement to the wet season crops, so the rice farming system will be intensified,
- Secondly, most farmers do not certify with their existing rice varieties. They prefer higher yielding varieties with early maturity and good quality in terms of meet their consumption as well as high market price,
- Several rice varieties released by CARDI have been introduced by the district agronomists, GRET, CEDAC and other organizations. Farmers have a good perception in testing these varieties and some of them have been quickly adopted, and
- The young generation of farmers is well educated and should provide a good pathway for the introduction of new technology.

5.3. Recommendations for increase rice production in the command area

The establishment of irrigation scheme in the command area aims to increase rice production by supply full irrigation in the dry season and supplement irrigation in the wet season. The main goal of the RCSS is to develop applied research programs for rice cropping systems to achieve the target goal of the SCIRIP. The SCIRIP aims to provide supplementary irrigation on 3,000 ha during the wet season and full irrigation on 1,800 ha during the dry season in the command area. The project also expects that rice is only crop produced from 3,000 ha during the wet season and from 1,500 ha during the dry season, and non-rice crops on 300 ha during the dry season, but not for the early wet season and wet season rice crops. However, this cropping system is also discussed in section 5.3.2.

In the command area, a few farmers cultivate upland and deepwater rice. However, since their upland and deepwater rice fields are located outside the irrigated command area, the recommendations for the upland and deepwater rice would not made.

The following recommendations discuss how the results of the present study can be used to improve rice production in the command area. In order to do so, a brief description of the released technologies by the plant breeding and soil and water program of CARDI for rice production in Cambodia is given first.

5.3.1. Rice varieties and fertilizer rates recommended by CARDI for rice production in Cambodia

Since 1989, the plant breeding program has released a total of 35 rice varieties developed from different sources (including local varieties) for diverse rice growing conditions in Cambodia. Detailed characteristics of these varieties are shown in Table 28.

Eight rice varieties have been released for the favourable growing conditions (dry season, irrigated conditions), early wet season which the other rice crops can grow after and for the upper fields of rainfed lowland ecosystem where there is no standing water after rain ceased. Among them, one variety is aromatic (Sen Pidao) and one is moderate resistant to brown plant hopper (IR Kesar).

Thirteen rice varieties have been released for the medium fields of rainfed lowland ecosystem. Out of them, five with insensitive to photoperiod (Santepheap 1-3, Popoul and Sarika) are performed very well under favourable growing conditions, three (Phka Rumchek, Phka Rumchang and Phka Rumduol) are aromatic rice with good grain and cooking quality and the remaining could perform well even under unfavourable growing conditions.

For the lower rainfed lowland fields, the plant breeding program has released eight rice varieties. All released varieties are sensitive to photoperiod and flower mainly after mid of November.

Three deepwater rice varieties that flower around mid November and have good grain quality were also released. Two upland rice varieties are also available.

