Doctoral Thesis

Effects of the System of Rice Intensification (SRI) on Farmers' Livelihood in Cambodia

(カンボジアにおける SRI 稲作の農家生計に与える影響)

CHES SOPHY

(チェッ ソピー)

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ABSTRACT

Unlike the development revolution in the last few decades; the trends of current development paradigm, especially in the developing countries, have been shifted to focus on the environmental conservation and sustainability. For example, in the agricultural field, the development of eco-friendly farming techniques is being focused in a bid to reduce the bad impacts on the environment and human well-beings. Toward this same goal, the System of Rice Intensification (SRI) has been introduced and practiced in most countries in Southeast Asia in a belief that it increases the paddy productions with less input. Although some claim SRI practice increases yields and saves water, others are still arguing in the opposite and demanding more clarifications on its merits. Besides controversies on the yields between SRI and conventional methods among practitioners, scientists, and researchers, there are also some debates on the labor requirement.

Cambodia is also known as an agrarian country, which heavily depends on agricultural sector as the core of economic growth. Rice is one of the main agricultural products for trade and staple food for the Cambodian. It is reported that since 1995 Cambodia has produced rice surplus and been able to export paddy to neighboring countries; while rice market in Cambodia is still immature and inaccessible. With rice surplus, it does not mean that all rice producing farmers can make themselves self-sufficiency. One of the main reasons that causes the food shortages is the low productivity. Therefore, SRI has also been introduced to Cambodia and included in National Strategic Development Plan to raise the productivity in the rice sector and also in many agricultural projects. On the other hand, irrigation expansion is also seen as the Government priorities in poverty alleviation and economic growth since principally irrigated agriculture is of importance to address poverty by achieving food security and promoting income generation in rural areas. Moreover, labor and irrigation play important roles in increasing of yield and in response to the fact that irrigation systems in Cambodia do not function well and rainfall patterns are not reliable. Hence, the main objectives of this research are: (1) to study the detailed labor requirement and the irrigation application; (2) to explain the amount of sale of SRI farmers to rice market which is believed to be inaccessible; and (3) to analyze the livelihood improvement of farmers at village based.

For the methodology in this research, various data collection methods had been employed such as field observation, household survey, follow-up activity, daily activity record, tracking location device, and document review. Primary data collection was conducted in irrigated upstream (g), irrigated downstream (h) and rain-fed (c) villages in Kampong Speu province; rain-fed (a) and (b) villages in Kampot province; rain-fed (d) village in Takeo province; and rain-fed (e) and (f) villages in Prey Veng province.

The research found out that in the study areas the average family members in each household is 4.48; however, the full availability of members who can help during rice growing is only 2.20. This is because the family members, especially the young ones, can help the farming only at weekends or during free times from study or work. Regarding the labor distribution, farmers hire people during land preparation, nursery preparation, transplanting and harvesting times. For the irrigation, two types of irrigation have been found: plot-to-plot irrigation and by-pumping irrigation. So far, irrigation fee has been priced and collected under the operation of Farmer

Water User Community (FWUC) which exists in irrigated upstream (g). However, the fee collection has not been working well. In rain-fed areas, there is no FWUC to collect the irrigation fee. Farmers still depend on rain for their farming. In case of water shortage due to the drought or insufficient rain, farmers in both irrigated and rain-fed areas need to find other sources for irrigation such as stream, river, or ponds nearby. However, with longer drought, farmers will miss or delay their farming; especially in rain-fed areas.

Moreover, by practicing SRI, most of farmers have increased their products up to 200% while the lowest increased ratio ranges from 0% to 11%. Therefore, it was concluded that farmer zeal and careful attention play important factors on improving SRI production since the availability of family members and distance from plot to home have no significant correlation with the increase of the SRI degree adoption. Moreover, they study also found that education level and sex of family head have no significant influence on SRI adoption. In addition to self-sufficiency for their consumption, farmers are able to sell their surplus to the markets from 17% up to 83% of their total production. Regarding the market situation, farmers normally agree on the price offered by the middle men even it is cheaper than the price set at the markets because farmers do not need to spend on the transportation and labor fee. Another interesting finding on this market issue is the benefit of collective sale. Farmers can get the higher price with collective sale than the individual sale. Based on the expenditures and incomes analyses, hired labor cost became the highest one followed by chemical fertilizer and irrigation; then the concept of “Sharing-hand” can help farmers save their expense on labor cost. “Sharing-hand” is an opportunity cost for poor farmers who cannot afford the hired labor when labors are needed for their farming and at the same time when their family members are not available. Since, most of farmers could share their productions to markets; they were defined as Net Buyers, only two farmers who practice conventional method are defined as the Net Buyers because they failed to produce enough for their self-consumption.

Based on intensive follow-up with six main farmers among the selected farmers on their farming records for two years, the results showed that there is no much difference in labor requirement between SRI and conventional practices. Although SRI requires a little bit more labors in water management, these labors can be reduced with a provided better irrigation system and proper water distribution. Moreover, owing to the two case studies in details on the income and expenditure of the two farmers selected from the above six main farmers, the results prove that SRI really can improve farmers’ incomes and livelihood. According to the increased production of SRI farmers and the number of SRI farmers in each village, it is found that paddy productions in villages or communities increase with the increasing number of SRI farmers, and this in turn can lead to the increase in the national country productions. The result in this study shows that SRI could lead to the increase in country production about 24.28% in 2009.

Based on the discussion of SRI practices from the results of this research, SRI can be defined as one of the sustainable agricultural systems because it can fulfill the four elements of sustainability concept and two components of sustainable agricultural systems as explained in details in the discussion chapter.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACI	: Agri-food Consulting International
ADB	: Asian Development Bank
AWD	: Alternative Wet and Dry
AWM	: Agricultural Water Management
CDRI	: Cambodia Development Resource Institute
CEDAC	: Centre d'Etude et de Développement Agricole Cambodgien / Cambodian Center for Study and Development in Agriculture
CIIFAD	: Cornell International Institute for Food, Agriculture and Development
CMA	: Cambodia Microfinance Association
CNCDM	: Cambodia National Committee for Disaster Management
CNMC	: Cambodia National Mekong Committee
CoM	: Council of Ministers
DAALI	: Department of Agronomy and Agricultural Land Improvement
DANIDA	: Danish International Development Agency
DoLA	: Department of Local Administration
ERV	: Early Ripening Varieties
FAO	: Food and Agriculture Organization of the United States
FWUCs	: Farmers Water Users Communities
FiA	: Fisheries Administration
GDA	: General Directorate of Agriculture
GDP	: Gross Domestic Product
GPCC	: General Population Census of Cambodia
GTZ/GIZ	: German Organization for Technical Cooperation (GTZ) is now the GIZ (Gesellschaf für Internationale Zusammenarbeit)
HYV	: High Yield Varieties
IFAD	: International Fund for Agriculture Development
IRRI	: International Rice Research Institute
IWMI	: International Water Management Institute
LRV	: Late Ripening Varieties
MAFF	: Ministry of Agriculture, Forestry and Fisheries
MOU	: Memorandum of Understanding
MOWRAM	: Ministry of Water Resources and Meteorology
NIS	: National Institute of Statistics
NSF	: Non-SRI Farmer
NSDP	: National Strategic Development Plan
OA	: Oxfam America
PADEK	: Partnership for Development in Kampuchea
RGC	: Royal Government of Cambodia
SAW	: Strategy for Agriculture and Water
SF	: SRI Farmer
SMEs	: Small and Medium Enterprises
SRI	: System of Rice Intensification
SRI-NAB	: SRI-National Advisory Board

UNICEF	: United Nations Children's Emergency Fund
USAID	: United States Agency for International Development
USDA	: United States Department of Agriculture

CHAPTER 1 INTRODUCTION

1.1 Significance and Problem Statements

Unlike the development revolution in the last few decades; the trends of current development paradigm, especially in the developing countries, have been shifted to focus on the environmental conservation and sustainability. For example, in the field of agriculture, the development of eco-friendly farming techniques is being focused in a bid to reduce the bad impacts on the environment and human well-being. While, after the wheat, rice is the world's most consumed food grain. The global consumption reached 444 million metric tons in 2011, (USDA, 2013). Again, according to USDA (2013), Southeast Asia is the world's largest source of rice exports. Therefore, the development of new rice farming techniques is being underpinned by the governments, researchers and NGOs. In Asia, more than 80% of the freshwater resources are consumed for irrigation, while 90% of the total irrigation water is used for rice production (Lee et al., 2005). Responding to these concerns, the System of Rice Intensification (SRI), firstly found by Father Henri de Laulanié in Madagascar during the 1980s and 1990s (Glover, 2011) has been introduced and practiced in most countries in Southeast Asia. SRI was defined by Uphoff (2008) as an extraordinary innovation that can increase the productivity by changing the ways of plant, soil, water and nutrient management in the paddy rice production.

Although, some claim SRI practice increases yields and save water, other are still arguing in the opposite and demanding more clarifications on its merits. Proponents have proved that SRI can increase yields with lower cost of production. This leads to the great adoption of SRI methods. Today almost 50 countries including major rice producing nations such as India, China, Vietnam and the Philippines have adopted SRI methods (Glover, 2011; Senthilkumar et al., 2008; Uphoff, 2012). In the Philippines, it was said that in 2003 SRI methods yielded around 7.33 t/ha which was more than double to the conventional methods yielding only 3.66t/ha (Satyanarayan et al., 2007). Moreover, in Tamil Nadu of India, SRI methods are perceived as a potential solution to deal with the shortages of water and rural labor expected to magnify in the coming years (Glover, 2011). However, opponents have argued that merits of SRI are still vague and need more clarifications. According to the study done in 2009 in Timor Leste, it showed that SRI plots yielded only 2.94t/ha while conventional plots did 3.24t/ha (Noltze et al., 2013).

Besides controversies on the yields between SRI and conventional methods, there are also some debates on the labor requirement. Experiments done at Bangladesh Rice Research Institute (BRRI) Regional Station Farm in 2003 and 2004 demonstrated SRI needed about 18% labor more than the farmers' practices (Latif et al., 2009). However, other studies said higher demand of labor inputs occurred only during the early stage of adoption; this demand starts to decrease with growing SRI experience (Barrett et al., 2004; Uphoff, 2012). Doubtfully, even from the original place of SRI, adoption of SRI in Madagascar is slow and there is high dis-adoption (40%) due to the requirement of additional knowledge and labor input (Moser & Barrett, 2003).

Being Located in the Southeast Asia, Cambodia is also known as an agrarian country, which heavily depends on agricultural sector as the core of economic growth. Then it is reported that since 1995 Cambodia could produce rice surplus (Hang Chuon & Suzuki, 2005) and has been able to export paddy to other countries such as Thailand, and Vietnam. However, most of

exporting activities are conducted in informal ways. Those exported rice is paddy, which is not yet processed. Additionally, Hang Chuon and Suzuki (2005) also argued that agricultural market system in Cambodia is still immature. This caused the farmers who could produce more were not able to contribute to the market due to the limited access to market information. These kinds of problems still exist till now in agricultural market system of Cambodia. The recent reports from CDRI (2014) wrote that the middle men or brokers determine the price and demand for products since farmers do not have adequate access to market information. Moreover, farmers who are in this kind of informal market system are vulnerable to price fluctuations and changes in demands; then at the end, the ones who will suffer from this instability are the poor small land holding farmers (CDRI & ANZ, 2013). Although Cambodia has produced rice surplus, it does not mean that all rice producing farmers could make themselves self-sufficient. IFAD in Cambodia (n.d.) said that 1.6 million rural households face seasonal food shortages every year. One of the main reasons that cause the food shortages is the low productivity. It is believed that traditional/conventional rice growing practice causes the low yield. In order to meet the rice quality standard for international markets, organic rice is the most preferable one. According to Heid Elisabeth (2006), even in rice-producing countries, North America, Europe and in Japan, the need for healthy food is increasing. Then, higher quality of rice is the most important qualification. Fortunately, most farmers are getting familiar with a new method that can improve their rice yields with organic fertilizer application. It is called the System of Rice Intensification (SRI). This technique has been proved by agricultural experts that it can increase the yield from 50%-100% (Uphoff, 2008). In 2009 there were about 110,530 Cambodian farmers practicing SRI on 59, 785 hectares in 4,534 villages. The average SRI yield was about 3.48t/ha (Department of Rice, MAFF)*.

Because of these great impacts, SRI has been viewed seriously in the Cambodian agricultural context as it leads to rural livelihood improvement and national economy development (Chhay, 2010). Therefore, SRI is expected to help farmers increase their rice production with ecological sounds. It can also assist farmers to adapt with climate change such as drought and flood. In this sense, SRI has been reflected as another way to mitigate climate change. And to make these expectations realized and visualized, the increases of number of SRI farmers are needed. However, high or low adoption and good or bad impacts of new innovations or knowledge are not due to a problem of those things alone but it somehow relates to the adopter characteristics. Noltze et al. (2012) said that SRI adoption patterns and impacts can be influenced by not only farm and farmer characteristics but also plot features. Therefore, the merits of SRI are still contradictory as discussed earlier. Labor requirement in practicing SRI also has remained unclear in Cambodia; based on the study of 15 SRI farmers in Kampong Sepu province, 66% of them said that practicing SRI can reduction of labors (CHES et al., 2012). While, this labor requirement was also found as one of the factors that deter farmers from adopting SRI practices in Cambodia (CDRI, 2016). In order to clarify this issue, the detailed study of labor requirement from SRI practices are needed; however, this kind of study has not yet been done.

**: Retrieved from http://sri.ciifad.cornell.edu/countries/cambodia/ on November 25, 2014*

1.2 Rationale of the Study

Agriculture plays a significant role in Cambodia's economic development since 80.5 percent of total population lives in rural areas based on the preliminary results of 2008 General Population Census of Cambodia (GPCC) published in Statistical Yearbook 2008, (NIS, 2008). Rice is one of the main agricultural products for trade and staple food for the Cambodians. Therefore, the agricultural development is a main concern for RGC. As mentioned in National Strategic Development Plan (NSDP) 2006-2010, RGC has taken into account to address agriculture as a priority sector among the fifteen priority sectors to reduce the poverty (MoP, 2008). Moreover, now Cambodia is on the well progressing path of exporting the rice to the international markets. According to the news posted on Tuesday, 12th August 2014 on the local media website (www.postkhmer.com), Cambodia agreed on the Memorandum of Understanding (MOU) with China on the export of 100 thousand tons of rice to China. Besides China, Cambodia is also exporting to other countries. These exports are showing the positive results toward the policy on one million milled rice exports set by the Government and it is expected to achieve by 2015. Moreover, this also clearly shows that increasing rice production is very important to the Cambodian rice exports as well as to the growth of economy. Regarding the acceleration of rice export policy, many involved activities are being conducted; and one of them is a project on the System of Rice Intensification (SRI) in the lower Mekong River Basin (LMB) countries. This project has been conducted since January 2013 and its main objective is to contribute towards the 2015 goal of exporting one million tons of rice and to alleviate poverty and hunger (according to Khmer Times issued on May 22, 2014 with link http://www.khmertimeskh.com/news/1643/sri-project-to-help-farmers-with-climate-change/, retrieved on February 2, 2016). In Addition, the government of Cambodia has prioritized SRI as potential way to increase the rice production as well as to improve the farmers' livelihood. As results, SRI was included in the NSDP for 2006-2010 to raise the productivity in the rice sector; and it was included again in the new revision of NSDP for 2009-2013 (based on the text retrieved on February 04, 2016 from http://sri.cals.cornell.edu/countries/cambodia/index.html). This shows that the promotion and dissemination on SRI are very important to the agricultural development in Cambodia. Finally yet importantly, irrigation expansion is also seen as one of the Government priorities in poverty alleviation and economic growth since principally irrigated agriculture is of importance to address poverty by achieving food security and promoting income generation in rural areas (Investment in land and water in Cambodia by Chann Sinath retrieved on November 27, 2014 via http://www.fao.org/docrep/005/ac623e/ac623e0c.htm,).

Therefore, this research is of great benefits to address the current agricultural practices of SRI with water and to explain the current situation of rice markets happening at the farmers' places. Furthermore, this research also tries to analyze the merits of SRI towards to farmers' livelihood. Eventually, this study tries to expose the progress of livelihood development through the SRI practices and through this it is expected to share with the government the on-going situation in very local areas. Consequently, it is hoped that the government and national or international development partners can take effective actions to support and promote the agricultural technology adoption that can increase the rice production and ensure the sustainability of rice exports.

1.3 Research Objectives and Questions

In order to look deeper into the SRI merits, affecting factors to SRI degree adoption and contribution to rice markets are crucial to be studied. Labor becomes higher input cost for the case of poor households. Therefore, the main objectives of this study are developed and elaborated here based on the aforementioned evidence:

- Study the detailed labor requirement and the irrigation application. Labor and irrigation play important roles in increasing paddy production and in response to the fact that irrigation systems in Cambodia do not function well and rainfall patterns are not reliable;
- Explain the current situation of rice market which is believed to be inaccessible and immature and the amount of paddies that SRI farmers can sell; and
- Analyze the livelihood improvement of farmers at village based. This is the main objective of this research since farmers' livelihood is a country economic mirror.

In order to respond to the above-mentioned objectives, three main research questions with sub research questions have been developed and used for this research.

a. How are labors and irrigation used during the rice growing seasons?
   a1. What are the sources and costs of the labor supply? How to deal with the labor shortage? And what is/are the reason(s) of the labor shortage?
   a2. What are the irrigation methods? What is the cost of each method? How to deal with the water shortage? And what is/are the reason(s) of the water shortage?

b. How much can SRI farmers sell their products to the markets?
   b1. How much can SRI farmers produce? Is that production enough for self-consumption? Are farmers able to sell production to markets in case of having surplus?
   b2. What do farmers think of the current markets and price offered by the buyers?

c. How does SRI affect the livelihood of adopters?
   c1. What are the expenditures and incomes on growing rice?
   c2. What is/are difference(s) of the livelihood condition of SRI farmers before and after adopting SRI?

1.4 Research Hypotheses

Research hypotheses shown below are the assumption of this research. Therefore, these hypotheses will be tested with the results of this study.

- There is still a limitation in applying irrigation while family members cannot help much; so demand of hired labor is high.
- SRI farmers are able to sell their products to the markets although markets are not fully accessible.
- SRI can improve the livelihood of farmers through increasing the productions.

1.5 Scope of the Study

In order to understand the whole process of rice production by practicing SRI, this study is expected to explain only the water application at the local levels, labor force changes in the villages and the comparison on rice consumption before and after farmers have started practicing SRI and go further to look at their possible amount of paddy sale to rice markets. Therefore, this study aims to cover only water application at the community level and domestic markets where farmers are able to deal with middlemen or rice millers in the formal ways which is agricultural market system is visible.

1.6 Approach of the Study

Concerning on the detailed labor requirement of SRI farmers, six main selected farmers were asked to record their daily farming activities for two continuous years, as requested by the author. Those data were critically analyzed with the results from the household survey and field observation. Additionally, GPS device was used to get the famers' plot locations. This can give the clear images of plots' situation and irrigation systems and its application. Moreover, the simple method of agricultural household model was employed to know the conditions of rice consumption and rice markets. The detailed approach of this research will be summarized in the analytical framework in Chapter 3: Research Methodology.

1.7 Dissertation Outline

This dissertation had been designed into seven chapters as follows. Chapter 1 begins with coherent introduction from significance and problem statements, rational of the research, research objectives and questions to the approach of the research. Chapter 2 talks briefly about agriculture and irrigation systems in Cambodia. Chapter 3, literature review, provides background information on agricultural practices from board concepts to specific ones related to this research, related information or previous research on SRI practices and promotion and agricultural policies in Cambodia. Chapter 4 discusses the research methodology employed in this research with the detail of the analytical framework. Chapter 5 focuses on research results and findings from household surveys, interviews with village chiefs, taken GPS points, 2-year farming records from main farmers, and field observation. Chapter 6 starts with discussion of research results; mainly to answer the research questions. Finally, Chapter 7 presents conclusions a long with the research implications.

CHAPTER 2 AGRICULTURE AND IRRIGATION IN CAMBODIA

Since Cambodia is considered as an agrarian country, understanding deeply its history of the agricultural practice and irrigation systems is crucial. The discussion as well as the explanation on the agriculture, agro-economy, irrigation, food supply and demand, labor consumption, input and output analyses here would make the whole discussion in this research easily caught up. This chapter intends to give the information on the geography of Cambodia following by climate and topography conditions and freshwater resources. It also covers the agricultural practices, rice farming systems, agricultural main indices, and irrigation systems attached with the constraints to these both areas.

2.1 Geography

The Kingdom of Cambodia hereinafter in short called Cambodia is situated in the Southeast Asia in the Southern part of Indochina. It shares the borders with Vietnam on the East and the Southeast, Thailand on the West and the North, Laos on the North, and the Gulf of Thailand. It covers the total area of 181,035 square kilometers sharing by the land of 176,515 square kilometers and by 4,520 square kilometers of the water (Retrieved on April 17, 2013 from https://www.cia.gov/library/publications/the-world-factbook/geos/cb.html). With this total area, Cambodia is occupied by the total population of 14,952,665 people (the estimated figure in July 2012 by CIA: Central Intelligence Agency). Because recently the government has created another new province called Tbong Khmu (in the past it was one of the districts in Kampong Cham province); therefore, now Cambodia was split into twenty-four provinces with their own cities and one capital city called Phnom Penh.

The main central features of Cambodia landscape are large, almost centrally located, Tonle Sap or called as the Great Lake, Bassac River and Mekong River System crossing the country from the North to the South (MoE, 2009).