Table 28: Rice varieties released and their characteristics

No.	Variety name	PS	Duration (day)/DF	Plant height	Brown rice Shape	Brown rice Appear.	Aroma (Scent)	Cooked rice	Max. yield (t/ha)
a) Varieties recommended for dry season/irrigated, early wet season and for the upper fields in rainfed lowland ecosystem									
1	IR 66	Ins	105-115	80-118	S	T	None	Soft	6.5
2	IR 72	Ins	110-120	77-117	S	T	None	V. soft	6.0
3	Kru	Ins	105-116	80-120	S	T	None	V. soft	6.0
4	IR Kesar	Ins	105-120	85-120	S	T	None	V. soft	6.0
5	Chul'sa	Ins	95-110	95-110	S	ST	None	Soft	6.0
6	Baray	Ins	100-115	75-95	S	T	None	Soft	6.0
7	Rumpe	Ins	100-115	70-90	S	T	None	Medium	6.0
8	Rohat	Ins	105-120	80-95	S	T	None	V. soft	6.0
9	Sen Pidoa	Ins	110-120	95-110	S	T	Yes	V. soft	5.5
b) Varieties recommended for the medium fields in rainfed lowland ecosystem									
1	Santepheap 1	Ins	130-140	105-150	S	T	None	Soft	6.0
2	Santepheap 2	Ins	130-143	105-150	S	T	None	Medium	6.0
3	Santepheap 3	Ins	140-145	105-155	Medium	ST	None	Soft	6.5
4	Popoul	Ins	132-140	85-110	S	ST	None	Soft	6.0
5	Sarika	Ins	132-140	85-105	Medium	T	None	Soft	6.0
6	Phkar Rumchang	Sen	Oct 25- Nov 1	105-155	S	T	Yes	V. soft	5.0
7	Phkar Rumchek	Sen	Oct 25- Nov 1	110-160	S	T	Yes	V. soft	5.0
8	Phkar Rumduol	Sen	Oct 20-30	105-170	S	T	Yes	V. soft	5.5
9	Riang Chey	Sen	Nov 5-11	105-165	S	T	None	V. soft	5.5
10	CAR 1	Sen	Nov 2-9	125-175	Medium	T	None	Medium	4.0
11	CAR 2	Sen	Nov 6-12	125-185	Medium	ST	None	Soft	4.0
12	CAR 3	Sen	Oct 30-Nov 7	120-165	Medium	ST	None	Medium	4.5
13	CAR 11	Sen	Nov 5-11	135-175	S	T	None	V. soft	4.5
c) Varieties recommended for the lower fields in rainfed lowland ecosystem									
1	CAR 4	Sen	Nov 8-15	130-170	Medium	T	None	Soft	5.0
2	CAR 5	Sen	Nov 10-17	135-190	Medium	ST	None	Soft	4.5
3	CAR 6	Sen	Nov 10-17	120-177	Medium	ST	None	Soft	5.0
4	CAR 7	Sen	Nov 15-21	145-205	Medium	ST	None	Medium	4.0
5	CAR 8	Sen	Nov 19-26	145-200	Medium	ST	None	Soft	4.5
6	CAR 9	Sen	Nov 10-17	140-180	Medium	ST	None	Medium	4.5
7	CAR 12	Sen	Nov 17-24	130-170	Medium	ST	None	Soft	4.5
8	CAR 13	Sen	Nov 19-26	130-185	Medium	T	None	Soft	4.5
d) Varieties recommended for deepwater ecosystem									
1	Don	Sen	Nov 20-27	195-255	S	T	None	Medium	4.5
2	Khao Tah Petch	Sen	Nov 15-22	200-210	S	T	None	V. soft	4.0
3	Tewada	Sen	Nov12-19	200-205	S	T	None	V. soft	4.0
f) Varieties recommended for upland ecosystem									
1	Sita	Ins	90-100	92-108	Medium	ST	None	V. soft	4.0
2	Rimke	Ins	90-95	105-121	Medium	ST	None	Soft	4.0

PS=Photoperiod sensitivity, Ins=Insensitive, Sen=sensitive, S=slender, Appear.=appearance, T=translucent, ST=semi-tramslucent, V. soft=very soft, Max. yield=maximum rice yield obtained from the multiple location on-farm trials.

Theses released rice varieties could produce also good grain yield under unfavourable conditions. The results obtained from the multi-location on-farm trials conducted by the plant breeding and soil and water science programs of CARDI indicate that the released rice varieties also produce grain yield relatively higher than the local check varieties under both favourable (with fertilizer/good water conditions/good soil/good practices etc.) and unfavourable (no fertilizer/drought/flood/poor soil/poor crop maintenance etc.) and respond to the fertilizer stronger than the local check varieties (Annual research, 1995). Thus, the idea suggests that these released rice varieties are required high input is not correct.

The study by Pheav et al. (2003) identified four rice soil groups in the command area and they are: Prey Khmer, Prateah Lang, Bakan and Kampong Siem groups. Table 29 summarizes the recommendation rates for fertilizer management for these soil groups based on the long-term study conducted by White et al. (1997a).

Table 29: Fertilizer recommendation rates for the four soil groups in the command area

Soil group	Recommendation rate (kg of N:P_2O_5:K_2O:S)		Split fertilizer
	Favourable conditions	Unfavourable conditions	
Prey Khmer	52:15:20:10	28:12:0:0	N and K
Prateah Lang	60:29:30:10	40:23:20:0	N and K
Bakan	70:40:30:15	36:23:20:0	N
Kampong Siem	110:40:0:0	66:23:0:0	N

(Modified from White et al., 1997a)

5.3.2. Recommendations for cropping calendar

Indeed, water plays the most important role for rice crop. To change the cropping systems from the uncontrolled to controlled irrigation, it is a need to develop cropping calendar first. This cropping calendar allows the use of water more effective, but it will affect the daily activities of farmers who used to adapt particularly with the rainfed lowland conditions. Fortunately, farmers in the command area reported that they would grow better crop and more crops as well when they can access or control water. Some of them also reported that they would stop to produce sugar form the palm trees and grow dry season rice. Therefore, the recommended cropping calendars for different cropping systems are discussed below.

Dry season and wet season rice production (Rice-Rice)

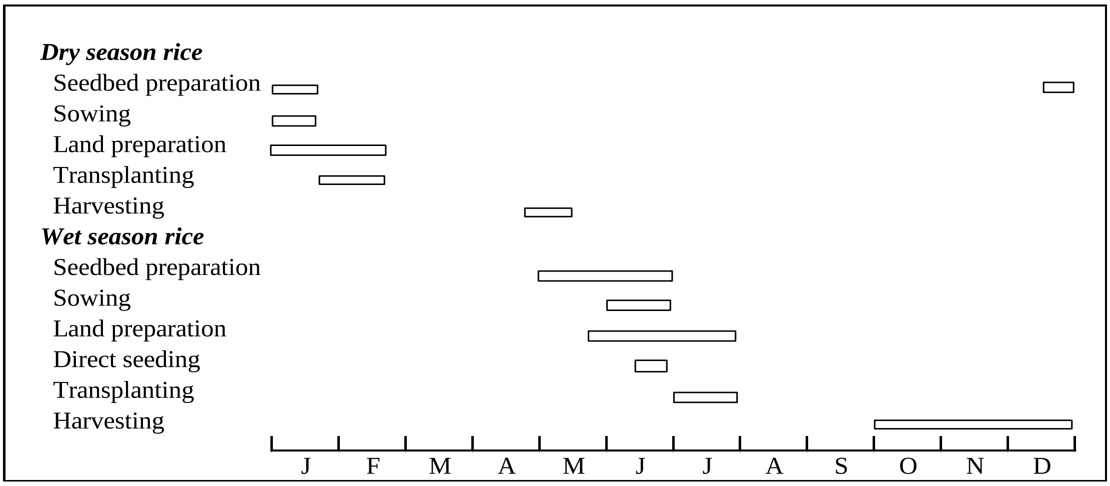
The total area for dry season-wet season rice cropping system expected by the SCIRIP is 1,500 ha. The recommended calendar of activities for this system is given in Figure 3.

For the dry season rice, the seedbed preparation may start from the mid December and ends by the 3rd week of January. Sowing can take place during the first three weeks of January. Direct seeding would not recommended although this method requires less labour input, if the irrigated water is limited and the rice fields are uneven.

Land preparation for the main-fields may start from the beginning of January and lasts at one week before the end of February. Two times of plowing is recommended as the first one is for decomposing the rice stubble and the second for transplanting. In order to provide enough time for the rice stubble to decompose well, the period between the first and second plowing would not shorter than 3 weeks.

Two to three of 20-30 days-old seedlings would be recommended for transplanting, which may start at the third week of January and ends after one-month period. The use of one seedling per hill is high risk for the fields where crabs and rats are presented. Harvesting may commence from the 4^{th} week of April and lasts at the 3^{rd} week of May.

Figure 3: Recommended cropping calendar for the rice-rice cropping system



For the wet season rice, the seedbed preparation would start from the beginning of May and for two months. Two times of plowing would be recommended as for the dry season rice. The period of sowing is one month of June.

The main-field preparation would start at the 4^{th} week of May and lasts at the end of July. Transplanting will take place for one-month period in July with two to four of 30 days-old seedlings per hill. For this area, the practice of transplanting one seedling per hill would not recommended since the crabs and rats are often reported by the farmers as rice pest.

Direct seeding can start from the mid to the end of June.

Harvesting can start as early as October for the early maturity varieties listed in Table 28a and ends before January as the dry season will start soon.

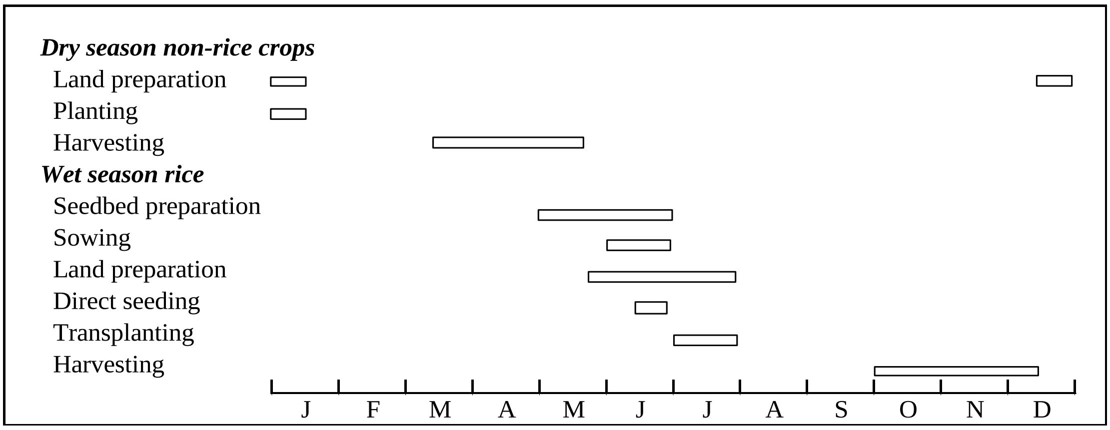
Wet season rice and dry season non-rice crops system (Rice-Non-rice)

The area for the rice-non-rice cropping system is planned by the SCIRIP for 300 ha and for this particularly system, the recommended cropping calendar is shown in Figure 4.