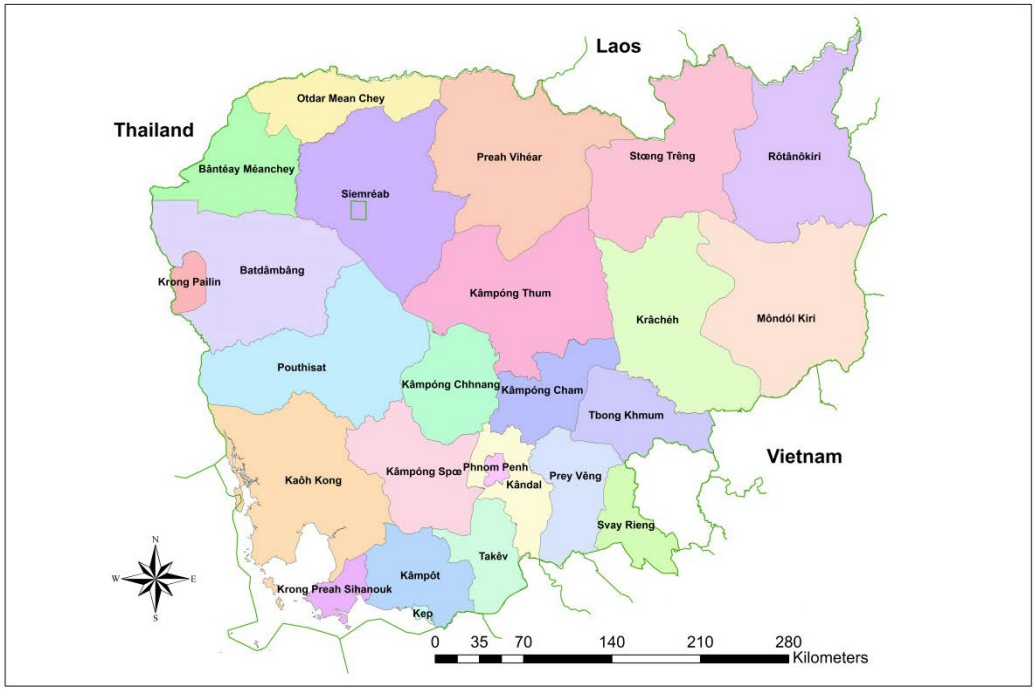

Figure 1: Administrative Map of Cambodia

2.2 Climate and Topography

Like other countries in the Southeast Asia, climate in Cambodia is managed by monsoon; resulting in most of Southeast Asia countries known as tropical wet and dry areas. Monsoon generates two distinctly different seasons. The first one is called rainy season starting in mid-May and ending in mid-September. The other one is dry season from early October to early May. The hottest month is April and the coldest period starts from early December to the end of January.

The rainfall patterns in Cambodia change based on the elevation. Much rainfall is rich in the mountain areas along the coastal areas from 2,500 mm to more than 5,000 mm of precipitation. The annual rainfall in the central lowland regions is 1,400 mm and can reach to 5,000 mm in the central coastal zones or in the highland areas (Save Cambodia's Wildlife, 2006).

Based on climate condition and geographical features, topography in Cambodia can be divided into two different parts (MoE, 2009). Firstly, it is called the central low lying or the central plains and the flat coastal areas consisting mainly of plains around Tonle Sap Lake and Mekong River. The regions are located with the elevation of less than 100 meters or around 20-30 meters above the sea level (Save Cambodia's Wildlife, 2006). Mekong River is well-known as the Cambodia's longest river with the length of 450 kilo meters; its tributaries mainly provide the water supply for the country. Secondly, it is named as the mountainous ranges and high plateau surrounding the low lying land areas comprising the Cardamom and Elephant Mountains of the Southwest and Western regions, and the Dangrek Mountain to the North adjoining the Korat plateau of Thailand (MoE, 2009).

2.3 Freshwater Resources

Even though highly depending on the water resources for the economic pillars of agriculture and fishery for the majority of the population, Cambodia, an agrarian country, has no any concern because of its favorable richness in these resources (Nang et al., 2011). The main sources of water in Cambodia are recognized as main rivers and water bodies. The main rivers flowing across the country are Mekong, Tonle Sap, and Bassac Rivers (MoE, 2009).

About 86% of the country land areas spread down Mekong catchment areas. The annual average inflow from upstream countries is estimated at 410 billion cubic meters and internally generated flow 90 cubic meters per year (MoE, 2009). However, the overall estimated water resources are at 500 cubic kilometers. The total use of water is about 0.75 cubic kilometers per year including 94% for agricultural purposes. Besides the surface water, Cambodia also holds the extensive and abundant amount of groundwater resources. It is believed to be 17.6 billion cubic meters. The groundwater is being used for community and household water supplies as well as for irrigation (MoE, 2009).

2.4 Agricultural Sector and Its Share to GDP

Due to the high percentage of population living in the rural areas around 80% and 71% of them solely depending on agriculture for their livelihood (USDA, 2010), agriculture in Cambodia has become the most important role in its economic development since it is considered as one of the

largest sectors contributing to the GDP growth. In 2012, agriculture, the third largest one, shared 27% of total GDP; while the service sector, the first largest, contributed up to 41% and the second one, industry, covered up 32% (according to accessible article titled STURTURAL POLICY COUNTRY NOTES: CAMBODIA, retrieved on December 10, 2014 from www.oecd.org/site/seao/Cambodia.pdf). Based on the same source, it reported that agriculture absorbed labor forces about 4.75 million workers out of 8 million workers in 2011.

Owing the favorable conditions of land and water resources, Cambodia has now put great efforts in diversifying and improving its agricultural sector. Therefore, the following parts will explain and show some important indices on other sub-agricultural sectors such as fisheries, livestock, and major crops. Among the major crops, rice is the leading crop in Cambodian agriculture and the main food for the Cambodians' daily lives. The rice-based farming system has existed in the country for more than 2,000 years (according Nesbitt, 1997 cited in Yu & Diao, 2011).

2.4.1 Fisheries and Aquaculture

Fisheries are one of main natural resources in Cambodia, contributing greatly to the people livelihood as well as to the country's GDP. Great Lake called Tonle Sap and Mekong River provide the abundant amount of freshwater fish. Therefore, Cambodia becomes one of highest fish consuming countries in the world. The annual fish consumption per capital is about 52.4kg. It provides about 82% of animal protein in the Cambodian diet (FAO, 2012). Recently, the over-fishing and illegal fishing are the concerned problems to the sustainability of fisheries resources in Cambodia. In order to deal with these, the Government has revealed "the Strategic Planning Framework for Fisheries: 2010-2019".

Besides the large-scale fishing and illegal catching, on-going hydropower development and construction on the Mekong River have been reported that they will badly affect freshwater fish by blocking fish migration and reducing the population and catch (FAO, 2012).

Table 1: Fisheries Production in Cambodia from 2007-2011 in tons

Year	Inland Fishery	Marine Fishery	Aquaculture	Total
2007	395,000	63,500	35,260	493,760
2008	365,000	66,000	39,100	470,100
2009	390,000	75,000	50,080	515,080
2010	405,000	85,000	60,001	550,000
2011	445,000	91,000	72,000	608,000

Source: FAO, 2012 in Fisheries Administration (FiA), Diary, Department of Fisheries, MAFF, Cambodia

2.4.2 Livestock Numbers

Due to low adoption of agricultural technology, farming practice in Cambodia still depends on the animal labors such as cattle and buffalo. Other poultry production has been raised for the self-consumption and extra incomes. According to FAO's report in 2012, livestock and poultry production accounted for 15.3% of total agricultural GDP in 2009.

Table 2: Livestock Numbers in Cambodia from 2007-2011

Year	Cattle	Buffalo	Swine	Poultry
2007	3,368,449	772,780	2,389,389	15,825,314
2008	3,457,787	746,207	2,215,641	16,928,075
2009	3,579,882	739,646	2,126,304	28,486,237
2010	3,484,601	702,074	2,057,431	20,677,397
2011	3,406,972	689,829	2,099,332	21,619,148

Source: FAO, 2012 in Department of Animal Production and Health, Cambodia

2.4.3 Major Crops besides Rice

Major crops in Cambodia include both cash and industrial crops such as rubber, corn, cashew nuts and cassava, etc. These crops also contribute a lot to the GDP share of agricultural sector. Some provinces in the north and southeast of the country are favorable to rubber plantation due to red soil condition. Currently, rubber is considered as the second largest commodity crop after rice and the production of rubber latex is expected to reach 300,000 tons by 2020. Corn production went up to 770,860 tons, cashew nuts to 60,000 tons and cassava to 6.86 million tons in 2012 (according to accessible article titled STURTURAL POLICY COUNTRY NOTES: CAMBODIA, retrieved on December 10, 2014 from www.oecd.org/site/seao/Cambodia.pdf).

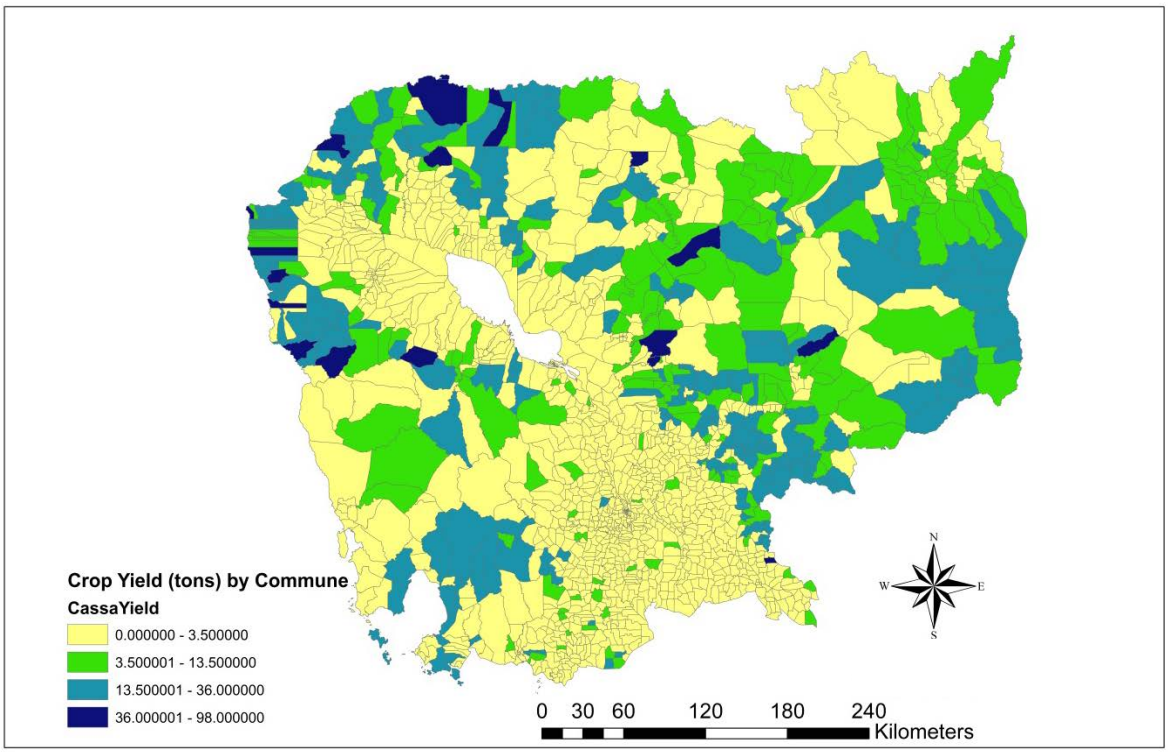

Figure 2: Map on Annual Cassava Yields by Communes in Cambodia

Source: http://www.opendevelopmentcambodia.net/odc_main_category/agriculture-fishing/?post_type=download_maps (in Shapefile); retrieved on 1st February, 2016

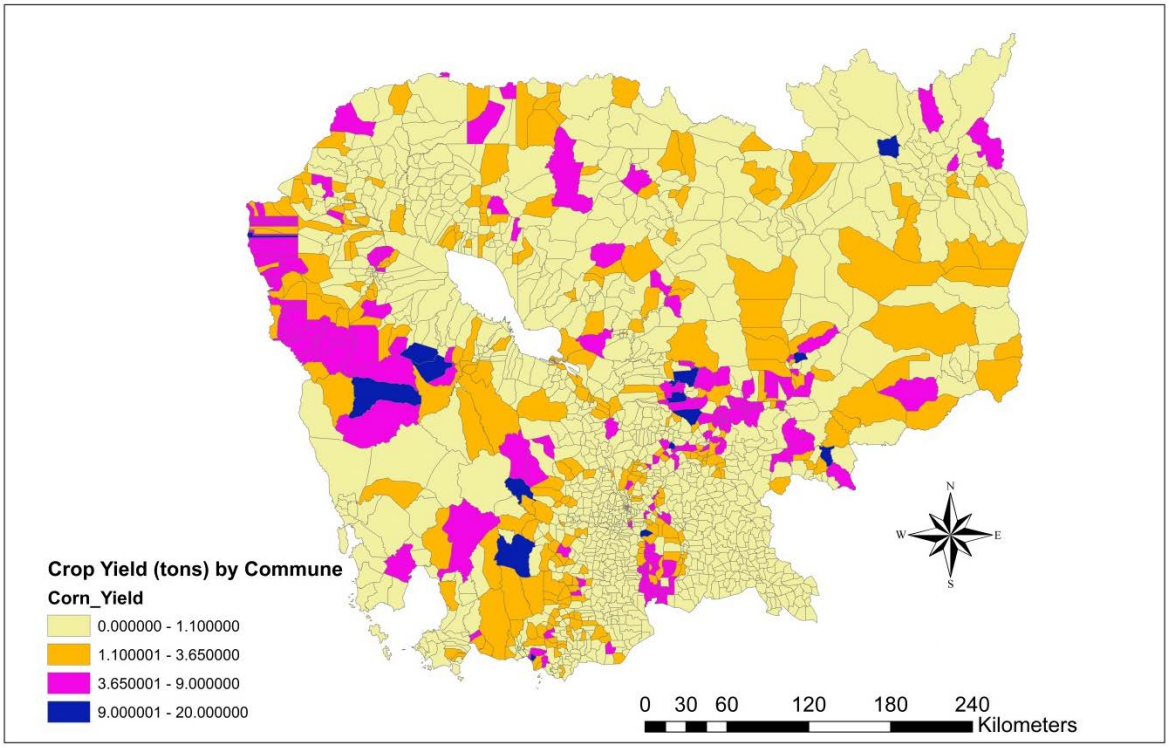

Figure 3: Map on Annual Corn Yields by Communes in Cambodia

http://www.opendevelopmentcambodia.net/odc_main_category/agriculture-fishing/?post_type=download_maps (in Shapefile); retrieved on 1st February, 2016

2.4.4 Rice Farming Systems

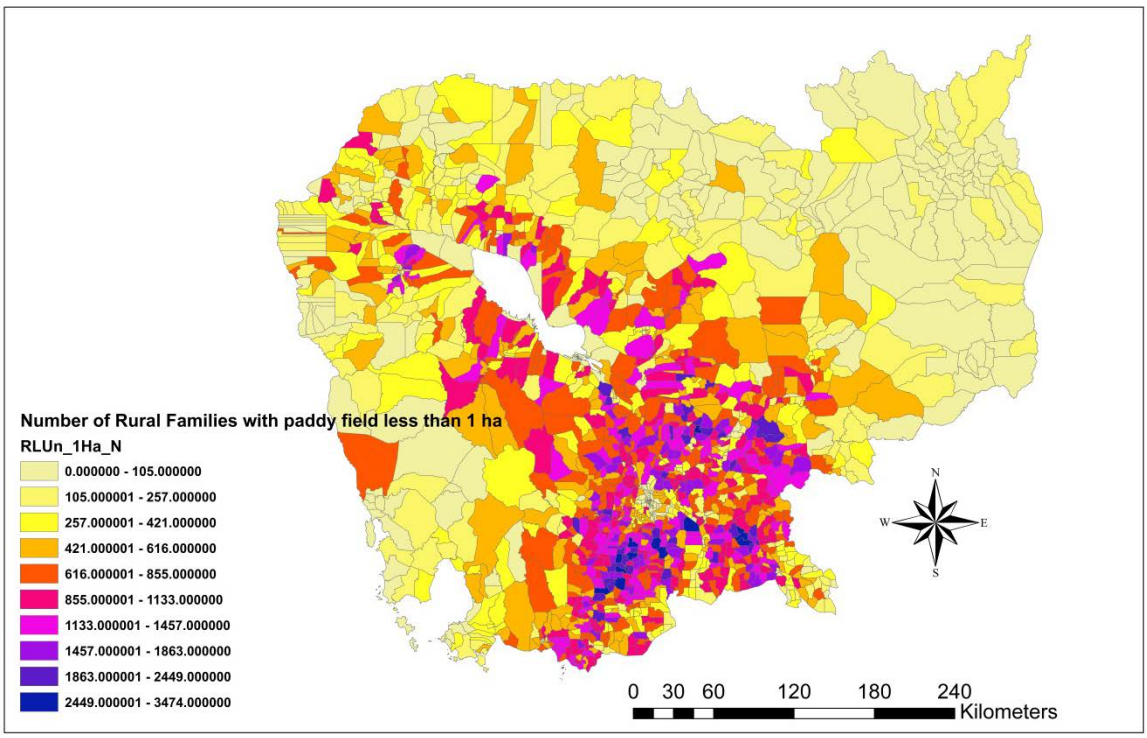

Figure 4: Map on Number of Families with Paddy Field Less than 1 ha by Communes

http://www.opendevelopmentcambodia.net/odc_main_category/agriculture-fishing/?post_type=download_maps (in Shapefile); retrieved on 1st February, 2016

Agrifood Consulting International (ACI, 2005) classified farms in Cambodia by size into three categories: small, medium and large. Small farms are those whose size is less than 3 hectares; medium-sized farms are from 3 to 10 hectares; and large farms are larger than 10 hectares in size. However, in general the average size of agricultural land of more than two million Cambodian farm households is around one hectares or less than that (Mund, 2011). Additionally, in the Southern lowlands of Cambodia, more than one million rural people have no agricultural land (Sokha et al., 2005 cited in Mund, 2011). Eighty four percent of agricultural land is under rice cultivation and the rest is shared between subsidiary and industrial crop production (Ngo & Chan, 2010). Therefore, most of Cambodian farmers are classified as small farm holders.

As most of rural households depend on rice farming as their main source of food and incomes; it is important to understand the farming systems. There are four agro-ecosystems of major rice growing areas in Cambodia (see Figure 5). Firstly, the rain-fed lowland rice ecosystem covers around 86% of Cambodia's cultivated rice cropping areas and is located around Mekong River and Tonle Sap. Secondly, the rain-fed upland rice ecosystem deals with around 2% of Cambodia's cultivated rice cropping areas. Thirdly, the deep water/floating rice ecosystem shares the total area of 4% of Cambodia's cultivated rice cropping areas. This rice ecosystem happens in low lying areas with water from a depth of 50cm to 3m in maximum for at least one month. Lastly, the recession rice ecosystem covers 8% of Cambodia's cultivated rice cropping areas. The classification of agro-ecosystems depends on the influence of rainfall, soil suitability and topography (Save Cambodia`s Wildlife, 2006).

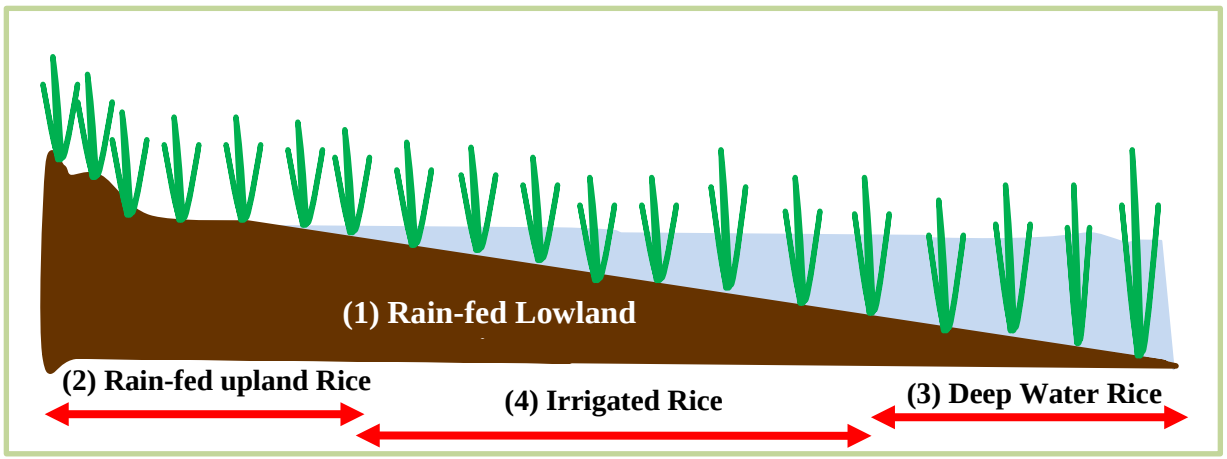

Figure 5: Agro-Ecosystems of Rice Growing Areas in Cambodia
Source: Country report on rice cultivation practice: Cambodia (Seng, 2011)

2.4.5 Rice Varieties and Crop Calendar

Local rice varieties are still popular among the Cambodian farmers. Generally and traditionally, farmers select and keep their good harvests as seeds for next year cultivation. They normally exchange the seeds among villagers or outsiders in case they want to try new variety. Rice varieties are classified as (1) photoperiod-sensitive type; and (2) photoperiod-insensitive type with different growing period as early, medium and late.

Due to climate and topographic conditions and accessibility to irrigation, varieties are chosen to fit those factors. For example, during the rainy season in the lower lying areas, late varieties are chosen. While, during dry season with accessible irrigation, early varieties are the best choice for

farmers. For example, in small village of Banteay Meanchey province located in western part of Cambodia, farmers choose early varieties for dry season irrigated rice cultivation (Farmer et al., 2009). Table below gives the images of crop calendar and rice varieties in Cambodia based on the study by Farmer et al. (2009). However, this can apply to almost over rice growing areas in Cambodia; just there more local common varieties based on the areas.