The calendar for the wet season rice is similar to the wet season rice in the former system except the harvesting should finish at the mid of December. The earlier finishing harvest proposed for this system is because the seedlings of non-rice crops could be grown well with the remaining soil moisture, resulting in less water use.

The non-rice crops grown by the farmers in fields after the wet season rice in the command area are watermelon, tomato and cucumber. For these crops, main-fields plowing can be started from the mid December and end at the mid January. Planting would start at the beginning of January and lasts for half month period. Harvesting can start from the mid of March and ends at the 3^{rd} week of May, depending on the crops.

Figure 4: Recommended cropping calendar for the rice-non-rice cropping system



Single wet season rice cropping system

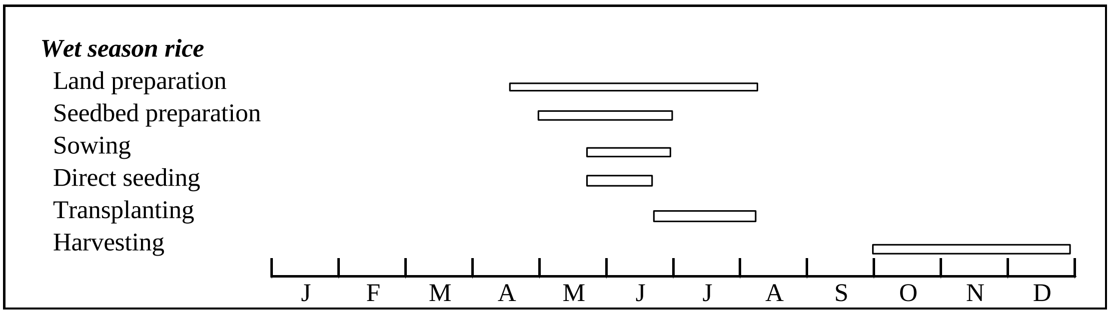
Expected area for this cropping system is 1,200 ha and rice grown depends on rainfall and supplementary irrigation. Figure 5 shows the recommended cropping calendar for this area.

The land preparation for the main-fields can be started as earlier as mid of April and finishes at the 1st week of August with recommendation of two times of plowing. Seedbed preparation takes place for two months from May to June and sowing can be started three weeks later.

Farmers should complete direct seeding practice before the transplanting starts, which is proposed at the 4th week of June. Transplanting should be finished before the 2nd week of August.

Harvest may start at the beginning of October for the early maturity varieties and ends before January for the late maturity varieties.

Figure 5: Recommended cropping calendar for the single rice cropping system



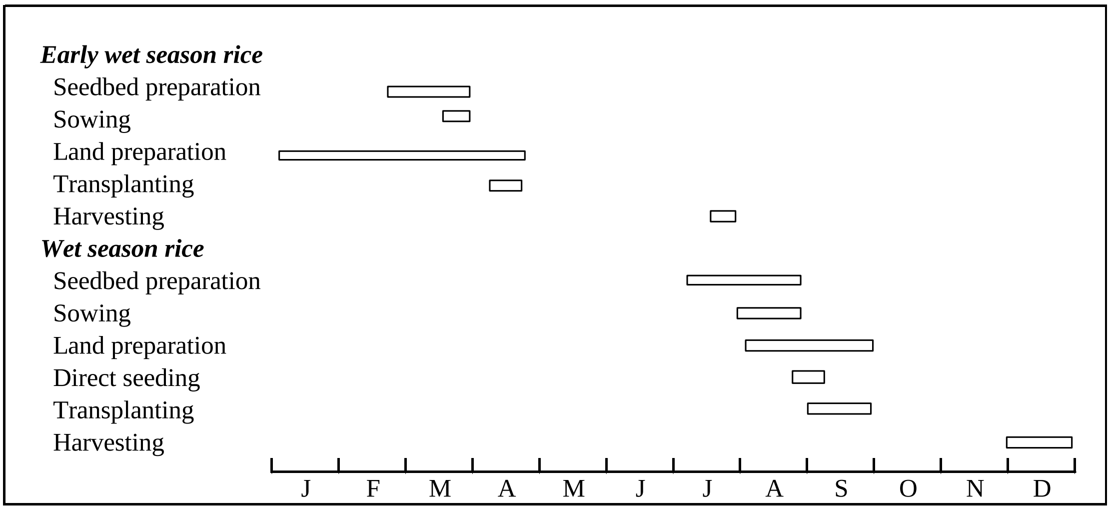
Early wet season and wet season rice cropping system

There is no area for this system to be expected by the SCIRIP. However, the rainfed lowland farmers who could access supplementary irrigation particularly from the tube-well mainly practice this system. The recommended cropping calendar for this cropping system is shown in Figure 6.