Table 3: Local Common Rice Varieties and their Growing Calendars

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainy Season Rice												
Early Varieties												
Medium Varieties												
Late Varieties												
Dry Season Rice												
Early Varieties												
Rice Varieties	***Early***					***Medium***				***Late***		
Photoperiod-sensitive cultivar	Phkar Romdul Phkar Tnong Somali					Car 8 Phkar Doung Phkar Kheig Dok Malis				Neang Khon Neang Ming Malis Loy		
Photoperiod-insensitive cultivar	Sen Pidor IR66					-				-		

Source: Farmer et al. (2009)

2.4.6 Paddy Growing and Production

Due to the differences in geography and soil conditions, paddy normally and mostly has been growing in the central and plain parts of the country where water resources are available.

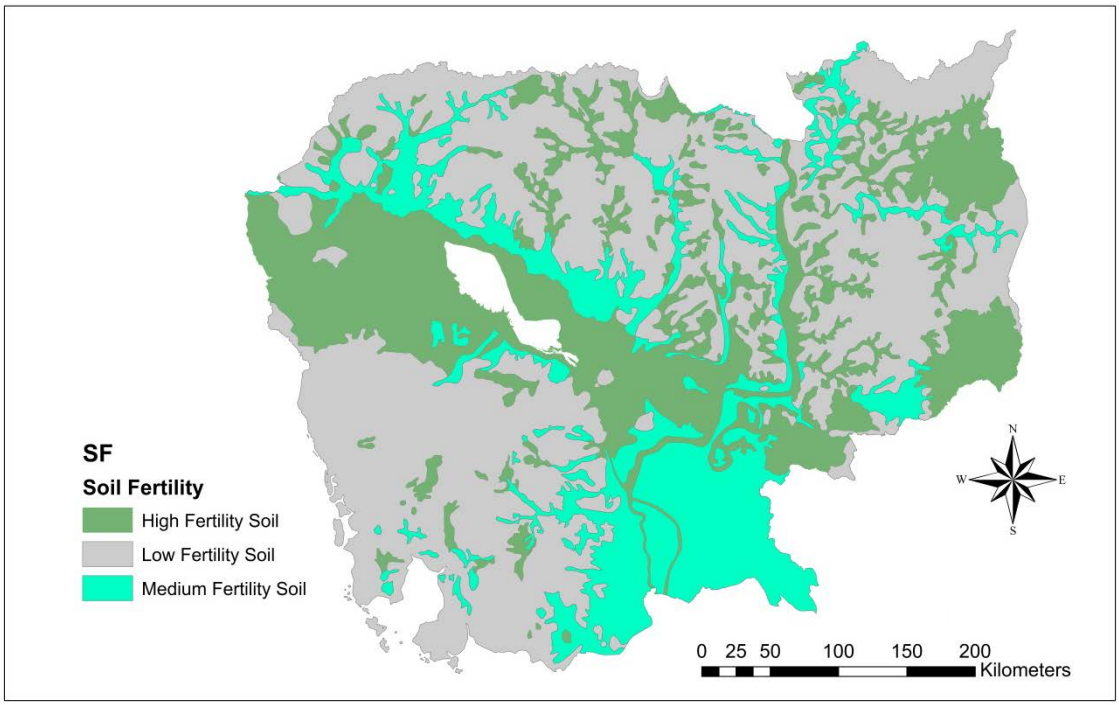

Figure 6: Level of Soil Fertility over the Country

http://www.opendevelopmentcambodia.net/odc_main_category/agriculture-fishing/?post_type=download_maps (in Shapefile); retrieved on 2nd February, 2016

Areas along the Mekong River and around the Tonle Sap Lake become the main rice growing areas (see Figure 6 and 7). Other parts of the country become the crop areas. Farmers select their crops to grow based on the soil condition, input availability and demand from the markets.

The statistics from the Ministry of Agriculture, Fisheries, and Forestry (MAFF) showed that the total rice cultivated area in 2009 was 2.72 million hectares while in 2010 was 2.80 million hectares. The areas were expanded because of the rebuilt or rehabilitated irrigation systems.

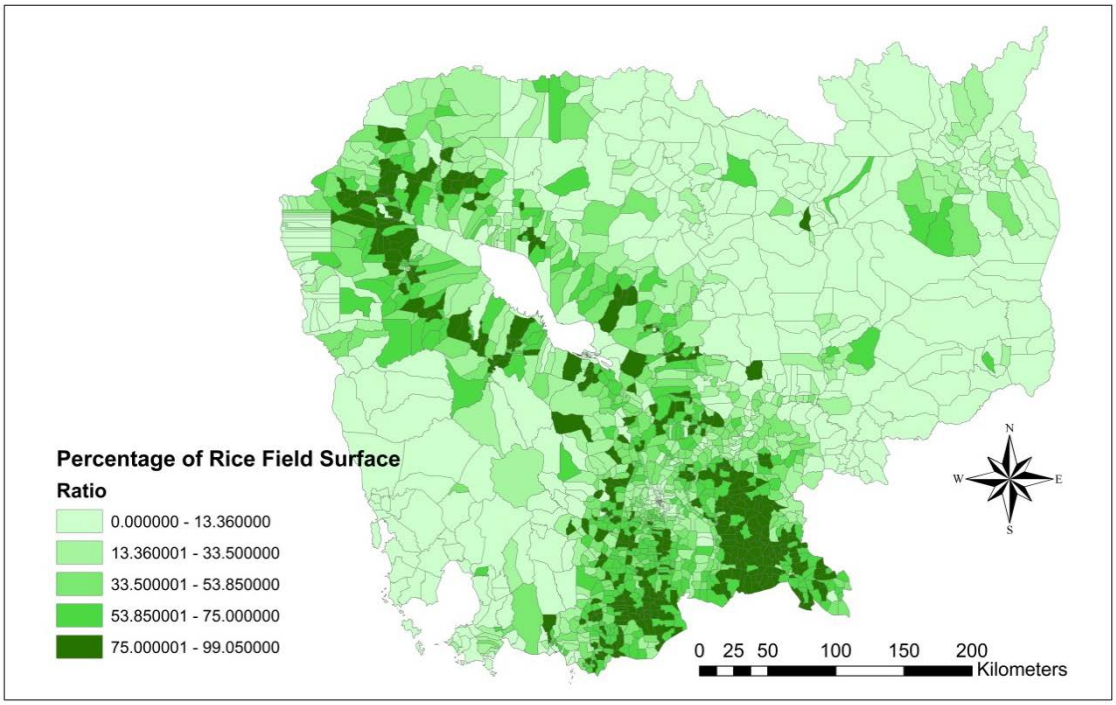

Figure 7: Percentage of Rice Field Surface

http://www.opendevelopmentcambodia.net/odc_main_category/agriculture-fishing/?post_type=download_maps (in Shapefile); retrieved on 2nd February, 2016

However, some areas are still facing the water shortage. The harvested area was 2.76 million hectares in 2011 and it increased up to 2.98 million hectares in 2013.

Table 4: Paddy Production in Cambodia from 2000-2013

Year	Cultivated Area (ha)	Harvested Area (ha)	Productivity (t/ha)	Production (t)
2000	2,318,495	1,903,159	2.12	4,026,092
2001	2,240,917	1,980,295	2.07	4,099,015
2002	2,137,125	1,994,645	1.92	3,822,509
2003	2,314,285	2,242,036	2.10	4,710,957
2004	2,374,175	2,109,050	1.98	4,170,284
2005	2,443,530	2,414,455	2.48	5,986,179
2006	2,541,433	2,516,415	2.49	6,264,123
2007	2,585,905	2,566,952	2.62	6,727,127
2008	2,615,741	2,613,363	2.75	7,175,473
2009	2,719,080	2,674,603	2.84	7,585,870
2010	2,795,892	2,777,323	2.97	8,249,452
2011	2,968,529	2,766,617	3.17	8,779,365
2012	3,007,545	2,980,297	3.12	9,298,527
2013	3,052,420	2,986,967	3.16	9,438,816

Source: www.stats.maff.gov.kh

Based on the above table, there was gradual increase in paddy production at the same time with the expansion of the cultivated areas. This extension really responds to the population growth in Cambodia; while considering the yield, there were the positive changes during that period. Nevertheless, by comparing the paddy production in the region during 2008, Cambodia could produce the lowest one. It was around 2.75t/ha; while in Thailand was 2.97t/ha and Vietnam was the top with the paddy production around 5.22t/ha (FAO Agricultural Statistics, 2008).

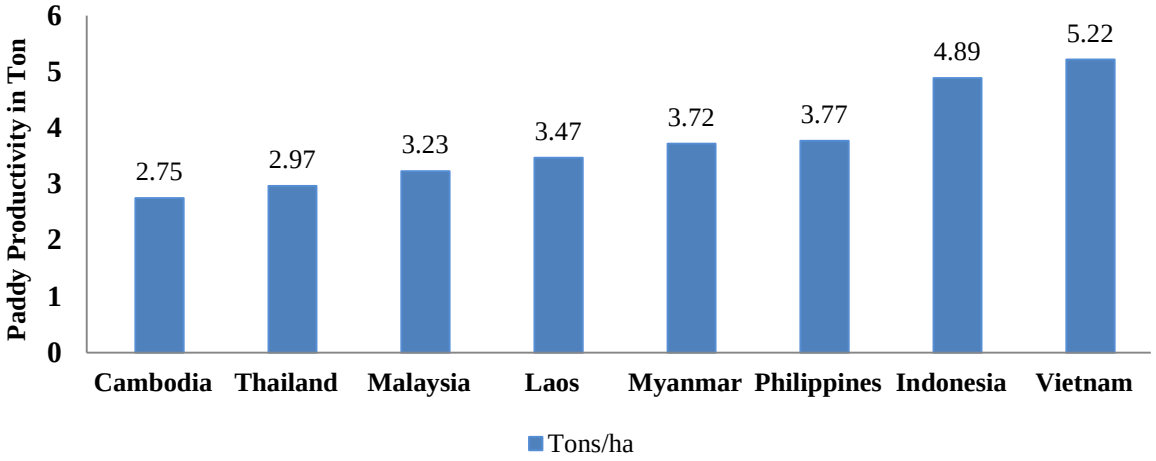

Figure 8: Paddy Productivity Compared with other Countries in the Region in 2008

Source: FAO Agricultural Statistics 2008

2.4.7 Rice Consumption per Capita in Cambodia

Rice is a main dish for the Cambodian. Rice is also re-produced for other foods such as noodles and flour, etc. According to MAFF, rice consumption per year per person is about 143kg but other government institutes say 153kg (FAO, 2012). Here will show the data from FAOSTAT in 2007 to compare with other Southeast Asian countries as shown in figure below. For other cereals, Cambodian people also consume but with small amount such as maize, wheat and soybeans with 5kg, 3kg and 8kg per year per person; respectively (FAO, 2012).

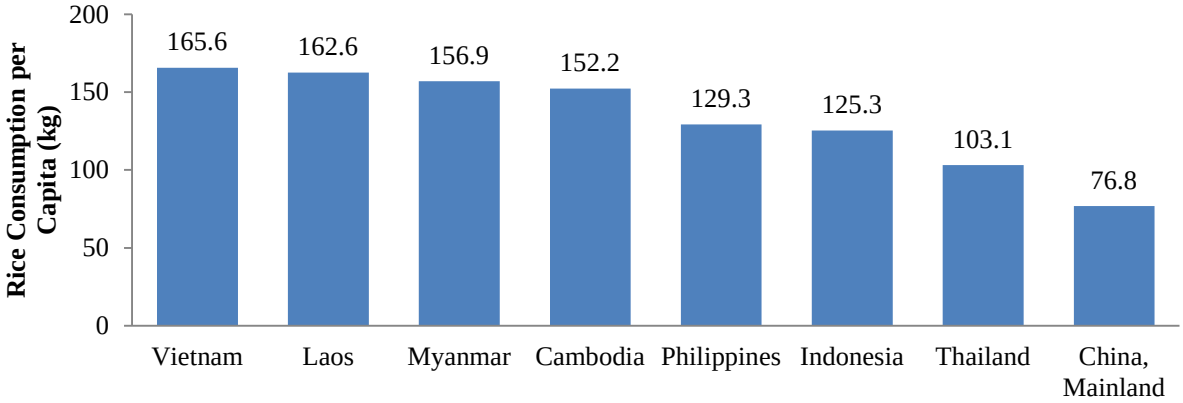

Figure 9: Annual Rice Consumption per Capita in Selected Asian Countries for 2007

Based on figure above, in 2007 Cambodian people consume rice about 152.2kg more than others did in the Philippines, Indonesia and Thailand. Vietnamese people consumed the highest amount of rice in some selected Asian countries; followed by Laos and Myanmar.

2.4.8 Constraints to Paddy Production Growth

Noticeably Cambodia has achieved the surplus in rice production by the increase in rice exports from zero during 2000-2001 to approximately 800,000 tons during 2009-2010 based on the estimate by United States Department of Agriculture (USDA, 2010). This can be concluded that the local consumption is enough; that is why the government is able to export the rice. However, from the viewpoints of USDA predicted that the growth of rice production in the future for Cambodia seems uncertain. It is arguable between the government and USDA's statement regarding this prediction. Nevertheless, USDA has strong evidences to support this statement and the government is recommended to take them into account.

The first challenge to rice production growth is the unmet extension programs. According to USDA (2010), funding for the agricultural extension program is currently under the funding. The United States Agency for International Development (USAID) calculated that in 2010 the government spent only 1% of the national budget for the agricultural program excluding irrigation development. Even in the policy paper on the rice exports (CoM, 2010), the government also mentioned the limited extension program to its challenge. Therefore, lack of extension programs can worsen the situation that in the future Cambodia might not be able to reach rice production growth. Contracting to this challenge mentioned by USAID, there are positive results showing rice production growth. In sum, this is a good respond to the found challenge.

The second challenge is the land issue. Again based on the policy on the rice exports (CoM, 2010), the government has mentioned that in general land is underutilized. Some crops do not fit the soil conditions. Moreover, arable land for agriculture is used for other purposes or left unused. Some farmers sold their land for the industrial sector. This is a big problem that in the future farmers will become landless and not be able to produce rice or grow other crops. Of course, this is really happening now since farmers cannot find out what will happen next; they foresee only a short term benefits.

The last mentioned challenge is that not only do Cambodian farmers produce the lowest rice yield in the region but most of them also can only cultivate paddy rice once per year in the rainy season. In Vietnam's delta, farmers can cultivate 3.5 times per year. It is amazing. Therefore, it is important to provide assistances to Cambodian farmers in order to help them be able to grow rice more than one time. One of the assistance is agricultural inputs such as fertilizers, seeds, equipment, techniques and especially irrigation, which is still a big concern. Then, some brief information on the irrigation sector in Cambodia will be given in the next part.

2.5 Irrigation Sector

Irrigation is seen as the main factor for an agrarian country like Cambodia since the majority of people are living in the rural areas and cultivating rice. Therefore, there is a long history about the irrigation system development in Cambodia. In Asia, China involved surface irrigation diverted from rivers since 2,000 years ago. China built canals to carry the larger amount of water to fields with the long distance (Retrieved from www.ehow.com/about_6739656_history-irrigation-systems.html on April 17, 2013). In Cambodia during the Angkor period, between the

9th and 14th century, a complex large-scale system of canals and ponds and reservoirs for irrigation and water storage were made.

Time has passed; the irrigation system situation in Cambodia, from political viewpoints, has fluctuated from one period to another. After the first success of irrigation system development in Angkor period, Cambodia experienced the second success during the French colony from 1863 to 1953. During that time, some modern irrigation schemes with proper reservoirs and dams were built (Perera, 2006 cited in Ros, 2010). However, just small achievement was done due to the communication gap in water management between the colonial state and local people.

After that, more luckily Cambodia acquired another better success after the colonial period was over in 1953. To be independent from the French colony, Cambodia was led by the Prince Norodom Sihanouk. The Prince introduced the idea of the self-reliance program to enlarge the irrigation schemes. During that time, farmers were motivated to join the irrigation management and dam construction under the instruction of local authorities and monks. In the meantime, the government assisted in employing gate operators and providing the financial resources to farmers (Ros, 2010). This program successfully led to high rice production and Cambodia became a major rice exporter (ADB & MOWRAM, 2001). Following the end of the Prince's period in 1970 resulted from the coup done by Lon Nol, it is said that there is no any written document related to the operation of irrigation management during that period (Ros, 2010).

Cambodia later jumped into another political period called Khmer Republic or Pol Pot regime. It was the hardest and the most tragic time for Cambodian people. All Cambodian people were forced to leave cities and started new lives in rural areas. They were pushed to construct irrigation schemes for rice farming by using hands and spades. Due to the poor designs and lack of technical supports, those schemes did not function well (Ros, 2010).

Finally, this rough time came to the end in 1979 and a new government called the Khmer People's Revolutionary Party was set up. During that time from 1980 to 1985, irrigation schemes built during Pol Pot Regime were managed by a group of local people, Krom Samaki (literally translated as Solidarity Group). Some new irrigation schemes were also constructed but still under poor designs (Chem & Craig, 2008).

After 1985, the government came to control the irrigation management and farmers were also encouraged to engage in irrigation maintenance. Then, after the establishment of the Ministry of Water Resources and Meteorology (MOWRAM) in 1999, the government delivered all aspects of irrigation schemes maintenance to farmers (Perera, 2006 cited in Ros, 2010).

According to Thun and Chem (2007), in 2003 MOWRAM made an inventory of all types of irrigation schemes and discovered that as a whole Cambodia had more than 2000 irrigation schemes with the capacity of irrigating around 1 million hectares. Moreover, MOWRAM (2000) has classified irrigation schemes into three categories: (1) small scale with the area less than 200 hectares; (2) medium scale covering the area from 200 hectares to 5,000 hectares; and (3) large scale wrapping up the areas from 5,000 hectares. Additionally, based on MOWRAM and Cambodia National Mekong Committee (CNMC) in 2003, irrigation systems can be divided into four main types as follows:

- The first one is Canals off-taking in the Mekong basin from natural lakes, rivers or streams by gravity. This system has no storage and is used in the wet season to supplement the irrigation. Double cropping is quite possible if water is available.
- The second is Canals abstracting from rivers via pump station provided by the Government. The pumps typically 500L/s in capacity are either mounted on pontoons or installed in pump houses. The responsibility for operating the pumps is on the farmers. Some areas are potential for double cropping.
- The third is Reservoirs storing water from run-off, streams or rivers for supplementary wet season irrigation and a small dry season area. Water can be extracted from reservoirs by gravity or mobile pumps belonging to farmers.
- The last one is Reservoirs storing flood waters from Tonle Sap, Bassac, and Mekong systems and then released by gravity or mobile pumps for only dry season recession crop. For special cases, water may be able to be abstracted directly from the rivers without reservoirs.

2.5.1 Irrigation Techniques

There are three main irrigation methods. They include (1) surface irrigation, (2) sprinkler irrigation and (3) Drip Irrigation. The functioning irrigation structures used by Cambodian farmers for irrigation are still poor. Of course, the most common irrigation method is surface irrigation. The ways that farmers carry water from surface to paddy fields consist of traditional lifting, mobile pumping stations, gravity, or a combination of those techniques. However, recently another new method has been introduced by several NGOs. It is a treadle pump (Retrieved on July 27, 2012 from www.unescap.org/rural/doc/sads/cambodia.PDF). It can be made of wood with less cost. The capacity of the mobile pumps is around 10-30L/s (MOWRAM & CNMC, 2003). It normally belongs to an individual farmer or a small group of farmers. These pumps carry water from the canals to the paddy fields. The above-mentioned traditional methods are commonly utilized by farmers with low incomes. Those include “Rohat” (pedal pump), “Kleng” (oscillating fume), and “Snach” (tripod water shovel). Their capacity in carrying water is small; the speed is low as well as they consume a lot of time.

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2.5.2 Irrigation Development

Although rice farming is the main agricultural activity, most of rice cultivated areas have depended on the rainfall rather than the irrigation system. This is because only small cultivated areas have been irrigated. Through the much effort of the government in rehabilitating and constructing the irrigation systems with the invested money from government, development partners and loans, it is reported that in the dry season 15% of total cultivated area is irrigated and 35% in the wet season, according to text titled Irrigation Development in Cambodia in 2011 accessed through https://trustbuilding.wordpress.com/2011/04/27/irrigation-development-in-cambodia-in2011/ on December 19, 2014.

Direct and indirect irrigation plays an important role in agricultural development. In this sense, in order to enhance the agricultural practice as well as to reduce the poverty rate, quick and huge supports for irrigation from the government and other development donors are indeed required. In response to this, in 2003 the Cambodian Prime Minister elevated his government as an

“irrigation government” (Yang et al., 2011). Moreover, in 2011 the government bolstered its efforts to increase the budgets for rehabilitating the existing irrigation systems and building new irrigation systems through encouraging cooperation from foreign donors. Furthermore, the Rectangular Strategy of the government has emphasized the importance of increasing agricultural productivity resulting from effective water management particularly irrigation as the central of this strategy (RGC, 2004). As mentioned earlier, the potential benefits of irrigation development not only improve the rice production, but also reduce the poverty rate as 30.1% of the population live in the poverty (ADB, 2010b). Taking effective water management into account, the government issued Prakas No. 306 in 2006 (Perera, 2006). The essence in this Prakas states that the government has delivered the responsibilities for the operation and maintenance of irrigation schemes to Farmers Water User Communities (FWUCs). This means that water is no longer free public goods but it belongs to the state and is managed by FUWCs. Therefore, farmers are required to pay fees to FWUCs in which their plots are located. Those collected payments are used by FWUCs for the operation and maintenance of irrigation schemes.