For the early wet season rice, seedbed preparation starts from the 4th week of February and ends before April with the sowing period between mid and late of March and transplanting at the 2nd and 3rd week of April. The main-field land preparation can start as soon as possible and ends at the 3rd week of April. Early maturity duration rice varieties are strongly recommended for the early wet season rice and the harvesting period of this maturity group should fall between mid and late of July. Drying early wet season rice grains is very critical as the wet season is already started. Therefore, the period between mid and late of July is the best chance for drying the grains as frequently there were no or little rains between mid of July and Mid of August (a small dry season within the wet season).

The wet season rice can start by preparation for the seedbeds from the 2nd week of July. The seedbeds preparation should end before September with sowing period in whole August. The main-field preparation starts immediately after harvesting the early wet season rice and ends before October. Whole September is the transplanting period and crops should harvest in December. Rice varieties mature before December are not appropriate as they have a shorter growing period that can lead to lower grain yield.

Figure 6: Recommended cropping calendar for the early wet season and wet season rice cropping system



Single rainfed lowland rice could not meet the farmer demands particularly for their yearly consumption (see Section 4.7). To solve this problem a number of family members went out for the off-farm jobs (see Table 24). By adding one more crop resulting in more activities for the farmers. However, if the aided crop will benefit them, they would accept that and stop moving out. During the interviews, several families with a couple members (husband and wife) reported that they would prefer cultivating dry season rice instead of producing sugar from the sugar palm trees.

The recommended schedule provides also enough time for farmers to complete the others necessary activities mainly for wood logging for house construction and fire wood (May, April, August-September).

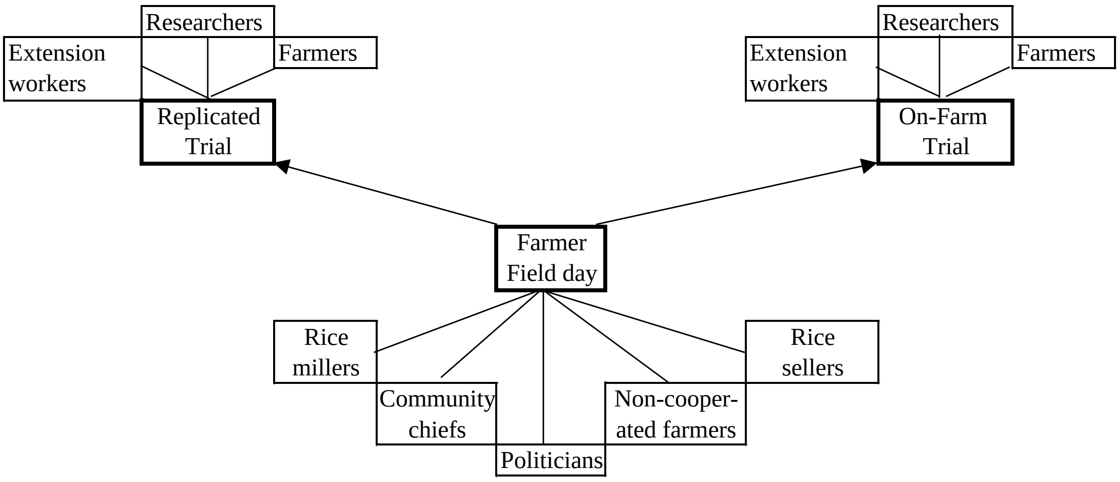
Cattle grazing may be difficulty for the farmers to manage it. However base on the practices by the farmers in elsewhere (e.g. Kbal Po commune, Takeo province), this problem can be solved after the one year practice by feeding the cattle with mainly rice straw properly stored at the households and the grasses harvested from the levees or elsewhere. With the cattle kept around the households for most of the time, farmers would have more manure for making appropriate compost, which is the best fertilizer for the crops.

Farmers practice all cropping systems would encourage to use exchanged labour particularly for the transplanting and harvesting activities in order to finish these jobs for a shorter period.