RGC also promoted the investment in Agricultural Water Management (AWM) especially for irrigation. The investment in AWM is set for the increase of rice exports at the national level and improvement of food security and reduction of poverty at the local levels (Johnston et al., 2013). In order to identify the range of investments in irrigation, the National Strategy for Agriculture and Water called SAW was established. In 2012, it was reported over 260 million USD was planned to be invested in both loan and grant forms for on-going irrigation investments with outside partners and plus 868 million USD for large-scale infrastructure (Johnston et al., 2013). Through this large amount of investment, it is expected that irrigation structures will be much improved and help farmers increase their productions and be able to double their farming.

In order to achieve the big goal of the policy on the Promotion of Paddy Rice Production and Export of Milled Rice officially approved by the Council of Ministers on July 25, 2010 in Phnom Penh, the government mentioned the solutions to deal with the irrigation system, one of the big challenges. Those solutions can be summarized as (1) maximizing the use of existing water resources in the system; and investing in small-scale irrigation networks to benefit from the existing or future large-scale irrigation facilities, (2) encouraging NGOs and charitable people to participate in building small-scale irrigation canals, and (3) strengthening institutional capacity of MOWRAM in the maintenance and management of water user communities. Even though the above mentioned policies and activities are being implemented, the irrigation development is still a big concern.

2.5.3 Constraints to Irrigation Development

Here intends to highlight some issues related to irrigation development in Cambodia based on author’s observation and opinions, the review of documents and current situation. The Royal Government of Cambodia, of course, has emphasized the right points on the right issue but the actions have been taken very slow. That is the first constraint to the development. The second one is the technical and financial supports for FWUCs from the government is still limited (Yang et al., 2011). This can be assumed that, at FWUC level, the knowledge on operation and maintenance of the schemes is still weak. Moreover, a big problem for FWUC to maintain the

schemes is not only the technical skills but also the collection of water fees from the farmers. The reason why the farmers do not pay the water fees is that because they do not understand the "value of water" and how the water should be priced (WOKKER et al., 2011).

To cope with those constraints, the government should try to promote FWUCs in the broader concept; as a result, the farmers could understand the importance of FWUCs and the reason why they are required to pay the water fee. Moreover, starting rehabilitation of the existing canals or systems is the best way and vitally needed because they will not be costly and time-consuming (Yang et al., 2011). By doing so, some areas where are suffered from the drought or water shortage can be secured on time. Finally, increasing the fund for irrigation development is recommended since it can accelerate the development speed and improve the capacity of FWUCs.

CHAPTER 3 LITERATURE REVIEW

This chapter provides the clear context of this research with explicit information and discussion over issues or on-going activities related to this research from various resources. It is divided into eighteen sub main points including (1) Agricultural systems and their determinants, (2) Growth stages of rice crop and used seed rate, (3) Post-harvest losses and milling ratio, (4) Water requirement for paddy fields, (5) Irrigation and its cost, (6) System of rice intensification (SRI), (7) Introduction of SRI in Cambodia, (8) SRI, a climate agriculture, (9) Evidences on aspects affecting adoption and not adopting of SRI, (10) Evidences on labor requirement: SRI versus conventional practices, (11) Agricultural system adoption in Cambodia, (12) Changes in SRI practices, (13) Differences between SRI practices in irrigated and rain-fed areas, (14) Debates over SRI practice, (15) SRI promotion in Cambodia, (16) Policies to promote agricultural development, (17) Rice markets in Cambodia, (18) flow of credit accessibility for rice farmers, (19) "Social Capital" and livelihood improvement in rural areas of Cambodia, (20) Sustainable agriculture and agricultural sustainability, and (21) Summaries of discussion.

3.1 Agricultural and Farming Systems and their Determinants

Agricultural and farming practice varies from time to time, and from one place to another. Other factors such as climate, culture and geography cause the farming systems differ from one place to another. Based on these factors and others influences, Duckham and Masefield had broadly classified farming systems into three foundational types: (1) shifting cultivation; (2) pastoral nomadism; and (3) settled agriculture (Duckham & Masefield, 1970 cited in George et al., 2006, p: 138-145). Refer to Figure 10 for the details of classification of world farming systems.

Shifting Cultivation is the oldest farming system. However, it still has been practiced in many parts of many countries in the world. It is also known as slash and burn cultivation. Group of people who practice this system keep moving from one place to another within some years. They clear the land and grow their crops with very simple tools such as hoes, and stick. It is believed that this kind of farming activities causes some environmental problems such as soil erosion and soil fertility degradation. Another farming system is Pastoral Nomadism which is a group of people traveling with the herds of livestock. They feed their animals with natural pasture. They also do some cultivation but their productions are low. Every farmer tends to maximize a number of their animals and doing this causes the overgrazing since grazing takes place on common land. The other one is Settled Agriculture which is seen in the farming practices today. Settled agriculture consists of many farming systems as shown in the Figure 10. Various farming in the settled agriculture categories can produce a variety of foods to feed the world population. Each farming system still exists in today-practices; however, these systems could not be constantly practiced in the original forms. Technologies, environmental conditions and increases in demands due to the population growth can change the systems.

Regarding the current farming system or settled agriculture, FAO (retrieved on February 09, 2016 from http://www.fao.org/farmingsystems/description_en.htm), has defined a farming system "*as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate*". Also, the classification of the farming

systems varies based on the factors mentioned above. Again owing to FAO, in the developing regions, the classification has been based on following criteria:

- *Available natural resource base, including water, land, grazing areas and forest; climate, of which altitude is one important determinant; landscape, including slope; farm size, tenure and organization; and*
- *Dominant pattern of farm activities and household livelihoods, including field crops, livestock, trees, aquaculture, hunting and gathering, processing and off-farm activities; and taking into account the main technologies used, which determine the intensity of production and integration of crops, livestock and other activities.*

Because many factors can influence the farming practices, by the time of their book got the first publication in 2006, George et al. (2006) mentioned three main determinants such as technical, human and institutional in the farming systems. They emphasized that when these determinants become constant for some years, one of or two of or all the farming systems that work(s) out well will get along well with the environment. However, different farming systems still have different impacts on the environment; therefore they need different supports from public or the government. By comparing the details of major determinants in Figure 11, it can say that those effects still work out in today practices. All the determinants actively interact one to another. Many researches and experiments have been conducted almost on all the determinants in order to develop better agricultural practices; however, some determinants are still uncontrolled due to some complex physical conditions such as precipitation, and temperature. Moreover, during the globalization era, technologies, marketing, economics and policies are still playing as complicated determinants.

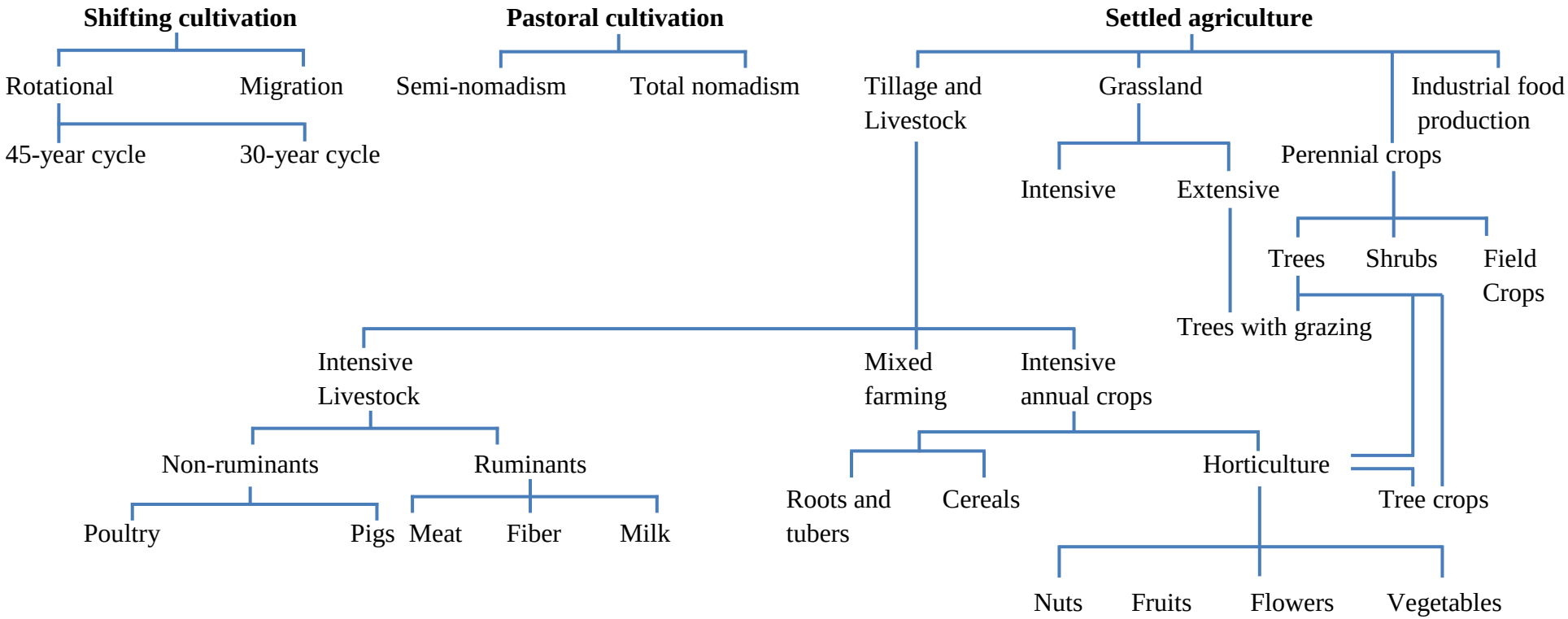


Figure 10: Classification of World Farming Systems

Source: Duckham & Masefield, 1970 cited in George et al., 2006, p: 142

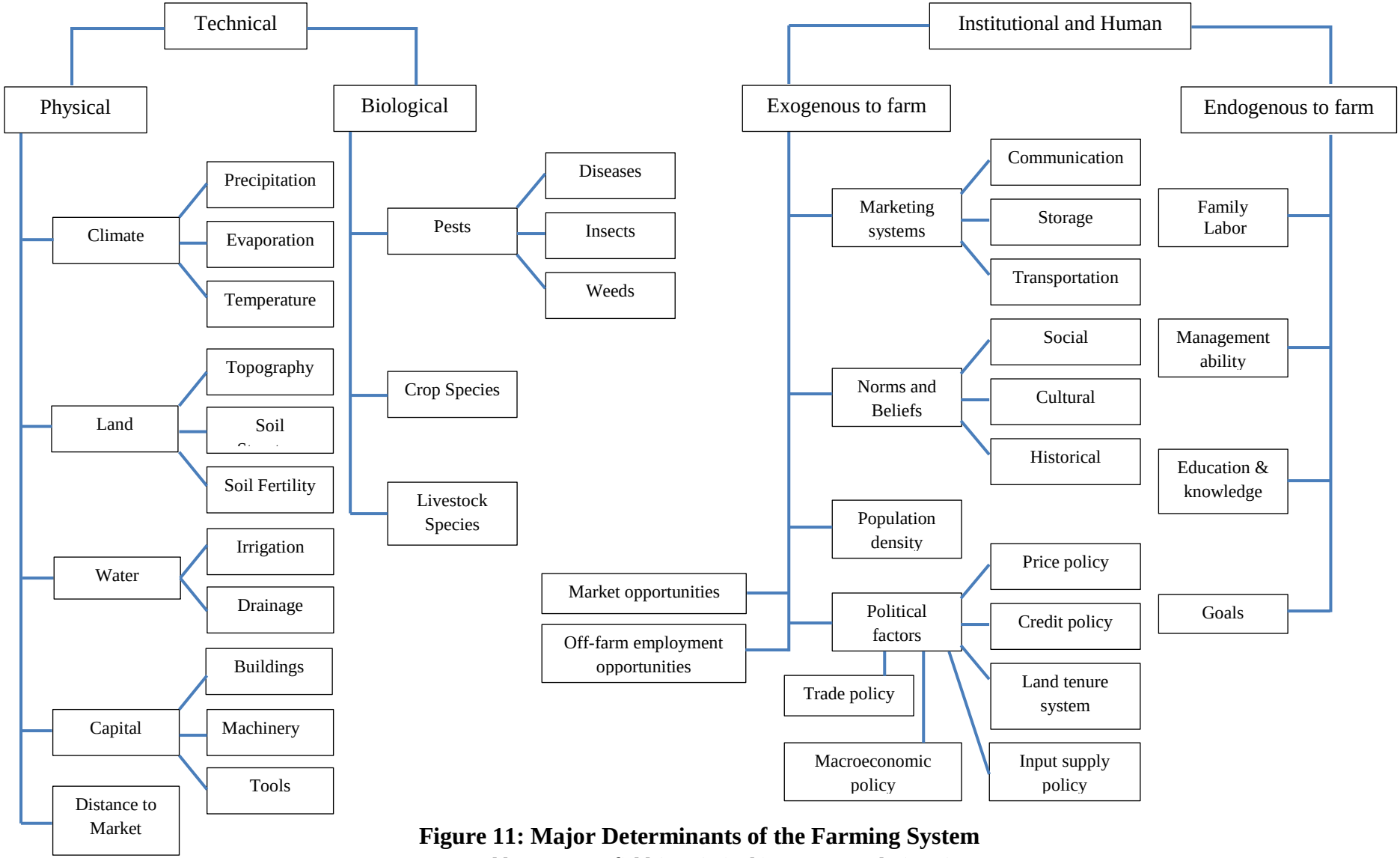


Figure 11: Major Determinants of the Farming System

Source: Duckham & Masefield (1970) cited in George et al., (2006) p: 139

3.2 Growth Stages of Rice Crop and Used Seed Rate

Rice is a common crop in Asia and also in some parts of the Pacific. It becomes the staple food for most population. According to FAO, over 90% of the world's rice is produced and consumed in the Asia-Pacific Region (Retrieved from www.fao.org/docrep/003/x6950e/6950e04.him, on May 03, 2013). Therefore, growing rice is also the most common activity in Asia-Pacific. While, in Southeast Asia, total rice cultivation in 2015-16 is estimated about 47.0 million ha which about 45% of total area is irrigated (USDA, 2015). Being situated in the monsoonal areas, most of Southeast Asia countries can grow rice both in rainy season (mostly depending on rainfall) and in dry season (mostly depending on irrigation system). As in Thailand, Cambodia, and Laos, the rice cultivation areas in dry season cover about 19, 16, and 11 percent of total cultivated areas, respectively (USDA, 2015).

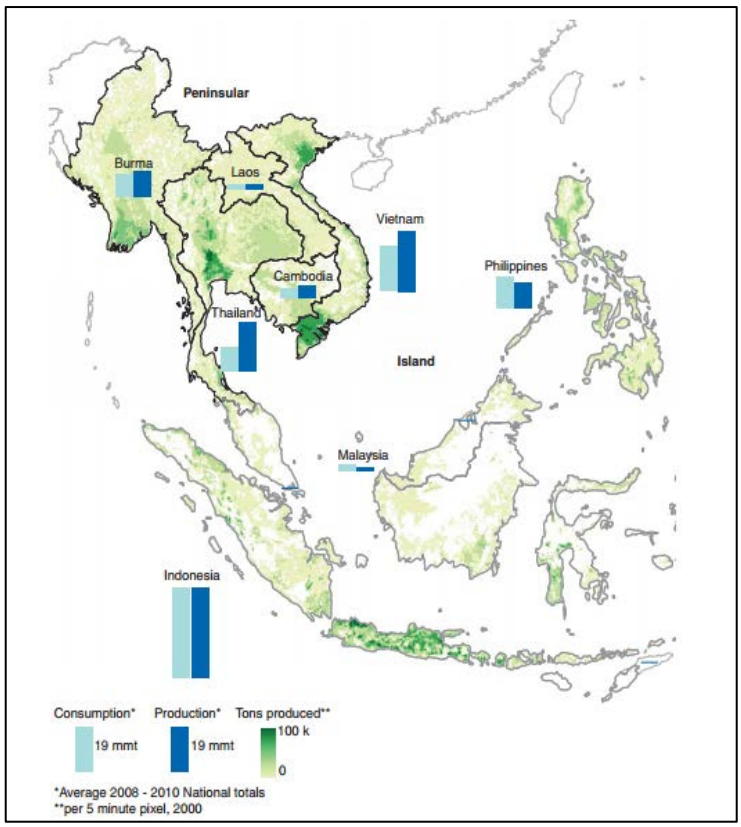


Figure 12: Distribution of Rice Land in Southeast Asia

Source: http://www.ers.usda.gov/media/978994/rcs-12l-01.pdf, retrieved on February 09, 2016

Although rice has many varieties, the tropical rice varieties have their life span with a range from 110 days to 210 days (Zawawi et al., 2010). The growth period is divided into main three stages as vegetative, reproductive and ripening stages (Figure 13). In the vegetative stage, the duration varies from 1½ months to 3 months. This stage includes the tillering one. The reproductive stage or mid-season takes about 1 month from panicle initiation to flowering. The ripening stage or late season also consumes time about 1 month from flowering stage to full maturity one. This stage includes grain growth. The seed rate to grow rice also varies from the quality of varieties and planting systems. According to FAO (2012), from the nursery bed to the transplanted fields, the seed rate is around 65kg to 80-100kg per hectare if sown by mechanical seeder and about 150-250kg per hectare for hand broadcasting.

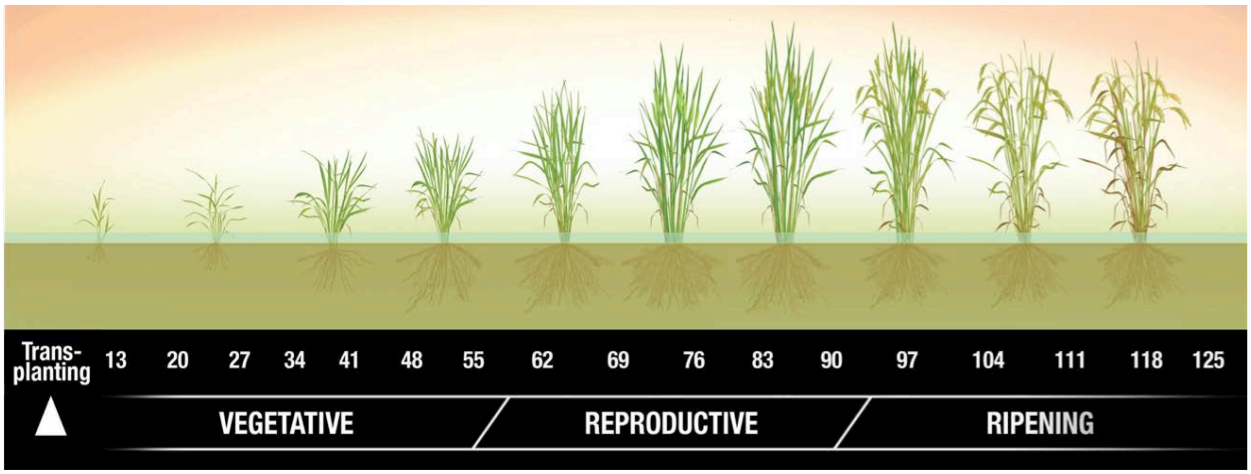


Figure 13: Rice Growth Stage

Source: ricexpro.dna.affrc.go.jp/images/growth-condition.png. Retrieved on May 02, 2013

3.3 Post Harvest Losses and Milling Ratio

Growing and taking care of rice plants are time-consuming tasks. These kinds of tasks are called Pre-harvest works. Farmers expect to get the higher yields from their hard works. However, farmers will experience the small or great losses after the harvest tasks. These tasks are called Post-harvest works. Post-harvest works refer to the works after harvesting such as transporting harvests from field to the storage, managing the storage, and threshing. In most of developing countries, harvesting works are still done by human. It takes much time and many labors. After finishing harvesting work, farmers tie all harvests into many bunches which will be carried by ox carts or tractors from field to the storage. During lifting bunches from the ground to the ox carts or tractors and on the way from field to the storage, some grains drop or detach from main stems. Moreover, during the threshing, some losses will also occur. Bad storage management will cause another loss of harvested grains. According to International Rice Research Institute (IRRI), the physical post-harvest losses are estimated to be approximately 15 to 20 percent in Southeast Asia (FAO, 2012).

Another loss will occur during the milling process. A milling ratio of paddy varies based on the some conditions such as moisture ratio of paddy, varieties of rice, and types of milling machines. In Cambodia, MAFF assumed that a milling ratio of paddy is 64 percent (FAO, 2012). This ratio is still currently applied. Again owing to FAO (2012), the total harvested paddy for 2011-2012 of agricultural year was about 8.78 million tons which was equivalent to 5.62 million tons of milled rice. This can indicate that milling ratio mentioned above is still applied.

Post-harvest losses and high milling ratio are still the concerns to both farmers and businessmen. Better post-harvest management is required to prevent the losses during the storages and transport. More extension works on post-harvest are needed to help farmers reduce the losses. Compared with China, milling ratio of Cambodia is lower. Milling ratio is China is 67%. To make 1kg of rice, 1.5kg of paddy is needed (David, 2013).

3.4 Water Requirements for Paddy Fields

Due to the expansion of urbanization and other non-agricultural activities, water availability for irrigation on rice crops becomes scarce. In Asia, more than 80% of the freshwater resources are consumed for irrigation, while 90% of the total irrigation water is used for rice production (Lee et al., 2005). Besides irrigation, another source is rainfall. Some countries still heavily depend on it. Over 70% of the rice areas in the Mekong Region are defined as the rain-fed lowland rice ecosystem (Tsubo et al., 2007). However, crop failure can occur if poor distribution of rainfall during the growing season happens. With the crop failure, farmers will face the food shortage; gradually they will fall in the poverty trap. Improvement of irrigation will reduce the risk as it is believed to help the poor increase the yields and decrease the risk level of crop failure (Hussain & Hanjra, 2004 cited in Wokker et al., 2014).