5.3.3. Recommendations for applied research programs in year 1 for all cropping systems

It is difficult for farmers to adopt any introduced technologies unless they have seen that they would be benefited from them. Therefore, Figure 7 provides a pathway for the applied research program for all cropping systems. This pathway consists of three activities: replicated trial, on-farm trial and farmer field day.

Figure 7: Pathway for applied research in year 1 for all cropping systems



Section 5.1 summarizes the constraints to rice production under the rainfed lowland conditions. There were water, soil, biotic, genetic and socio-economic constraints. However, water problem is solved by the establishment of irrigation scheme.

Replicated trials will allow the farmers to select the best materials based on their own judgment. Two types of replicated trials are recommended and they are for variety and fertilizer selection. Both variety and fertilizer replicated trials will be conducted at two sites in the farmer's fields for each soil type found in the command area. Researchers, extension workers and farmers would work together for this type of trial. The replicated trial aims to provide farmers to select the appropriate varieties or fertilizer types and rates based on their observation.

Variety trial should include a maximum of 15 tested varieties composed from the common local varieties, introduced varieties and re-introduced varieties (if available). These tested varieties will be replicated three to four times with 2x5 m plot size. Planting schedule and practices should follow the cropping calendar for each cropping system showed and described in section 5.3.2.
Fertilizer replicated trial should include different fertilizer treatments as sub-plots and for several rice varieties as main-plots. Three replications with 3x5 m plot size would be recommended. Planting schedule and timing of fertilizer application should follow sections 5.3.2.

On-farm trials also compose of variety and fertilizer trials. Researchers, extension workers and farmers are also required to work together. For the on-farm variety trials, 15-20 interested farmers will be provided three varieties tested in the replicated trial (different set with different combinations of tested varieties in the replicated trial) to test around the replicated trial with their own variety. The plot size for each variety should not smaller than 100 m^2. Farmers manage this trial by their way but with an equal input if any.
A number of interested farmers (15-20) who have rice fields around the fertilizer replicated trials will also selected for the on-farm fertilizer trial. Different sets, each composes of four fertilizer treatments (including nil treatment) tested in the replicated trial, will be tested in this trial by different farmers.

Farmer field day plays an important role for spreading a good technology to community and market as well. Select one replicated trial for both variety and fertilizer and several on-farm trials contrasting in management (good and poor management) in all soil types under all topography levels for farmer field day at different growing stages particularly at maximum tillering, flowering, maturity and harvesting stage. At harvest, it is importance to invite non-cooperated farmer, community chiefs (village, commune and district chiefs), rice millers, rice sellers and if possible politicians as well to discuss about the plant type, maturity duration, yield, quality and market performance of tested varieties and the fertilizer treatment as well.

Researchers and extension workers will analyse and compare among tested varieties and fertilizer treatments using the data obtained from the replicated and on-farm trials and together with the results obtained from the farmer field day to judge several well performed varieties and the appropriate fertilizer treatments for different growing environments (soil type, topography levels, season, etc.).

Rice varieties selected for testing
There are four main criteria for selecting the tested varieties and they are maturity duration (to fit with the recommended cropping calendar for all cropping systems), popularity of local varieties (see Table 5 for proportion and Table 6 for the common varieties), grain quality in order to have high market price and yield potential to provide farmers enough rice grains.

Dry season and early wet season rice. For the dry season and early wet season areas, the early maturity rice varieties listed in Table 28a are strongly recommended. Among them, IR66 is the most popular and well adapted varieties, Sen Pidoa is a new released variety with aromatic and IR Kesar is moderate resistant to brown plant hopper.

Wet season with supplementary irrigation. The replicated and on-farm trials should involve a maximum of 15 varieties composed of popular local varieties, introduced varieties released by CARDI (see Table 28) and the available re-introduced varieties preferred by the farmers. For example, for the upper fields; Krem, Phka Kabas, Neang Rith and Chhma Chang Koam will be used as the popular local varieties; IR66, IR Kesar, Sen Pidao and Rohat will be used as the introduced varieties; and Kaun Trey and Neang Raech (if available) will be used as re-introduced varieties.

Non-rice crops. Most farmers cultivated tomato, watermelon and cucumber after rice. Compare different varieties available in the markets and in the research program (CARDI). Other leafy vegetable, mungbean, soybean and maize should also include in the testing system in order to provide farmers to select these non-rice crops based on their performance.

Proposed fertilizer treatment for testing
The fertilizer treatment for the replicated and on-farm trials can be 1) nil, 2) chemical fertilizer recommendation rate (see Table 29), 3) cow manure, 4) compost, 5) chemical fertilizer + cow manure and 6) chemical fertilizer + compost.