Since paddy fields consume a lot of water, it is important to know how much water is needed. The water requirements (WR) for paddy crops can be defined as the total depth of water needed to meet water loss such as evaporation (E), transpiration (T), seepage (S), deep percolation (P), and surface drainage. While evaporation and transpiration occur simultaneously in the field, the term Evapotranspiration (ET) is used to describe the combined process of (E) and (T) from land surfaces (Tomar & O'toole, 1980). The other loss, surface drainage, can be minimized because levees or bunds around the paddies were built in the wetland rice fields.

In Thailand, water requirements of rice were from 520 to 2549mm, whereas percolation used up to 273 to 1275mm (Kung et al., 1965 cited in Zawawi et al., 2010). In India, percolation was around 60% of total water requirement ranged from 750 to 2500mm (Dastane et al., 1970 cited in Zawawi et al., 2010). These results show that much water loses through percolation. In order to save water for irrigation; especially to decrease the volumes of water losses through percolation, Guerra et al. (1998) have introduced three possible ways targeting at reducing SP (Seepage and Percolation). Those three methods include (1) reducing the depth of ponded water; (2) keeping the soil just saturated; or (3) applying alternative wet and dry (AWD).

The irrigation experiments with wetland rice (Oryza Sativa L.) paddies done by Tripathi et al., (1986) for 2 years in India showed that applying intermittent submergence can save irrigation water from 34-43%; while SP losses were reduced by 36%, 31%, and 25% in clay loam, silty clay loam, and loam, respectively. However, this method can lead to yield reduction because of possible drought-stress effects on the crop (Bouman & Tuong, 2001). Possible drought-stress effects can be resolved if there are well-functioning irrigation systems and farmers possess good knowledge on the rice growing cycle. For example, they can understand in which stage rice plant is so sensitive to drought.

3.5 Irrigation and Its Cost

Although there is abundant water on the earth, water is priced for all kinds of usages such as water for domestic supply, drinking and even for irrigating the fields. Since water is priced, International Water Management Institute (IWMI) indicated that the irrigation water in agriculture has its economic value, ranging from 0.05 to 0.90USD/m^3 (Perry, 2001 cited in Chapagain et al., 2011). Price of irrigation water varies, depending on the location of the fields.

While, Kunimitsu (2006 cited in Chapagain et al., 2011) stated that for the paddy field economic value of irrigation water is from 0.4 to 0.65USD/ m^3.

Water is owned by the state or the government in most of the countries. In Cambodia, water is the property of the state (Jennar, 1995 cited in Wokker et al., 2014). Royal Government of Cambodia has viewed water as one of contributing priorities to poverty alleviation and economic growth since principally irrigated agriculture is of importance to address poverty by achieving food security and promoting income generation in rural areas (Investment in land and water in Cambodia by Chann Sinath via http://www.fao.org/docrep/005/ac623e/ac623e0c.htm, retrieved on November 27, 2014). Farmers also need to pay for irrigation fee to their associations in their communities; however, payment collection is not going well due to some obstacles.

3.6 System of Rice Intensification (SRI)

Due to rapid growth of the world's population, food security has become a big concern for all countries. To fight against food shortage or hunger, new agricultural innovations to increase the food production have been continuously discovered.

Figure 14: Map of SRI Validation

Source: http://sri.ciifad.cornell.edu/images/global/SRIspreadMap2012.jpg Retrieved on May 31, 2012

The innovation of System of Rice Intensification (SRI) was first found by Father Henri de Laulanié, a French Jesuit missionary, who had put his hard work in the field in Madagascar during the 1980s and 1990s (Glover, 2011). Moreover, SRI was defined as an extraordinary innovation that can increase the productivity by changing the ways of plant, soil, water and nutrient management in the paddy rice production (Uphoff, 2008). Uphoff also emphasized that it can raise the rice production at least 25-50%. Because SRI is believed to increase the rice production, it has been currently validated in 45 countries as shown in Figure 14. From the first discovery of SRI by Father Henri and subsequent further studies done by Professor Uphoff or by other agriculturalists, Key elements of SRI consist of (1) Land Preparation, (2) Seedling Preparation, (3) Innovation Transplanting, (4) Intermittent Irrigation, (5) Rotary Weeding, and (6) Organic Fertilizer. It reported that SRI, from the viewpoints of local NGOs in Cambodia, is a set of innovative rice cultivation practices or techniques that can help rice plants to reach their natural potential for growth and yields (Sothy, 2008).

3.6.1 Characteristics of SRI

What makes SRI considered as an effective innovation? According to Mishra et al. (2006), SRI has become an effective method for rice farmers because it can offer them a chance to learn or use new knowledge by adopting their own local requirements with less external inputs. At this point, CIIFAD (2002) concluded that SRI is literally considered as a “system” rather than a “technology” since this system is not a fixed set of practices but a flexible one. It can be practiced or tested based on the local conditions of adoption. SRI encourages rice farmers to consider about the biological concerns by applying natural fertilizers to grow healthy crops. Therefore, SRI methods are different from the conventional practices that farmers have normally applied chemical fertilizers and spent much on external inputs. A brief summary of explanation on those differences is in the following table.

Table 5: Comparison between SRI Methods and Conventional Practices

Cultural Practices	Conventional	SRI
Age of transplanted seedlings	3-4 weeks, or sometimes more	8-12 days, generally not more than 15 days
Number of seedlings per hill	3-4, and sometimes more	1 seedling or sometimes 2 if soil conditions less good
Spacing of seedlings	Dense planting: 10-20 cm apart, in rows; 50-100 plants/m^2	25 x 25 cm to 35 x 35 cm, in square pattern, 16 to 9/ m^2; with best soil, up to 50 x 50 cm, may have only 4/ m^2
water management	Continuous flooding, 10-20 cm depth, through the entire growing period	Keep soil from being continuously saturated during vegetative growth period; minimum water applications to maintain soil moisture, or alternating flooding-drying; shallow flooding (1-3 cm) during reproductive period
Weed control	Mostly through flooding; manual or chemical weed control as needed	Weeding with simple mechanical, recommend up to four times, done also for soil aeration
Fertilization	Application of NPK fertilizer as recommended	Application of compost recommended

Source: N. Uphoff (2003)

Based on the table above, SRI methods were innovated by reducing the weight of seeds and the amount of water. Importantly, they require fewer seedlings, wider spaces for transplanting and compost application. Regarding their characteristics, SRI methods can fall into the "Agro-ecological Approaches". These approaches were explained to find the higher and sustainable outputs from agricultural systems by (Uphoff, 2003):

- "enhancing beneficial biological interactions and synergies. For example, through poly-cropping, plant-animal complementarities, and the use of organic material;
- drawing on diverse species and genetic resources below as well as above ground;
- managing the soil as a complex biological system to sustain its health and fertility;
- minimizing losses of energy and other growth factors through practices such as mulching and zero-tillage; and
- recycling nutrients as efficiently as possible to ensure balanced and sufficient nutrient flows over time (Altieri, 2002 cited in Uphoff, 2003)."

3.6.2 SRI versus Green Revolution

"Green Revolution" was defined as the series of agricultural changes in cereal production which occurred after 1965 (Nagarajan, 2004). Based on the science dictionary (The American Heritage Science Dictionary, n.d.), green revolution is referred to "the application of science to increase agricultural productivity; including the breeding of high-yield varieties of grains; the effective use of pesticides; and improved fertilization, irrigation, mechanization, and soil conservation techniques". To sum up, the definitions of Green Revolution from various understanding convey the same meaning. Therefore, to make it short and clear "Green Revolution" is the new technique used to increase the yields, especially rice and wheat.

Although Green Revolution is well-known in increasing the paddy production, it has its serious side effects in the future. One of the worst effects of Green Revolution is to cause environmental pollution—soil and water pollution. Practicing Green Revolution or using HYV (High Yield Varieties) seeds requires farmers to use large amount of chemical fertilizers for soil quality improvement and pesticide and insecticide for the increase in the yields. Chemical fertilizers can provide the good result only for a short period, but eventually the quality of soil will decrease. Moore and Parai (1996) said that using large amount of chemical fertilizers does not rebuild the soil fertility and using those pesticides decrease the resistance of soil to diseases. The study of Society for Promotion of Wastelands Development in the 1980s showed that in India 39 % of 329 million hectares in total were deteriorated (Brown Lester, 1988).

Unlike Green Revolution, SRI methods provide the agricultural sustainability in terms of reducing the amount of chemical fertilizers, fossil fuel that is used for machinery in Green Revolution and other external inputs. Additionally, SRI methods offer the ability and willingness to rice growing farmers to be good in growing healthy crops (Mishra et al., 2006). Thus, it is very important to raise awareness of farmers on the organic food as well as how to protect themselves from the harms of using chemical fertilizers. Last but not least, SRI methods empower the farmers to gain the merits of biological conservation and control by using local biodiversity to manage pests instead of using pesticides or insecticides (Gallagher et al., 2005 cited in Mishra et al., 2006).

3.6.3 Experiences of SRI Practices

SRI trials on 1,363 hectares in Indonesia conducted by Nippon Koei by the end of 2005 provided the average yields of 7.23 tons/ha; while conventional methods did only 3.92 tons/ha (Satyanarayan et al., 2007). Another positive effect of SRI was also found in the Philippines. Again Satyanarayan et al. (2007) reported that in 2003 SRI methods yielded around 7.33 tons/ha which was more than double to the conventional methods did only 3.66 tons/ha. From these results, SRI is really a practical innovation in farming system in order to improve the paddy production. Therefore, it can be a tool to improve the economic status of farmers by increasing paddy production for commercial activities and to ensure the food security. Table below illustrates more experiences from other 10 countries.

Table 6: Average and Maximum SRI Yields versus Comparison Yields from 10 Countries

Country	Average Comparison Yield (t/ha)	Average SRI Yield (t/ha)	Average Maximum SRI Yield (t/ha)
Bangladesh	4.9	6.3	7.1
Cambodia	2.7	4.8	12.9
China	10.9	12.4	13.5
Cuba	6.2	9.8	12.7
Gambia	2.3	7.1	8.8
Indonesia	5.0	7.4	9.0
Madagascar	2.6	7.2	13.9
The Philippines	3.0	6.0	7.4
Sierra Leone	2.5	5.3	7.4
Sri Lanka	3.6	7.8	14.3

Source: N. Uphoff (2003)

According to the above table, China is recorded with the highest average SRI yields; followed by Sri Lanka, Cuba, Indonesia, Madagascar, Gambia, Bangladesh, The Philippines, Sierra Leone and Cambodia. Besides these mentioned countries, Tamil Nadu state of India is recorded as the most intensively SRI adopting state. Based on Sothy (2008), during the main seasons of 2007-2008 in Tamil Nadu state, there were 430,000 hectares of SRI application. The next current year after 2008, the Indian Ministry of Agriculture stated that the target was 750,000 hectares.

3.6.4 Advantages and Disadvantages of SRI Methods

SRI has been proved by farmers, researchers, practitioners or some NGOs on the positive effects on rice growing such as higher rice yields, less water requirements, and less inputs, etc. Practicing SRI, however, might face some difficulties. Next is the detailed discussions on advantages and disadvantages of SRI methods with supporting information from some reports or journals.

Advantages of SRI Methods

- *Higher yields and incomes:* practicing SRI can increase the yields than doing the conventional ways do as mentioned above. Video on SRI prepared by the World Bank Institute shows that SRI can increase in both yields and incomes for the cases in India, Indonesia, Cambodia, Vietnam and the Philippines (Retrieved on August 1, 2012 from http://info.worldbank.org/etools/docs/library/245848/files/flash/SRI_applying/index.html). In India, additional 2 tons were earned; compared to the conventional practices. Moreover, in China, farmers said that practicing SRI can increase the paddy production by 40% more; compared to the conventional practices (Retrieved on April 16, 2013 from http://info.worldbank.org/etools/docs/library/245848/files/flash/SRI_overview/index.html). In Cambodia, according to Satyanarayan et al. (2007), the evaluation reports of 120 farmers done by Cambodian Center for Study and Development in Agriculture (CEDAC) mentioned that farmers can increase their incomes after 3-year adoption from 460,700 Riels to 869,800 Riels.

- *Less water requirements:* water saving by practicing SRI is the critical point for some areas where water availability is a big problem. Uphoff (2008) proved that SRI can save water for irrigation from 25-50%. For example, in India, Africare et al. (2010 as cited in Glover, 2011) wrote that "a coalition of international NGO projects has described SRI as a method to reduce water consumption...," as policy makers and environmentalists understand SRI as a tool for speeding up the rice production with the water scarcity, climate change, and/or labor shortages. The five-year study in Indonesia on SRI showed that SRI could save water by 40% (Retrieved on April 16, 2013 from the link prepared by the World Bank: http://info.worldbank.org/etools/docs/library/245848/files/flash/SRI_overview/index.html).

- *Resisting ability:* in the Philippines, because of many longer roots and stronger stalks, SRI rice plants can resist the impact of typhoon and drought (Benaning, 2011). Additionally, according to Earth Day (April 22, 2012), it reported that SRI not only helps farmers increase yields, but also protects the environment from water logging, drought and flooding like in the case of Sri Lanka.

- *Lower production cost and seed-saving:* spending less production input costs also contributes to the increase in incomes. Another advantage of practicing SRI is to reduce the amount of seeds. Thus, farmers can save seeds for the next growing seasons, and for their consumption or for sale for additional extra incomes. In Indonesia, the experiment on land of 9,429 hectares proved that there was 20% reduction in the production costs and 50% in fertilizer application (Sato & Uphoff, 2007).

The above-mentioned advantages of SRI are really practical for farmers to try, especially the poor famers or small land holding farmers. There is no any economic risk to try these methods. However, other farmers have not yet started practicing SRI, due to some constraints or disadvantages of SRI as mentioned below:

Disadvantages of SRI Methods

- *Water control skills or ability:* in order to get the higher potential of SRI, farmers need to apply intermittent irrigation or other recommended irrigation, Alternative Wet and Dry (AWD) with the well leveled land. It is not easy for farmers who do not have access to reliable water or they are busy with other non-farming activities. Moreover, it may work well with smaller plots where water and weed can be controlled; however, it will not work with the large areas. In southern Russia with large areas of 3.6 hectares, implementing the water-saving irrigation is difficult because land leveling and water management are poor. To intermit irrigation can cause the yield deduced due to the drought stress, weed growth and nutrient loss (Dobermann, 2004). As the result, this can increase the weed population and decrease the nutrient availability as compared to continuously flooded areas.

- *Labor intensive:* this occurs during the first 2 or 3 years of practicing SRI. Some farmers with fewer members or less labor sources find these methods difficult to practice.

Therefore, labor intensive work is the barrier for farmers to adopt the SRI methods (Fernandes & Uphoff, 2002).

3.6.5 SRI Development towards Sustainable Development

SRI methods are believed to be the new innovation for agricultural sustainability as well as for the sustainable development in terms of environmental aspects. As mentioned above, one of the special characteristics of SRI methods is to recommend or encourage farmers to use compost instead of applying chemical fertilizers. This shows that practicing SRI methods can contribute to raising awareness of the environmental conservation. There are no soil quality degradation and water pollution, but sustainable development and friendly environment.

Practicing SRI methods were reported to reduce the amount of water usage about a half (Uphoff, 2003). Also it can increase the productivity approximately 3.5 times greater. These are the advantages of SRI methods in saving water since now the water scarcity is a big concern due to the global warming. Besides that, by saving water, farmers are able to use the remaining water for daily using, vegetable watering and animal raising.

Again, SRI development contributes to the food security guarantee in terms of providing higher yields compared to other methods. Higher yields will provide enough rice supplies to feed the growing population. When every person is out of hunger, there will be a sustainable development. All in all, SRI development can ensure the sustainable development in terms of environmental conservation, water resources saving and food security guarantee.

3.6.6 SRI Practices towards Economic Growth

Not only do SRI practices contribute to environmental aspects, but they also lead to economic growth. It reported that SRI practices reduce the weight of seeds and chemical fertilizers and provide the higher yields. Moreover, SRI methods empower farmers to use local biodiversity resources to reduce the costs on other external inputs. Those things clearly show that SRI practices can improve the economic status of rice growing farmers, based on the findings on the economic analysis from agricultural economists visiting Sir Lanka (Uphoff, 2003). The findings showed that practicing SRI can increase the economic status in Sir Lanka. See the table 7 for more details.

Table 7: Economic Comparison of Rice Production System in Sri Lanka

	DSR (Direct-Seeded Rice)	SRI	Difference
Yield (t/ha)	4.5	8.0	+88%
Market Price (Rs/t)	1300	1,500	+15%
Total expenditure (Rs/ha)	22,000	18,000	-18%
Gross returns (Rs/ha)	58,500	120,000	+105%
Net returns (Rs/ha)	36,500	102,000	+178%

Source: N. Uphoff (2003)

3.6.7 SRI towards Human Resources Development

Besides its contribution to environment and economics, SRI also helps farmers find out new knowledge from the fields. Although there is no clear evidence to prove this claim, farmers unconsciously learn how to reduce the costs. As the aforementioned, farmers have tried to reduce the amount of chemical fertilizers which cost a lot and downgrade their health condition. Instead they have tried to increase the amount of natural fertilizers. The economic status can be improved because farmers can save the input costs and increase the yields by practicing SRI. This is the evidence showing that SRI can improve farmers' understanding beyond agricultural concepts. Besides understanding the environmental, physical and economic concepts, there are more newly discoveries that farmers can learn from their SRI practices.

3.7 Introduction of SRI in Cambodia

Agriculture plays an important role in the daily life of most Cambodian people due to naturally favorable agricultural condition. Most paddy growing farmers are able to produce rice for their family consumption, but only some can have surplus for sale. Additionally, based on the CEDAC's survey in 2009, on average around 60% of farmer households produced rice for their family consumption, while the rest could produce the surplus for sale (Yang Saing Koma from http://www.cedac.org.kh/Report%20SRI.pdf). Many people, however, are still living under the poverty line. Consequently, the best way is to improve the living standard of people in rural areas.

SRI is considered as the best practical method to improve the rice production. SRI was introduced to Cambodia in 2000 by CEDAC. Dr. Yang Saing Koma, director of CEDAC, learning about SRI from the ILEIA's newsletter in December 1999 (Yang, 2002). Moreover, he got more information about SRI from CIIFAD. From the beginning, only 28 farmers in four provinces had agreed to do the experiment by using SRI methods (Sothy & Rattana, 2008).

SRI has been viewed seriously in the Cambodian agricultural context as it leads to rural livelihood improvement and national economy development (Chhay, 2010). Therefore, SRI is expected to help farmers increase their rice production with ecological sounds. It can also assist farmers to adapt with climate change such as drought and flood. In this sense, SRI has been reflected as another way to mitigate climate change.

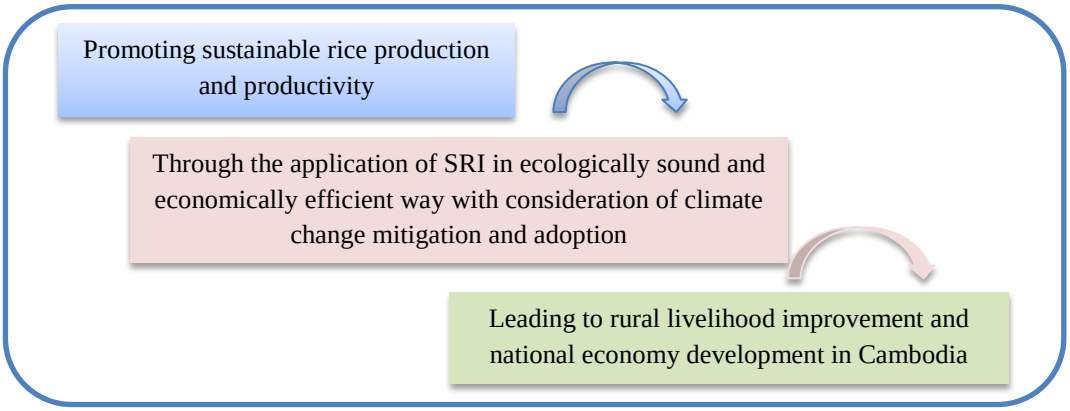


Figure 15: SRI Vision in Cambodia

Source: N. Chhay, 2010

3.7.1 SRI Principles

CEDAC has introduced SRI in Cambodia with 12 principles. Those principles are exactly the same as the original elements of SRI found by Father Henri. CEDAC just simplified and elaborated those elements to be easily understood by farmers. Twelve principles are as follows:

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

Source: JICA, May 2008. Draft Final Report on the Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia

These 12 principles have been adapted or adopted by farmers based on their conditions or abilities to apply these principles. Farmers are recommended to be flexible to apply these methods. Therefore, farmers are expected to be better at adapting these methods rather than adopting since the differences of the availability of water, labor and geography conditions could make some farmers hesitate to practice these methods.

Having seen the positive results from the practicing farmers during the first experiment, nowadays in Cambodia there are many NGOs, government institutions or other development agencies working in promoting and disseminating SRI methods. These efforts result in the increase in the number of farmers, number of villages, and size of SRI areas.

Table 8: SRI Practices in Cambodia

Description	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Number of SRI farmers	28	500	3,000	10,000	17,092	40,000	60,000	82,386
Number of villages	18	122	350	815	1,397	2,500	2,685	3,023
Number of provinces	4	7	11	14	17	20	24	24
Total SRI area (ha)	1.6	28.7	900	4,700	4,786	11,200	16,386	47,039

Source: Sothy (2008)

After 2007, the number of farmers and areas in Cambodia keep increasing due to the efforts of NGOs, international development agencies and government institutions, especially the Ministry of Agriculture, Forestry and Fisheries in Cambodia (MAFF). By the end of 2009, the Department of Rice announced that there were 110,530 farmers using SRI methods in Cambodia. The increase in the number of SRI farmers also results in the increase in SRI land areas. It jumped from 47,039 hectares in 2007 up to 59,785 hectares in 2009 (Chhay, 2010). Moreover, according to Cornell's website (http://sri.cals.cornell.edu/countries/cambodia/index.htm, retrieved on February 4, 2016), during the 4th National Farmers Conference held on April 4, 2013, minister of

MAFF reported that SRI is one of factors of the increases in rice productivity from 2.74t/ha in 2008 to 3.13t/ha in 2012. He continued that cultivated areas under SRI are about 101,719 ha with SRI households ranging from 150,000 to 200,000. This shows the positive acceptance of SRI methods by farmers. On the another hand, although the number of farmers accepting SRI methods keeps increasing, many farmers still do not believe in and practice these methods. They are still firmly holding the concept of traditional practices left by their ancestors. To change the mindset of farmers can be one of challenges for NGOs, government institutions and development agencies in promoting and disseminating SRI. However, the best results from SRI practicing farmers will be the potential tools to influence them.

Since the first start of disseminating SRI techniques, the 12 principles introduced by CEDAC have been applied in many project activities. However, the Department of Rice Crop of General Directorate of Agriculture in MAFF has compiled new SRI principles with only 9 basic principles. Although there is another revision of SRI principles originated by CEDAC, the main messages of SRI techniques remain the same. Just some small parts were combined and added. Below is the 9 SRI principles from the Department of Rice Crop.

1- Good quality seed usage
2- Dry Bed Sowing
3- Land Preparation
4- Transplanting or Direct Seeding
5- Seedling Application
6- Soil Fertility Management
7- Water Management
8- Pest and Weed Control
9- Harvesting and Storage

Source: Translation from the Leaflet on "The Technical Components of Rice Intensification" prepared by Department of Rice Crop of General Directorate of Agriculture cooperating with Oxfam in March, 2012

In addition, based on the recent published article by CDRI (June, 2015) on the discussion of adoption and adaptation of SRI practices, 8 SRI practices were listed with the details of each practice. Those practices are: (1) variety selection focusing on various kinds of varieties such as high yielding, pest, drought and flood tolerant, ecosystem suited, and market demanded varities; (2) seed preparation; (3) field preparation based on the plowing, harrowing and leveling works; (4) seedlings, (5) planting methods determining direct seeding or transplanting application; (6) fertility management referring to organic or inorganic fertilizer application; (7) water management discussing on water storage, water depth in the field and intermittent irrigation application; and (8) weed management.

Up to now, most of SRI promoting NGOs have been followed the new principles revised by the Department of Rice Crop. Although the number of SRI principles varies from one NGO to another or from one institution to another or from one practitioner to another, the main messages of SRI are still the same in an attempt to increase the rice yields with less input cost and ensure the environmental sustainability.

3.7.2 SRI Field Demonstration and Farmer Practices

In order to get more attention from farmers on SRI, field demonstration is the best way. Oxfam America (OA) cooperating with General Directorate of Agriculture (GDA) in Kampong Thom province conducted the field demonstration on SRI practices. One of the main objectives of this

field demonstration was to provide recommendations on best rice cultivation methods to improve production and the response to flood related disaster (Report on SRI experiments and field demonstrations in dry season in Kampong Thom 2009-2010 prepared by Department of Rice Crop of General Directorate of Agriculture in cooperation with Oxfam America).

There were 13 field demonstrations conducted in farmers' fields from November 2009 to April 2010 in four districts of Kampong Thom province. SRI plots were transplanted with one seedling aged less than 15 days with space of 30x30 cm, 25x25 cm or 20x20 cm based on soil types. Fertilizer application was based on recommended conditions and weeding was based on field conditions. Farmers' plots were transplanted with 4-5 seedlings aged 25-30 days with space of 15x15 cm. Fertilizer applications and pest management were based on farmer practices.

As results, the average yield of SRI application was 5.61 tons/ha and the average one of farmer practices was 3.09 tons/ha for IR66 variety, whereas for the Malis Sral variety, SRI plot provided yield of 6.22 tons/ha compared to farmer practices of 3.82 tons/ha. In the economic term, the analysis also gave the credit to SRI methods. Based on the economic analysis of this report, the benefit from SRI Field was 2,270,200 Riel compared to farmer practices of 875,800 Riel. SRI methods not only provide higher yields but also improve the economic status of farmers.

Thanks to this experiment as well as the report, differences between SRI methods and farmer practices were shown clearly. Although it was not from real SRI practices of farmers, it can give a big image for farmers to consider or change their traditional practices.

3.7.3 SRI in Rain-fed Areas

As mentioned in disadvantages of SRI practices, water management is the most difficult task for some farmers in rain-fed areas where proper irrigation system is lacking. However, SRI has been promoted in such rain-fed areas. Here is the sample of SRI practices in the rain-fed areas done by one local NGO named Partnership for Development in Kampuchea (PADEK). Although SRI practices by farmers were supported by that NGO and are not the real practices without any support, this sample is useful to make a meaningful discussion in the later chapter between the results of this sample with the research results from real practices of this research.

All summarized project results that are going to be shown here are from the PADEK report. The project entitled "Integrated SRI into Community Development Project" was done by PADEK in Svay Rieng and Prey Veng provinces located in the Southeast of Cambodia (Soksithon & Kannaro, 2012). Svay Rieng and Prey Veng provinces are vulnerable to drought and flood. The majority of local farmers in these two provinces heavily depend on rice production for their food and incomes. The rice farming is rain-fed rice growing possibly done only once per year. Before the SRI project started in these two provinces, the past farming situations were (1) low yields only from 1.2 to 1.35 tons/ha; (2) soil degradation; (3) limited access to technical information and support in rice intensification and agricultural diversification; and (4) high cost inputs. Due to these serious problems, PADEK has set 5 main objectives to improve the past farming situations. Those main objectives are as follows:

1- To improve the capacity of farmer experts on SRI techniques;
2- To enhance the cooperation with commune councilor and district and provincial agricultural offices;
3- To form SRI farmer groups;
4- To build capacity of SRI farmer groups to apply SRI techniques; and
5- To maintain and strengthen the existing SRI farmer groups

After one-year activities in these two provinces, PADEK had shown the SRI results from 10 farmers in each province compared with those of the traditional practices.

Table 9: SRI versus Conventional Results in Svay Rieng and Prey Veng Provinces

Province	Description	Conventional	SRI
Svay Rieng	1- Seed use (kg/ha)	57	***15.20***
	2- Yield (t/ha)	2.01	***2.80***
	3- Average number of tillers per hill	5	***11***
	4- Average number of panicles per hill	5	***10***
	5- Average number of rice grain per panicle	81	***112***
Prey Veng	1- Seed use (kg/ha)	129	**12**
	2- Yield (t/ha)	1.71	**3.21**
	3- Average number of tillers per hill	7	**28**
	4- Average number of panicles per hill	6	**28**
	5- Average number of rice grain per panicle	251	**265**

Source: Annual Narrative Report on Integrated SRI into Community Development (KHM 007/01)

Regarding the above results, it can be concluded that SRI has effectively worked in the rain-fed areas where water availability is limited. In Svay Rieng province, farmers reduced the amount of seeds for sowing or transplanting approximately 73.33% from 57kg to 15.20kg per ha. The yields increased from 2.01t to 2.80t per ha. In Prey Veng province, the percentage of change in the amount of seeds is 90.69% (117kg of seeds has been saved). The yields increased significantly from 1.71t/ha (Conventional) to 3.21t/ha (SRI) about 1.5t/ha in difference. These show the positive results of SRI practices in the rain-fed areas of Cambodia. In somehow, SRI not only increases the yields but also can help farmers save a big amount of seeds. By saving a huge amount of seeds, farmers can use the remainings for the next growing season, consumption or sale for extra incomes. More importantly, it can reflect that even in the drought or flooding areas, SRI can be still adopted.

3.8 SRI, a Climate-Smart Agriculture

Since matters on climate change adaptation and mitigation have attracted so much attention from researchers, institutions and donors, these concerns have been prioritized in many development projects. While, most of developing countries still depend on agricultural sector as main incomes to nation as well as to poor households; therefore, to deal with drought and flood is considered as the best solutions in rural areas. This is also happening in rural areas of Cambodia. According to DANIDA (2008 cited in CDRI, 2012), it reported that Cambodia has a high vulnerability to climate change and current capacity to deal with these issues is still limited. The clear evidence is based on the recent 2011 flooding. It destroyed 267,184 ha of paddy and around 21,929 ha of

other crops (RGC, 2012 cited in CDRI, 2012). Therefore, in order to deal with climate changes; especially their impacts on agriculture, and to build resilience, adoption of the climate-smart agricultural practices is recommended (CDRI, June 2015).

This concept is new but FAO (2013) has defined climate smart farming as "*agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gas (mitigation), and enhances achievement of national food security and development goals*". Because of SRI's advantages such as water requirement reduction, yield increasing and local inputs application, it has been considered as one of climate smart farming practices (CDRI, June 2015). Therefore, now many NGOs, donors and government agencies have put much effort in promoting SRI, in the hope of helping poor farmers adapt with climate changes and have better livelihood.

3.9 Evidences on Aspects Affecting Adoption and Not Adoption of SRI

Although SRI practices have been promoted with the effort of government agencies, NGOs and donors, there are some aspects affecting on the decision of SRI adoption. Based on the study conducted in some provinces around Tonle Sap and Lower Mekong areas by CDRI (June 2015), the results have listed the aspects that attract farmers to adopt and stop farmers from adopting SRI. Those positive and negative aspects are noted here.

Positive Aspects are:

- reduced labor requirement for transplanting, broadcasting and weeding;
- suitability for small farming systems;
- positive results;
- positive mindset;
- sufficient water;
- availability of pure seeds, organic materials, fertilizers and machinery;
- access to markets, technical information and rural institutions;
- reduced risk;
- high yield; and
- lower weed density.

Negative Aspects include:

- Labor requirement for transplanting, leveling, weeding and inspecting water level;
- unsuitability for multiple or large plots;
- traditional mindset and habits;
- insufficient water;
- lack of production inputs;
- limited access to market, technical information and rural institutions; and
- risk associated with lower seeding rate/transplanting density and higher weed density.

From the found aspects mentioned above, some positive and negative points are overlapped. This means that farmers can access to different resources in practicing SRI. For example, farmers have adopted SRI because of sufficient water; while others have not due to the insufficient water. Moreover, different accessibility to market is also one of major concerns. While as, farmers' mindset has played an important role in adopting or not adopting SRI. Agreed with the discussion in this study by CDRI (June 2015), more extension works and irrigation development and improvement of market accessibility are needed to increase the adoption of SRI. Importantly, farmers are recommended to adapt rather than to adopt SRI; based on their paddy fields' condition and resource availability.

3.10 Evidences on Labor Requirement: SRI versus Conventional Practices

Labor inputs for rice farming are still concern for most of farmers; especially who cannot afford the technology. In Cambodia, conventional rice farming is believed to be a labor-intensive farming. Farmers need to work all days in the field or spend a lot on the hired labors. In order to solve this problem, NGOs and relevant institutions have been trying to promote new farming technique here so called the System of Rice Intensification (SRI). However, there are controversies or debates on labor inputs for SRI. Some claimed that it can reduce the labor cost; while other said it cannot. Moreover, as mentioned-above on disadvantages of SRI, Fernandes and Uphoff (2002) said that labor-intensive work hinders farmer from adopting SRI methods but this problem occurs only for the first start of practicing, labor will be reduced based on the experience of farmers. To make it clear, there is a study conducted on the labor requirement for SRI practices with conventional practices in Cambodia. The next discussion will be utilized some results of Ly et al. (2012).

Ly et al. (2012) conducted the survey with 207 households in two districts (106 in Tramkak district of Takeo province and 101 in Santuk district of Kampong Thom province). Farmers in Tramkak were selected due to their earliest SRI adoption (since 2001 after the introduction of SRI in Cambodia in 2000 according to Yang, 2002). Agriculture there mostly depends on rainfall and is considered as rain-fed area. On another hand, farmers in Santuk district have adopted SRI since 2003. Unlike, Tramkak, Santuk is equipped with well-established irrigation system. The survey was done as focus group discussion and in-depth interviews in the early 2010 just after the end of farming season 2009-2010. The rice farming there was divided into 3 techniques by Ly et al. (2012): System of Rice Intensification-Influenced Practices (SRII), Conventional Management Practices (CMP), and Direct-Seeded Rice (DSR).

Table 10: Results of Labor Requirement from Evident Study (work-days*/ha)

Rice cultivation stage	Tramkak		Santuk		
	SRII	CMP	SRII	CMP	DSR
Seed bed preparation and nursery	4	4	3	3	1a
Land preparation	13	9	8b	7b	9b
Uprooting	3	16	9	12	1a
Transplanting	17	11	20	20	2a
Fertilization	5	4	3	2	1
Weeding	20	9	10	0	0
Water management	14	10	5	4	4
Harvest and transport	32	32	27	26	24
Threshing and storage	20	21	5	5	5
Total	***127***	***114***	***90***	***78***	***47***

Source: Ly et al., (2012)

** One work-day is defined as 8hrs of labor.*

a*: Some labor demand for seed bed preparation, uprooting and transplantation is present in SDR because some seedlings do not re-establish after plowing, so farmers must supplement with additional transplantation.*

b*: Land preparation takes only three work-days if using the plowing moto-cultivator. In Santuk, about 39% of the households interviewed use one, whereas in Tramkak all but one farmers use cattle.*

The table above, in both districts, shows that SRII required more labor than both CMP and DSR which requires the least labor inputs. Moreover, according to Ly et al. (2012), farmers generally happen to use their own labor for all works; just in case of peak period such as transplanting and harvesting, farmers need to ask help from their neighbors to exchange the labor or hire laborers. This kind of practice is commonly seen all elsewhere in rural areas of Cambodia. Mostly, farmers use their own family labor and during the labor shortage they need to hire extra laborers.

3.11 Agricultural System Adoption in Cambodia

Even most of recent reports on SRI show the positive points or good results of SRI practices, the adoption rate is still slow. CDRI (June 2015) explained some aspects on SRI adoption and non-adoption as explain in the earlier part. From that discussion, those aspects are overlapped from the adopters and non-adopters' viewpoints. These make adoption process complicated. Because farmers' perception on new system or innovation techniques is difficult to prove, Rogers (2003 cited in Farquharson et al., 2013) explained five different attributes of systems or techniques related to the characteristics of adopters. Those five attributes are (1): relative advantage which is understood to be better than old practices; (2): compatibility which is believed to be consistent with the existing values, past experiences, and needs of potential adopters; (3): complexity which is perceived to be more difficult to apply; (4): trialability which can be tested or adopted with a limited basis; and (5) observability whose results can be seen or visualized to others. Regarding these attributes, Farquharson et al. (2013) did the study on rhizobium adoption of Cambodian farmers. Their results significantly showed that because of relative advantage and observability, farmers decided to apply rhizobium; while, other attributes had no significant influence. Importantly, gender and age of farmers were found to have no significant to adoption. Based on this study, it can be made a draft conclusion that Cambodian farmers are willing to adopt the new innovations or systems based on its better results which can be exposed to their vision.

These attributes also can be applied to SRI adoption in Cambodia. Here can primarily explain that in general farmers do not adopt SRI because of trialability, compatiabilty and complexity of SRI methods. The first introduction of SRI to farmers in Cambodia by CEDAC was done based on the 12 principles which less irrigation is included. These principles are a bit complicated for farmers to apply and much different from their traditional practices. Moreover, to apply less irrigation is difficult or risky for farmers. Based on the recent report by Farquharson (June 2015), one of findings from workshop conduced in O'Adnoung village of Pailin province were written that farmers there consider rainfall as the needed primary factor to improve their farming products. Again, water or irrigation is every important for Cambodian farmers.

Regarding other factors influencing the SRI adoption, other research found that the number of household members at working age has no significant on the first decision of adoption in case of farmers in Timor Leste (Noltze et al., 2012). Moreover, Noltze et al. (2012) also found that less years of schooling may not be much related to rice farming. However, based on the study conducted by Khoy et al. (2016) in Cambodia on organic rice farming (not on SRI practices) found that level of education of the head of family has significant relation with the new farming techniques. From these various findings, it can be concluded that there is no clear explanation on factors directly influence the farming system or innovation; especially for SRI practices.

Moreover, farmers' characteristics are also considered as the obstacles for new farming system or innovation adoption. For Cambodian farmers, due to resource constraints (trialability and campatiability), risk aversion, lack of information and technical assistant, and lack of crop insurance, they have not changed their farming practices (based on the article entitle Cambodia Farms at risk written by Charles Rollet issued on the Phnom Penh Post on 14th October, 2014 accessed by http://www.phnompenhpost.com/national/cambodia-farms-risk, retrieved on 07th May, 2016). Therefore, Cambodian farmers are considered as the risk-averse farmers. Moreover, other reasons affecting the farmers' decision on new system adoption were also found. Based on the project report written by Farquharson and Cook (June 2015), Cambodian farmers' perception is that they expect their next generation to escape from being farmers; also report wrote that farmers do not adopt the new system, innovation or technology due to the opportunities of off-farm incomes. However; some farmers also said that they also want to adopt but they are reluctant due to weather or rain, production prices and their accessibility to market.

Therefore, to fully understand the farmers' perception on new system, innovation or technology adoption is still complicated and needed more studies and research. Moreover, recently it is hard to make conclusion on what factors affect and do not affect farmers' decision as Chouichom and Yamao (2010 cited in Khoy et al., 2016) concluded that farmers' perception on new farming adoption; especially for organic farming, depend on their applied location and their personal, farming and economic characteristics. This conclusion or result responds well to the ideas of Farquharson et al. (2008). They said that farmers' perception and attitudes will be context-sensitive; therefore, they suggested that technology or innovation dissemination should be taken in to account within the local social framework for indigenous farmer groups.

3.12 Changes in SRI Practices

Although practicing SRI requires farmers to follow its basic principles, those are only for the beginners. Based on experiences or desire to learn new things, SRI farmers or users can change the original practices over time and in different circumstances (CIIFAD, 2002). The following discussion was prepared to further understand the changes of SRI practices done by SRI farmers or users.

3.12.1 Age of Seedlings

Farmers were explained to use young seedlings with less than 15 days (CIIFAD, 2002). However, from their own experiences, some farmers have used seedlings younger than 15 days. For example, one farmer in Cambodia has started to use seedlings with 3-day old. In Madagascar some farmers have used seedlings with the age of 4 days (CIIFAD, 2002). This shows that age of seedlings can vary based on the experiences of farmers and their desire to learn new things. Nevertheless, the age of seedlings can be older than the recommended one if farmers have found out new ideas. For instance, some farmers can use very old seedlings by practicing SRI based on the varieties and climate conditions (CIIFAD, 2002). In short, by practicing SRI, farmers can be flexible based on their experiences in order to improve their rice production. They can learn more beyond what the basic they were introduced and explained.

3.12.2 Transplanting

One seedling per hill is strongly recommended for the better growing condition. Transplanting with care is the principle in order to avoid the trauma to the root condition affected by the uprooting. Uprooted seedlings must be put in the field no more than 30 minutes (CIIFAD, 2002). Nevertheless, some farmers in Madagascar have tried the direct seedling in order to avoid the trauma to the root condition. It was reported that there is no difference in yields compared to the normal transplanting but farmers can save time for labors (CIIFAD, 2002). Two seedlings or more are also accepted depending on some reasons. Again there is yet clear evidence to support this claim but here are some assumptions. Farmers might use two seedlings because of the sensitivities of natural harms. Uncontrolled number of crabs in the field can destroy the only one seedling. Uneven paddy field can make some parts of the field flooded then one seedling can be spoiled. These are what farmers concern about the transplanting with only one seedling.

3.12.3 Spacing

Based on the basic principles of SRI, for the beginners, recommended space from one plant to another is 25x25cm (CIIFAD, 2002). However, the highest yields were obtained with the wider space up to 50x50cm. The space varies from one place to another based on farmers' experiences, varieties and field conditions. In order to know the exact practical space, experiment is needed. Then no particular spacing is recommended as the ideal for all farmers and all fields (CIIFAD, 2002). In short, "wider spacing" is the best recommendation for SRI farmers. Traditionally, farmers use narrow space in order to increase the number of plants, then wider space is the starting point to practice SRI.

3.12.4 Soil Improvement

The discovery of SRI was firstly generated by applying chemical fertilizers in Madagascar in the 1980s (CIIFAD, 2002). After that many trial cases showed that higher yields could be obtained with the application of compost rather than with the applications of NPK (CIIFAD, 2002). Therefore, by taking environmental issue into account and reducing the cost of chemical fertilizers, application of compost and other natural fertilizers is strongly recommended. Applying compost can enrich the soil fertility and soften the soil texture.

3.13 Differences between SRI Practices in Irrigated and Rain-fed Areas

SRI has been originally developed for irrigated rice and its potential has attracted many researchers or practitioners. Nowadays, it has been also spread to other rain-fed areas where farmers do not have access to irrigation. In the Philippines, rain-fed SRI was tested by Robert Gasparillo learning about SRI methods at the first international SRI conference in China in 2002. According to Gasparillo et al. (n.d.), after the conference, arranged 20 farmers' plots were on trials from June to September 2002 in Negros Occidental province. As results, without any irrigation the average yield was 7.2t/ha compared to typical yield of 3t/ha. It was noticed that best spacing (20x40cm) could provide a yield of 7.7t/ha. Other experiments and trials on rain-fed SRI in other countries are summarized in the below table showing the comparison between irrigated SRI and rain-fed SRI based on the results of on-farm and on-station performances.