The fertilizer treatment for the replicated and on-farm trials can be 1) nil, 2) chemical fertilizer recommendation rate (see Table 29), 3) cow manure, 4) compost, 5) chemical fertilizer + cow manure and 6) chemical fertilizer + compost.

5.3.4. Other opportunities for improving crop production

a) Farmer field school

In fact, farmers believe their eyes rather than hearing somebody saying. Therefore, a farmer field school plays a very important role in introducing new technologies to the farmers. The best time for the school is the 2nd year. Farmer field school involved all activities starting from land preparation to post-harvesting practices. The land preparation should include the land leveling method as well as the importance of the levees. Timing of each activity, fertilizer management, water management, integrated pest management, harvest and post-harvest operations should be also included as well. Compost is a good fertilizer source for crop and soil productivity. Increasing the organic matter content by the composting results in a better soil structure and thus improved circulation of water, air and nutrients. This again is for the good of soil life and plant growth. Adding compost to sandy soil such as Prey Khmer and Prateah Lang can increase the water retention capacity. This means that water remains longer in the soil and thus remains available to plants for a longer period of drought. Therefore, a farmer field school on making compost is strongly recommended as the introduced irrigation system will force most farmers to keep their cattle in the household. Technology for the preparation of compost is well described in brochure published by the Cambodia-IRRI-Australia Project in 1994. This brochure is available in CARDI's library.

b) Seed production and seed purification

The seed production system should be developed particularly for the dry season rice varieties. It is expected that farmers will use a few varieties only for the dry season rice. These varieties are early maturity with insensitive to photoperiod and no dormancy. Such characteristics shorten the seed viability. The germination rate of these varieties decreases rapidly with the prolonged time. Meaning that farmers could not use the previous dry season harvested seeds for the next dry season. Therefore, the seed production system is needed.

Form two classes of interested farmers. The first class will produce certified seed from the foundation seeds produced by CARDI and the second will produce good seeds from the certified seeds for distributing or selling to the other farmers to grow for production.

In the other areas, where a large number of varieties are used (wet season rice), training farmers to purify their seeds is an effective way. First, the amount of seed that the farmers usually use for each variety will be recorded and then estimated the plot size that will be required to produce such amount of seed. Prepare well the plot for transplanting (if possible in row with one seedling per hill), manage properly with high fertilizer and water management and cut the off-type plants at different growing stages. This plot should be separated by leaving 0.5-1.0 m space form the rest of the field. The field selected for this purification must be close to the household, high soil productivity and easy to manage with water. The best way is to grow plants of a purified variety in the field where the other variety having different flowering time is growing. This is because of protection out crossing.

A project strategy that incorporates these opportunities would be targeted at improving broadly adapted varieties that have the potential to achieve reliable yields and grain quality, respond well to the fertilizer, and have the correct flowering time for the major rice production areas in the command area of the SCIRIP.