Table 11: Irrigated SRI versus Rain-fed SRI

Country	Irrigated SRI*			Rain-fed SRI**		
	Description	Average Traditional (t/ha)	Average SRI (t/ha)	Description	Average Traditional (t/ha)	Average SRI (t/ha)
Madagascar	11 on-farms 3 on-stations	2.6	7.2	Replicated trials	0.8-1.5	4.02
India	On-farm trials	4.0	8.0	SRI-users	2-3	7.2
Philippines	4 on-farms 1 on-station	3.0	6.0	20 Trials	3	7.2-7.7
Myanmar	121 Farmers field school trials	2	5.38	Farmers Field School	2	6-7

Source: * Roberto V., (July, 2008); ** Uphoff, N., (n.d.)

Table 11 indicates that in general SRI methods provide higher yields than traditional ones in both irrigated and rain-fed areas, owing to on-farm and on-station experiments and Farmers Field Schools. In the case of Madagascar and India, irrigated SRI provided higher yields than rain-fed SRI. However, in the case of the Philippines and Myanmar, rain-fed SRI did provide the higher yields than irrigated SRI. These cases can be interpreted that in some areas irrigation system does not help much. However, there is no clear explanation about conditions of irrigated and rain-fed areas where those experiments done.

3.14 Debates over SRI Practices

The above-mentioned SRI method is believed to be a new agricultural innovation which helps increase the rice production. Many studies and most publications claimed that SRI methods provide higher yield than that of the conventional ones for irrigated rice (Stoop et al., 2002). Moreover, Fernandes et al. (2002) also gave a summary of SRI reports about SRI practices in 17 countries. Comparison between SRI and control treatments or here called conventional irrigated rice management was 6.8 Mg/ha and 3.9 Mg/ha. Still, some scientists and researchers do not support those claims about SRI advantages.

Dobermann (2004) argued that there are no clear descriptions about the site characteristics in most of the papers published in Uphoff et al., (2002). He emphasized that no sufficient explanation about the sampling methods, field management, soil and statistical data analysis, etc. that lead to the validity of the reported results. Additionally, Dobermann also questioned about the clear explanation of the plot management mainly on the conventional plots. For example, 3.9 Mg/ha is an average grain yield of conventional plot claimed by Fernandes et al., (2002). This average is less than the current global average irrigated rice yields of 5.3 Mg/ha (Dobermann, 2000). These are the weak points discovered by Dobermann regarding the validity of SRI results reported in most of papers.

Uphoff (2002 cited in Glover, 2011) introduced the capability and experiences of Uphoff and Stoop in SRI. Uphoff used to be the former director of CIIFAD and a political scientist. He differentiated between SRI and Green Revolution. He emphasized that SRI is an approach based on ecological scientific principles. Stoop was a soil scientist then he started to involve in farming systems research. He learned and worked with farmers. Both of them have worked together on several articles about SRI. These can prove that they are clear about SRI experiences. Therefore, their SRI reports are reliable. Furthermore, what SRI methods can increase the yields is true and happening now. For example, in India SRI is involved with the framework of central government's National Food Security Mission and it is believed that SRI may be included in India's 12th five year plan 2012-2017 (Glover, 2011).

Although some researchers or scientists are against and support SRI methods, those critics and appreciation are only to seek for the clear images of SRI. The best solution to this debate is what farmers really experience. They can make final judgment based on their real practices. Therefore, farmers should try to practice SRI and report back to the scientists or researchers about their impressions of SRI.

3.15 SRI Promotion in Cambodia

3.15.1 SRI Secretariat and General Directorate of Agriculture

The dissemination and promotion of SRI are needed in order to make sure that all farmers can learn and apply it. To do so, SRI secretariat was established in January 2005 by the Department of Agronomy and Agricultural Land Improvement (DAALI) of MAFF with the technical supports from CEDAC and financial supports from GTZ and Oxfam (Sothy & Rattana, 2008), after the national workshop on SRI in Cambodia in April 2004.

General Directorate of Agriculture (GDA) has many functions to fulfill such as coordinating and disseminating document and information on SRI and promoting the networks among stakeholders. Furthermore, SRI Secretariat is also responsible for organizing working group meetings, SRI workshops, field visits and annual national conferences and maintaining and updating the SRI website and materials for printing out and broadcasting.

3.15.2 SRI National Advisory Board and Government Commitment to SRI

In July, 2010, MAFF, CEDAC, General Directorate of Agriculture (GDA), other development agencies and research institutions have proposed to establish SRI National Advisory Board (SRI-NAB). The purposes of formulating the SRI-NAB are to advise MAFF on policies and strategies to promote SRI and assist the SRI secretariat. Now, it is not clear whether SRI-NAB has been established. However, Government and other stakeholders have paid much effort to promote SRI. Other much effort is still needed because farmers still need more supports to improve their SRI practices.

By 2015 Government needed to fulfill the goals in the rice export policy, SRI has become the useful tool for improving the paddy production. In the annual conference of MAFF on April 04, 2010, the minister emphasized that SRI plays an important role in contributing to the increase in rice production in Cambodia.

3.16 Policies to Promote Agricultural Development

3.16.1 Rectangular Strategy

The Rectangular Strategy is the core strategy for the whole country development of Cambodia. The main core of the Rectangular Strategy is Good Governance surrounded by the four implementing environment and four strategic growth rectangles. Each growth rectangle has its own four sides (see Figure 16).

Agricultural sector falls in the Rectangle No.1 "Enhancement of the Agricultural Sector". This growth rectangle covers four sides (1) Improving agricultural and diversification; (2) Land reform and clearing of mines; (3) Fisheries reform; and (4) Forestry Reform. Agricultural development is the main actor for the economic growth and poverty reduction in Cambodia as well as for the food security in the country.

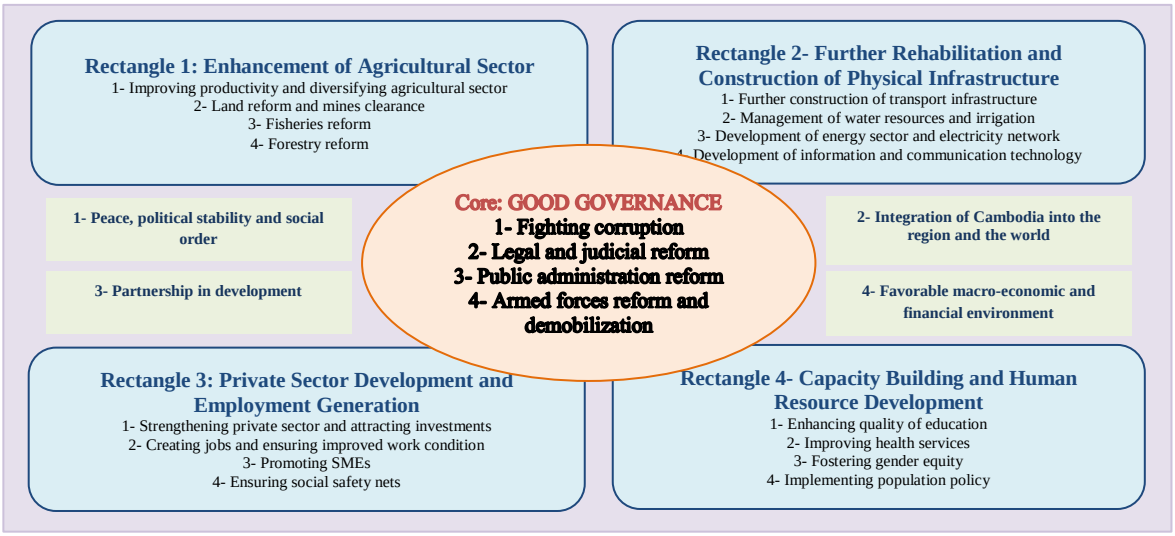


Figure 16: Rectangular Strategy Diagram

Source: ***Revised by the author from http://www.cdc-crdb.gov.kh/cdc/second_cdcf/session3/rectangular_strategy.jpg***

3.16.2 National Strategic Development Plan (NSDP)

In order to achieve all the goals set in the Rectangular Strategy, the Royal Government of Cambodia has established NSDP. The main purposes of NSDP are to reduce the poverty and implement the Government's Rectangular Strategy for the enhancement of all sectors, especially for agricultural sector (CDRI, 2010).

Besides that, the Ministry of Agriculture, Fisheries, and Forestry (MAFF) also assists the government to achieve the goals in the Rectangular Strategy as well as to support NSDP by formulating the Agricultural Sector Strategic Development Plan (2006-2010) including (1) food security, productivity and diversification; (2) improving and strengthening agricultural research and extension systems; (3) market access for agricultural products; (4) institutional and legislative development framework; (5) land reform, land tenure and pro-poor land access; (6) fisheries reforms; and (7) forestry reforms (CDRI, 2010).

3.16.3 Paddy Rice Production and Milled Rice Export Policy

The Royal Government of Cambodia (RGC) established the policy on the promotion of paddy rice production and export of milled rice with three clear objectives *(1) Strengthening the foundation of economic growth; (2) Accelerating poverty reduction; and (3) Improving the living standards of the Cambodian.* This policy was created because many Cambodian people are farmers and most of them are living in the poverty. Therefore, it is hoped that this rice policy can promote the living standard to grass-root levels as well the whole country. In order to achieve these three objectives, RGC had set the year 2015 as the target year to *(1) achieve paddy rice surplus of more than 4 million tons and achieve milled rice export of at least 1 million ton and to (2) ensure the international recognition of Cambodia rice called "White Gold"*.

Moreover, RGC had chosen the milled rice as a priority export items and paid much attention to this policy because of some rationales of strategic importance:

- Diversification of Cambodia's sources of growth through increasing paddy rice production and milled rice export could complement other sector growth, including garment.
- Rice sector could have a big potential comparable to that of the garment sector in terms of gross export value and value added generated throughout the supply chain including employment.
- The promotion of milled rice export is the first step to push other agricultural products such as rubber and other crops.

3.16.4 Results of the Milled Rice Export Policy

The end of 2015 was the deadline of rice export policy. However, there was an expectation that this policy will not be achieved. During the graduate ceremony of one university in Phnom Penh, the prime minister said that it is still too far to achieve this policy. Moreover, the minister of Agriculture, Forestry and Fisheries reported that by November, 2014 the amount of exported milled rice was about 330.000 tons only (based on the article from the Phnom Penh Post issued on December 19, 2014).

Prime minister continued that there are two main obstacles: (1) lack of investment in rice processing and (2) lack of capital to buy the rice stocks. Moreover, the chair of Cambodia Rice Federation also said that Cambodia might not able to achieve this goal. Lack of capital and investment is still a big challenge for Cambodia to export the large amount of milled rice to the international markets. Finally, this policy could not be achieved but the Gov't has improved much better in milled rice exports.

3.17 Rice Markets in Cambodia

This part discusses only the domestic rice market situation and system because the study of this research focuses or discusses only on the farmers' contribution to the domestic markets. Generally, formal rice market system in Cambodia is dealing with milled or processed rice (Singh et al., 2007); while, rough rice or paddy are being traded informally. It was reported that during the harvest of 2008, one million metric ton of paddy rice from Cambodia was informally exported to Vietnam (Phallyboth, 2009). Even now, local farmers still depend on this kind of

informal trade. The middlemen or brokers come to the farmers' areas and buy. They are able to determine the prices and demand for the products due to the limited information farmers have on the rice markets (CDRI, 2014). According to the very old survey conducted by the Ministry of Commerce of Cambodia in 2000, it showed that about 70 percent of farmers sold their paddy to middlemen directly with the limited bargaining power; while only 40 percent of them sold rice (Singh et al., 2007). In the domestic rice market systems, main players are farmers, middlemen, commercial mill, wholesalers or retailers, and consumers. The flow of rice market is shown below.

Although the market systems exist and still function, there are some major constraints directly or indirectly affecting those processes. First is the small amount of supply to the market due to the low production produced by the farmers. Cambodian farmers are still facing the low productivity because of low quality inputs such as fertilizers, seeds, irrigation and techniques. It was reported that farmers have lost their incomes from 285-350USD per year because of low quality fertilizers which were re-labeled and sold as high quality one (CDRI, 2014). Moreover, low production is also resulted from the poor seed quality. Although the MAFF is trying to introduce the ten new high yielding varieties, farmers are still practicing with their own seeds. This is because of the lack of the extension service plus the supplies of new seeds are limited. Only 20 percent of demands of new seeds have been fulfilled so far (CDRI, 2014). Constraints on irrigation and farming techniques have been already discussed in previous chapter and this chapter.

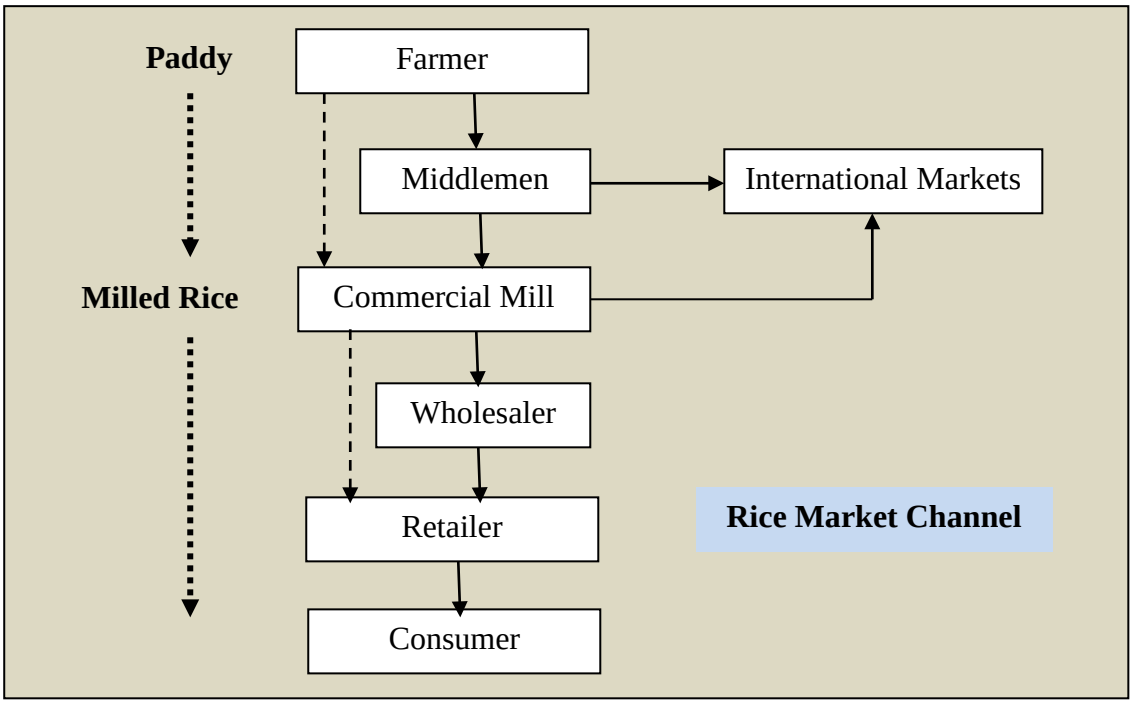


Figure 17: General flow of paddy and rice market in Cambodia

Source: Adapted from Hang Chuon Chamrong and Nobuhiro Suzuki_Characteristics of the Rice Marketing System in Cambodia: J.Fac.Agri., Kyushu Univ., 50 (2), 693-714 (2005)

Second challenge to the market systems is lack of physical infrastructure (CDRI, 2014). It is believed that poor infrastructure prevents the extension officers from directly providing the results of the research or new knowledge to the grass root level. Third is the expensive credit to the poor or vulnerable farmers. Farmers prefer to get the loan from the informal moneylenders during the shock or immediate needs rather than to get the loan from the micro-finance

institutions which require a lot of documents and collateral (CDRI, 2014).

Government and involving NGOs are working on solving these constraints by trying to provide better extension services, improving the buying and selling conditions, operating the farmer association which helps farmers to have more bargaining powers, and constructing or rehabilitating the infrastructures. However, in this study, SRI is recommended to be one of the practical techniques to help farmers increase their productions with less input. Moreover, this study explains as well as helps to inform policy makers the current situation of rice market at the grass root level and provide the new solutions to the existing problems.

3.18 Flow of Credit Accessibility for Rice Farmers

Agrifood Consulting International (ACI, 2005) emphasized that the cause of failure to move from low-input agricultural systems to more productive ones is that the farmers do not have enough access to working and investment capital. In Cambodia, Microfinance has popped noticeably (CMA, 2011); however, it has not been reachable for smallholder farmers due to uncertainty on agricultural returns and lack of official land titles (CDRI, October 2012).

Again owing to CDRI (October 2012), the study in Takeo province showed that most of farmers take loans mostly not for agricultural investment but for other purposes such as business running, migration, and household assets affording. Besides borrowing money from microfinances (MFIs), farmers prefer to take loans from informal moneylenders or their own existing saving groups in the villages with better conditions such as no collateral required. This is not happening only in Takeo province; most of provinces over Cambodia have the same situation. Another reason to take loans is due to the shocks such as sickness, accident or natural disaster. However, recently, some traders or local merchants have given loans to farmers who want to buy agricultural inputs with some interest. There some conditions applied such as farmers need to pay interest rate over the total cost, or farmers can return in the paddies or rice; instead of money.

Figure below indicates as well as explains the flow of credit access by various farmers included subsistent farmers, semi-commercial farmers and commercial farmers.

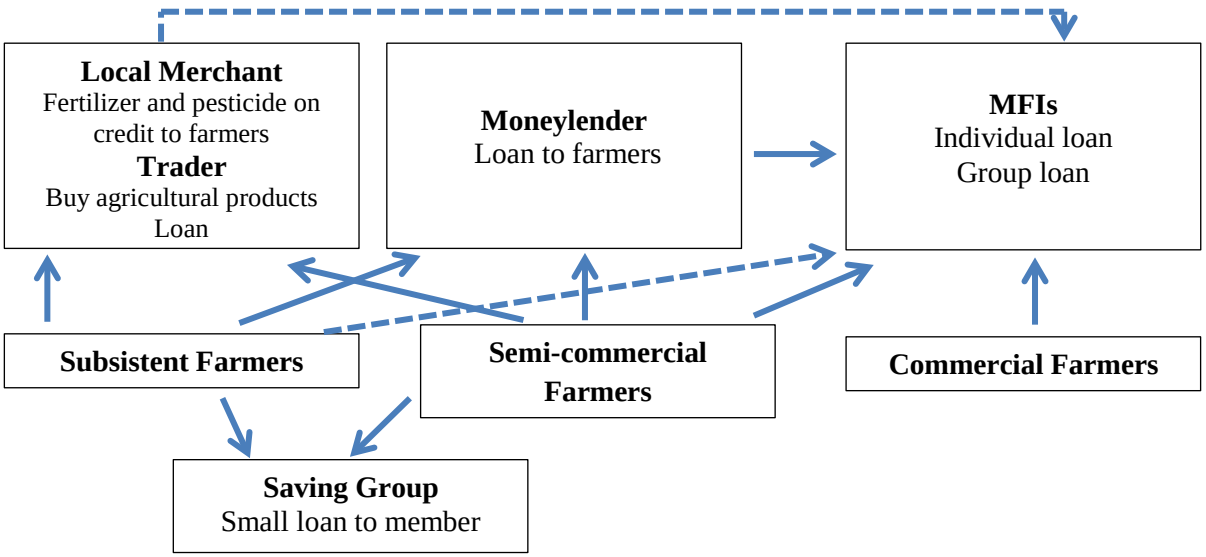


Figure 18: Flow of Credit Accessibility for Rice Farmers ***Source: CDRI (October 2012)***

3.19 "Social Capital" and Livelihood Improvement in Rural Areas of Cambodia

Increasing productivity and having better infrastructures are not enough to improve the livelihood in rural areas; social capital improvement also plays an important role as the World Bank (WB) states that in the progress of social-economic development in the society, social capital is an important push (CDRI, June 2012 cited in Krishnamurthy, 1999). Then social capital was defined by Putnam (1999) as "the features of social organization, such as networks, norms, and trust that facilitate coordination and cooperation for mutual benefit".

Social capital was categorized or divided into three dimensions (CDRI, June 2012 cited in Pellini & Ayres, 2005; OECD Insights: Human Capital retrieved on 30th May, 2016 from website of https://www.oecd.org/insights/37966934.pdf). First dimension is bonding social capital which links to people with a sense of common such as family, close friends and people sharing same culture; second dimension is bridging social capital which links to people sharing sense of identity such as colleagues, associates or distant friends; and the last dimension is linking social capital which links to people having upper social status such as authorities or government. Normally, bonding and bridging dimensions are connected in horizontal; while they are connected to linking dimension in vertical form.

The study on social capital and livelihood conducted by CDRI (June, 2012) in rural village of Prey Veng province showed that bonding relation is strong in rural areas because people seem to strongly trust their family members and relatives and in case of having risk, they seem to ask help from their relatives. Same condition applied in case of information sharing; while, it is unregulated or shared informally among outsiders or bridging and linking groups. This is really happening in the current rural areas of Cambodia; while information sharing is very important factor that can help people be able to access to opportunities that may improve their living conditions (CDRI, June 2012). For bridging relation, rural people are very supportive and cooperative in the village or community ceremonies; but they are defined as selfish and less willing to participate in activities for the benefit of the whole community; according to the UNICEF, 1996. It is more serious in case of the current status of linking relation. Again based on the study results of CDRI (June, 2012) indicated that people expressed a low trust in authorities and a high level of mistrust in political parties.

All in all, due to the lack of information sharing among the bridging groups, lack of participation in community and low trust in authorities, social capital in Cambodia; especially in rural areas causes the livelihood of people difficult to be better-off.