Appendix 1: Information obtained from the field observation

No.	Village	UTM, Thailand Datum	Date	Field level	Rice varieties observed	Others	Yield observed
1	Snao	48P 0515796/1383219	8-Dec	Sloping from the main canal to the national road	Krem was harvested, Chralueng is harvesting, Neang Morn in grain filling stage	Uneven field, small levees No serious weed and pest Late season drought Owned labour for harvest One field just grows watermelon	0.5 - 1.5 t/ha
2	Korng Sao	48P 0515219/1384580	8-Dec	Medium field with good soil (Bakan)	Riang Chey in ripening stage Neang Morn in grain filling stage	Uneven field, small levees No serious weed and pest	1.0 - 2.5 t/ha
3	Kvaek	48P 0515986/1384473	8-Dec	Medium field with good soil (Bakan)	Neang Morn in grain filling stage	Uneven field, small levees No serious weed and pest No serious weed and pest	1.0 - 2.0 t/ha
4	Boeung Lvea	48P 0515710/1386170	8-Dec	Medium field with Prateah Lang soil	Riang Chey in ripening stage Neang Morn in grain filling stage	Uneven field, small levees Weeds, Brown spot Late season drought	1.0-1.5 t/ha
5	La-ak	48P 0516750/1387086	8-Dec	Upper and medium fields poor soil (Prey Khmer)	Krem is harvesting, Sambok Angkrorng in ripening stage	Uneven field, small levees Weeds, Brown spot Impurity, Late season drought Owned labour for harvest	0.5-1.5 t/ha
6	Tbeng	48P 0515568/1389557	8-Dec	Medium to lower fields (Prateah Lang)	Sambok Angkrorng is harvesting CAR3 in ripening, Neang Chhma and Leak Sleuk in grain filling	Uneven field, small levees Weeds, Brown spot Owned labour for harvest	1.0 - 2.0 t/ha
7	Sre ta Kao	48P 0514566/1389485	8-Dec	Upper field with poor soil (Prey Khmer)	CAR3 in ripening, direct seeding	Uneven field, small levees Weeds, Brown spot	0.5-1.0 t/ha
8	Chambak Chrum	48P 0506537/1388736	9-Dec	Upper field with poor soil (Prey Khmer)	Krem was harvested Direct seeding	Uneven field, small levees Weeds, Late season drought	0.5-1.0 t/ha
9	Phnov	48P 0503468/1383854	9-Dec	Lower fields and Deepwater, good soil	Angka sral is harvesting, Kranhol in grain filling, Boeung Kak in milking stage, direct seeding	Uneven with no levees fields Late season drought Impurity Owned labour for harvest	0.5-1.0 t/ha
10	Thnaot Chum 1	48P 0505921/1384090	9-Dec	Lower fields Prateah Lang soil	Chhmar Changkoam is harvesting Neang Ty, CAR6 in milking stage	Uneven field, small levees Weeds, Brown spot Late season drought	1.0-1.5 t/ha
11	B. Yumreach	48P 0509668/1384281	9-Dec	Sloping from the national road to the west	Krem was harvested Phka Khney and Phka mlis is harvesting, CAR6 and Leak Sleuk in milking stage	Uneven field, small levees Several fields just grow tomato Late season drought Owned labour for harvest	0.5-1.5 t/ha
13	Prasat	48P 0507799/1386439	9-Dec	Sloping from the national road to the west	Krem was harvested, Kong Khsach are harvesting, Kranhol in milking stage	Uneven field, small levees Late season drought Impurity, Owned labour	0.5-1.5 t/ha
12	Prey Phlu	48P 0512749/1385145	9-Dec	Sloping from the east to the national road (Prateah Lang-Bakan)	Phka Khney and Somaly was harvested, Neang Morn in grain filling, Laek Sleuk in milking stage	Uneven field, small levees Impurity Late season drought	1.0-2.0 t/ha
13	Sa-ang	48P 0510520/1382916	9-Dec	Sloping from the south to the north (Prateah Lang)	CAR3 in the upper fields and Phka Khney are harvesting	Uneven field, small levees Owned labour for harvest Brown spot	0.5-1.5 t/ha

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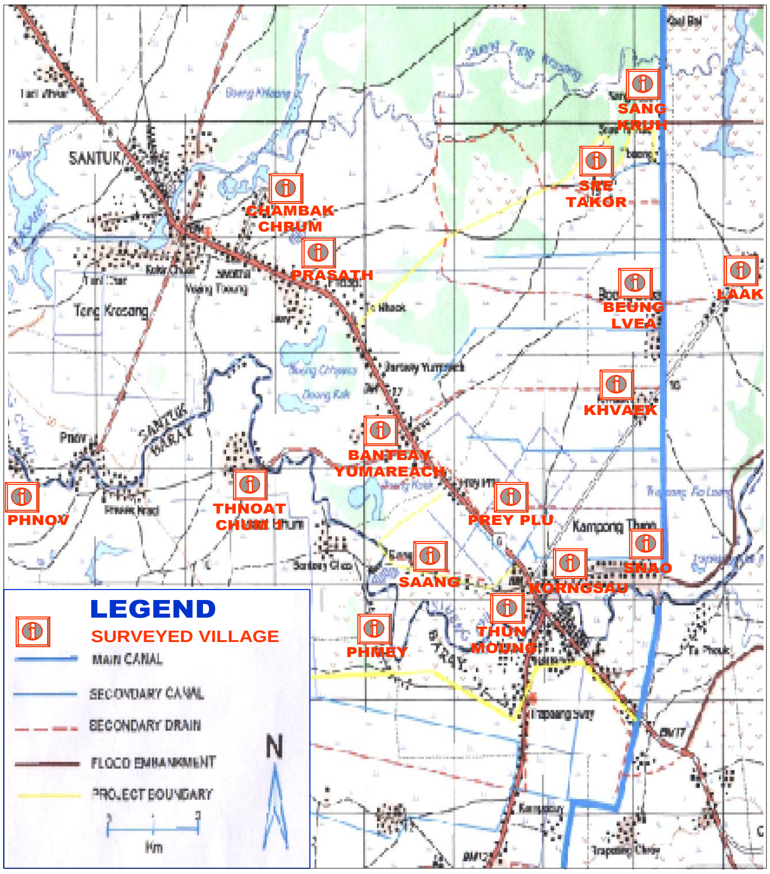
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PREY PLU
SAANG
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