3.20 Sustainable Agriculture and Agricultural Sustainability

The word "Sustainability" has become a very important and critical term in development concepts. What Sustainability is defined has been given by many authors and scholars. According to the definition of Sustainability on NC State University's website, it defines that "the concept of sustainability centers on a balance of society, economy and environment for current and future health. Responsible resource management in all three areas ensures that future generations will have the resources they need to survive and thrive" (Retrieved on May 17, 2013 from website of NC State University, http://sustainability.ncsu.edu/about/what-is-sustainability).

Moreover, the same three main components of sustainability were also modeled by Wilkinson and Yencken (2000). They are all inter-related to create sustainability, shown in Figure 19.

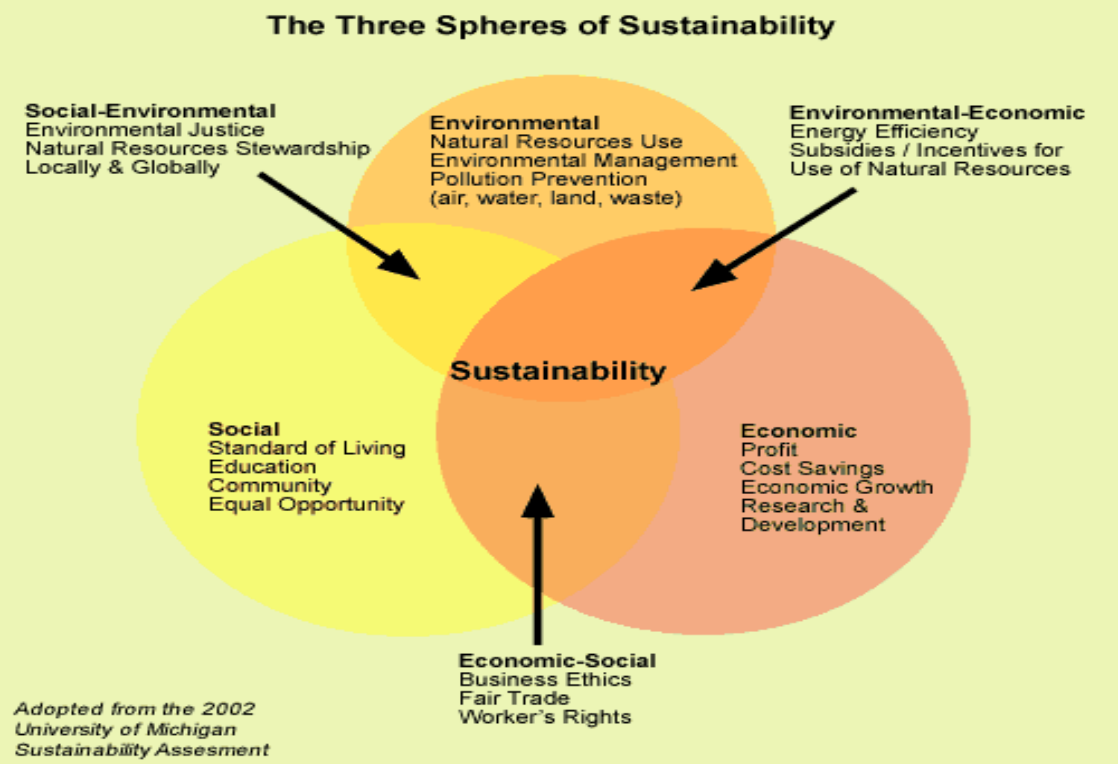


Figure 19: Concept of Sustainability

Source: Wilkson and Yencken (2000) cited on May 17, 2013, retrieved from website http://www.better-life.4utoc.com/saving_the_planet/environment_sustainability.php

As SRI is a new innovated agricultural system, it is believed that this system is one of sustainable agricultural systems. Then, sustainability of SRI is going to discuss here based on the general concepts of sustainable agricultural systems. Pretty (2008) said "sustainable agricultural systems tend to have a positive effect on natural, social and human capital, while unsustainable ones feedback to deplete these assets, leaving fewer for future generation". Therefore, discussion on SRI effects on 3 main factors of capitals including natural, social and human is elaborated below.

SRI towards sustainable development has already been discussed and explained in this chapter in the above section. As summarized here again, by practicing SRI, the amount of water for irrigation can be reduced from 20% to 50% as Uphoff (2008) already emphasized and proved this claim. Here, it can be said that SRI can save water, while water for irrigation is getting scarcer. This contributes to conserve the natural capital. Regarding the human capital development, the discussion was done in part of 3.6.7 in this chapter. For social capital development, the discussion will be done in the discussion part of this dissertation. However, it is assumed that SRI also positively contributes to social capital as farmers are believed to learn SRI from other farmers or in the same trainings with their people in the village or from neighboring villages.

Related to the context of agricultural sustainability, Pretty (2008) also mentioned that to ensure the sustainability in agricultural systems, those systems not only have positive effects on three main assets, but also have strong linkages with concepts of both resilience and persistence, and addresses many wider economic, social and environmental outcomes. Resilience here indicates

the capacity of systems to deal with shocks and stresses; while persistence is the capacity of systems to go on over long periods (Pretty, 2008). Therefore, whether SRI can build strong linkages is going to discuss in the discussion part of this dissertation.

Based on the results of other research, Benaning (2011) reported that, in the case of the Philippines, due to many longer roots and stronger stalks, SRI rice plants can resist the impact of typhoon and drought. This indicates the resilience of SRI to the shocks and stresses. On one hand, SRI has been disseminated and also been practiced by many farmers in many countries. Globally, nowadays, there are 45 countries supporting SRI (Uphoff, 2008). In Cambodia, the number of SRI farmers keeps increasing from 82,386 (Sothy, 2008) to 110,530 (Chhay, 2010) in 2007 and 2009, respectively. This number now goes up to more than 200,000 throughout Cambodia (Yang, 2012). This can reflect the persistence of SRI since the capacity of adoption and adaptation of SRI by farmers still going on. Moreover, it is believed that in the longer time, non-SRI farmers will be influenced by the successes of those SRI farmers. After that, non-SRI farmers will practice SRI. That process keeps going on and will lead to the sustainability of SRI.

Since SRI effects on social and environmental outcomes were already addressed in the earlier part, here mainly focuses on the economic outcomes. Again referring to the discussion in part of 3.6.6, SRI effects on economic aspects were already explained in the case of Sir Lanka. SRI provided higher yields and resulted in higher net incomes. For the economic analysis between Direct-Seeded Rice (DSR) and SRI, the net returns were 36,500 Rs/ha versus 102,000 Rs/ha, respectively (Uphoff, 2003). It was 178% difference. This shows that SRI also has the positive effect on economic outcomes. All in all, SRI not only responds well to the assets of agricultural systems, but also incorporates well in the context for agricultural sustainability. With these potentials, it can be concluded that SRI can be sustainable in the agricultural system. However, this sustainability will not happen if SRI is not disseminated or supported by external factors such as policies and financial support.

3.21 Summary of Discussion for Literature Review

Agriculture is still playing an important role in feeding the world population. Although the practices have been changed based on some uncontrolled or controlled factors, technologies help farmers increase their production. Rice is still the staple food for most of Southeast Asia countries. Better pre and post-harvest works and milling technologies are needed in order to reduce the losses. In Cambodia, milling ratio is still high. It is about 64 percent. It means that the loss ratio is 36 percent. Regarding the rice cultivation, water is the most important input. Since much water loses during the rice growing, 3 saving water methods were introduced: (1) reducing the depth of ponded water; (2) keeping the soil just saturated; or (3) applying alternative wet and dry (AWD). In Cambodia, water is the property of the state. Royal Government of Cambodia has viewed water as one of contributing priorities to poverty alleviation and economic growth since principally irrigated agriculture is of importance to address poverty by achieving food security and promoting income generation in rural areas. Farmers also need to pay for irrigation fee to their associations in their communities; however, payment collection is not going well due to some obstacles. Due to rapid growth of the world's population, food security has become a big concern for all countries. To fight against food shortage or hunger, new agricultural innovations to increase the food production have been continuously discovered. The System of Rice

Intensification (SRI) was discovered and has been applied in many countries. SRI is believed to increase the paddy production with less inputs and friendly environment. However, there are some discussions over the SRI's potential. In Cambodia, agriculture plays an important role in the daily life of most Cambodian people due to naturally favorable agricultural condition. Most paddy growing farmers are able to produce rice for their family consumption, but only some can have surplus for sale. Many people, however, are still living under the poverty line. Consequently, the best way is to improve the living standard of people in rural areas. SRI introduced to Cambodia in 2000 is considered as the best practical method to improve the rice production. Later, SRI has been viewed seriously in the Cambodian agricultural context as it leads to rural livelihood improvement and national economy development. Although the number of farmers accepting SRI methods in Cambodia keeps increasing, many farmers still do not believe in and practice these methods. They are still firmly holding the concept of traditional practices left by their ancestors. To change the mindset of farmers can be one of challenges for NGOs, government institutions and development agencies in promoting and disseminating SRI. Some positive and negative points on SRI adoption were found overlapped. This means that farmers can access to different resources in practicing SRI. For example, farmers have adopted SRI because of sufficient water; while others have not due to the insufficient water. Moreover, different accessibility to market is also one of major concerns. While as, farmers' mindset has played an important role in adopting or not adopting SRI. Therefore, more extension works and irrigation development and improvement of market accessibility are needed to increase the adoption of SRI. Importantly, farmers are recommended to adapt rather than to adopt SRI; based on their paddy fields' condition and resource availability. Labor inputs for rice farming are still concern for most of farmers; especially who cannot afford the technology. In Cambodia, conventional rice farming is believed to be a labor-intensive farming. Farmers need to work all days in the field or spend a lot on the hired labors. In order to solve this problem, NGOs and relevant institutions have been trying to promote SRI. However, there are controversies or debates on labor inputs for SRI. Some claimed that it can reduce the labor cost; while other said it cannot. Therefore, the main objectives of this study are to explain the labor distribution and irrigation application in the study area; also to study whether SRI farmers can sell their surplus to rice markets or not since practicing SRI can help them increase their production; and to analyze the SRI farmers' livelihood. The discussion in this literature review parts shows that this study is needed since results of labor requirement of SRI are still not persuasive; moreover, current irrigation application in rural areas of Cambodia should be exposed to get more attention from the government and NGOs; finally, this study will explain whether SRI farmers can sell their products to markets and current situation of rice markets at village level. This can help other farmers know the effects of practicing SRI with analyses of farmers' livelihood.

CHAPTER 4 METHODOLOGY

In order to collect data from multiple dimensions of SRI practices from SRI Farmers (SF), Non-SRI Farmers (NSF), local authorizes and other related data sources and to get clear direction to answer the research questions and meet the research objectives, the research methodology was designed as follows after the general information on the study areas.

4.1 Information on the Study Areas

One rain-fed village named Romon in Takeo province; two irrigated villages called Romleang and Srae Thnal and one rain-fed village termed Mohaleap in Kampong Speu province; another two rain-fed villages called Trapaing Russey and KhnheayKhangLech in Kampot; and also another two rain-fed villages termed Tbaeng and Ansaung in Prey Veng province were chosen as the study areas. Basic information on each province and each district where the study areas are located in have provided here based on the fact from found sources.

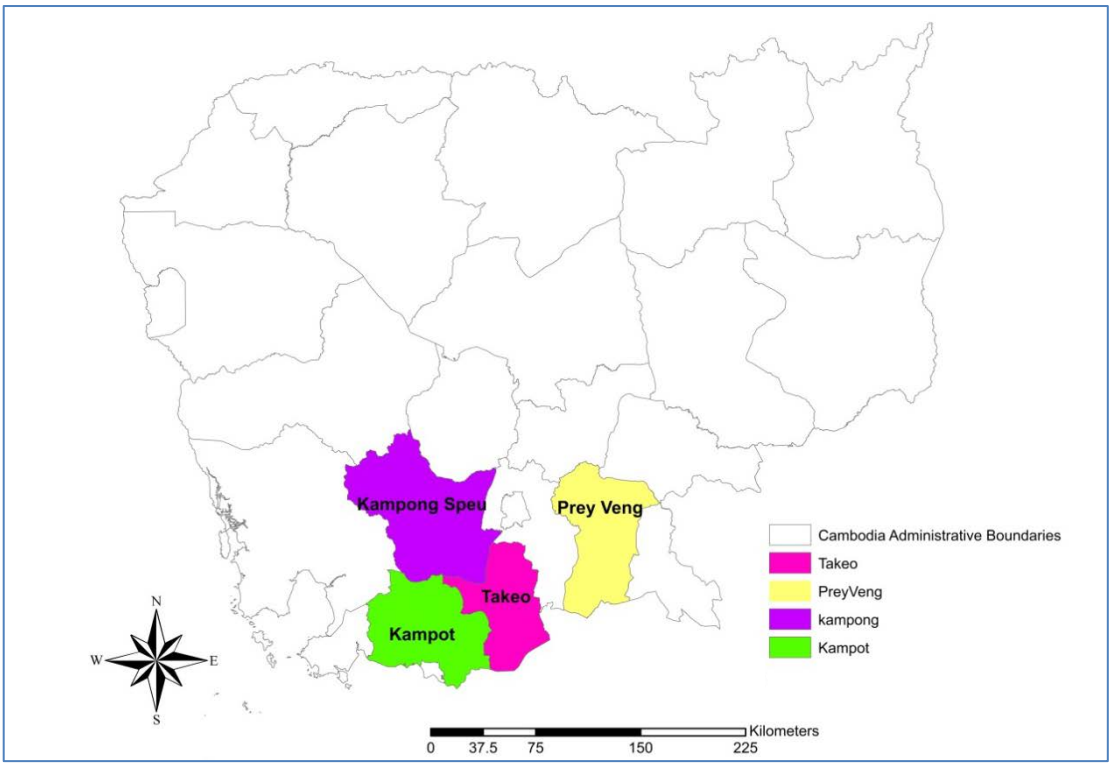


Figure 20: Map of Study Areas

4.1.1 Kampong Speu Province

Kampong Speu province is located to the West of Phnom Penh. It shares borders with Kampong Chhnang and Pursat provinces to the North, Phnom Penh to the East, Kampot and Takeo provinces to the South and Koh Kong province to the West. The topography is variable, from a large area of lowland paddy fields in the East to lowland/upland mosaic and upland forested areas in the West. Kampong Speu province is classified as a rural and second poorest province. Soil types in Kampong Speu province are mostly Red-yellow Podzols and Cultural Hydromorphics. Also some areas have soil types of Alluvial Lithosols, Acid Lithosols, Planosols and Grey

Hydromorphics. Soil fertility varies across the province from low to high (USAID_Kampong Speu, 2008).

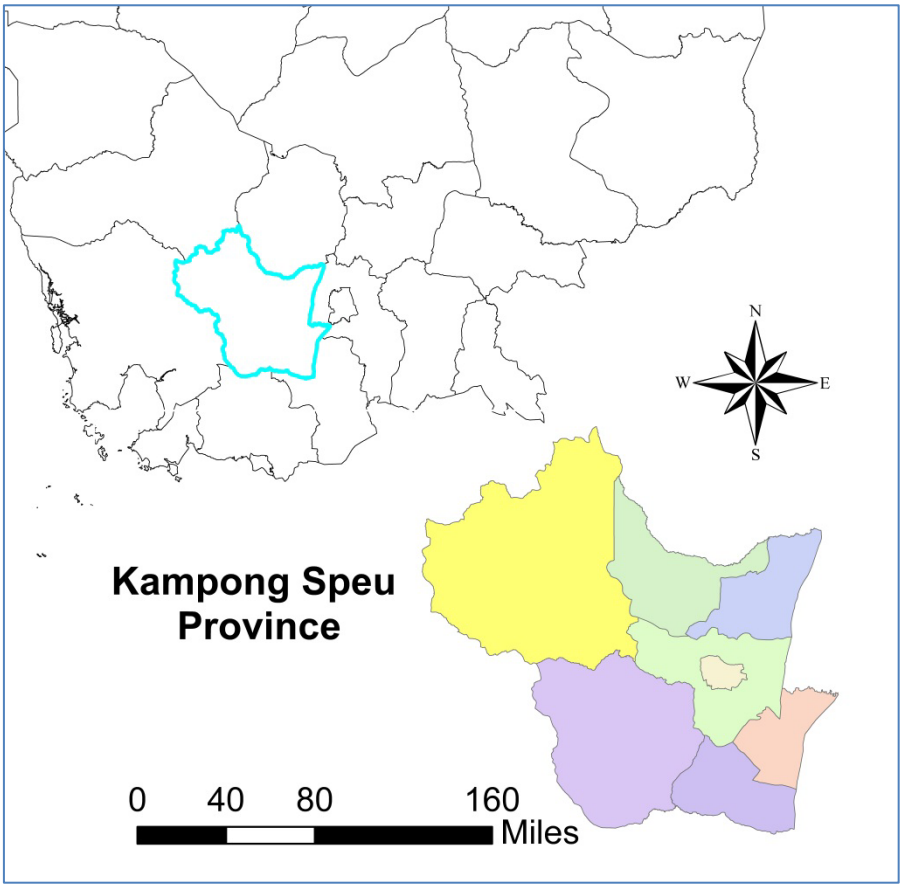


Figure 21: Map of Kampong Speu Province

Kampong Speu province covers over the total of eight districts. They share different sizes of areas in terms of forest land, cultivation land, construction land and others.

Table 12: Land Area (ha) by District in Kampong Speu Province by Mid-2009

District	Total land area	Forest land area	Cultivation land area	Construction land area	other land area
Basedth	28,371	5,320	18,665	4,386	-
Chbar Mon	4,738	943	2,782	758	255
Kong Pisei	29,007	6,704	16,594	2,876	2,834
Aoral	237,300	218,103	13,465	2,500	3,232
Odongk	57,426	3,452	21,054	10,960	21,960
Phum Sruoch	171,435	100,839	66,012	4,584	-
Samraong Tong	54,519	14,101	18,756	2,229	19,433
Thpong	70,600	40,814	10,443	9,460	9,833
Total	**653,397**	**390,276**	**167,771**	**37,753**	**57,597**

Source: NCDD_Kampong Speu (2009) from District Information System of DoLA

4.1.1.1 Rainfall in Kampong Speu

In Cambodia as well as in Kampong Speu province, there are two main seasons: Rainy season starting from May to October, and Dry season beginning from November to April. The

temperature seems to fall between November and March. The temperature is around 16^0C to 26^0C. (Source: www.tourismcambodia.com Retrieved on February 19, 2011). The distribution of rainfall in province is the key information because in some areas, rainfall is vital for farmers' farming activities and/or for filling rivers and canals in the irrigated areas. Moreover, this province rarely gets enough annual rainfall for drinking water, letting alone to water crops or raising farm animals.

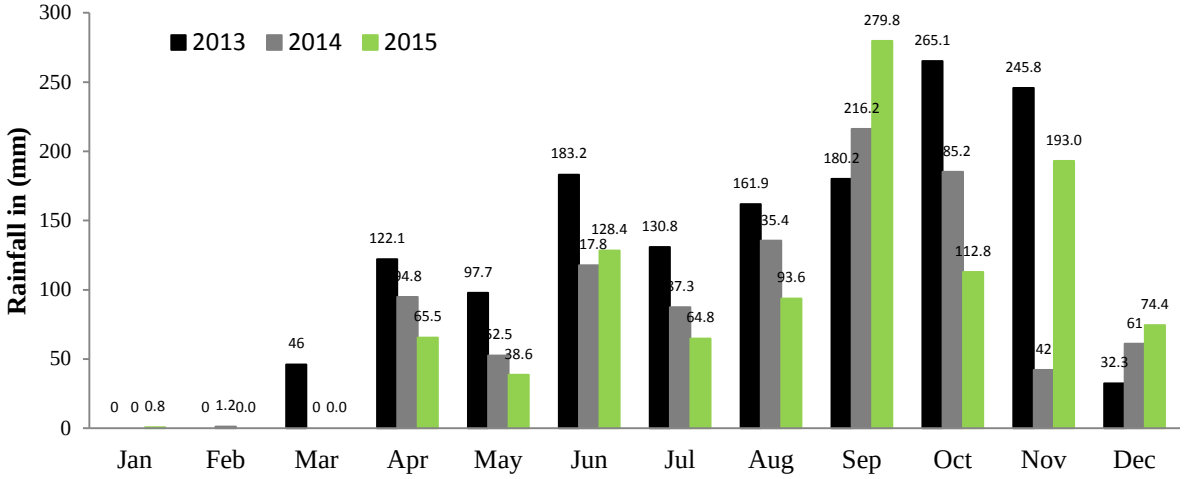


Figure 22: Rainfall Data in Kampong Speu Province for 2013 to 2015
Source: Department of Meteorology, Ministry of Water Resources and Meteorology (MOWRAM)

4.1.1.2 Rice Cultivation in Kampong Speu

In Kampong Speu province, total harvested area in 2004 was 44,800 ha with the average yield of 1.6 tons/ha. Because of small harvested areas and low productivity, Kampong Speu province faced the deficit of rice (-1,231 tons) to support the people in the province (based on the agricultural statistics 2003-2004, MAFF). However, based on updated data on rice cultivation and yield in Kampong Speu province from 2002-2007 by NIS (2008), harvested areas increased from 44,800 ha to 85,000 ha, 106,000 ha and 109,000 ha in 2004, 2005, 2006 and 2007, respectively. Additionally, the rice production went up from 70,500 tons in 2004 to 266,400 tons in 2007, with average yield of 1.6 tons/ha to 2.4 tons/ha, respectively. From this growth, it could be concluded that Kampong Speu province had moved away from rice deficit. Based on the recorded data in the statistical yearbook 2008 prepared by NIS, there is no clear separation between wet and dry rice practice. Only data on the cultivated areas for dry season is available.

Table 13: Rice Growing Data in Kampong Speu 2002-2007

Year	Rice Cultivated Area (ha)	Rice Harvested Area (ha)	Rice Production (ton)	Average Yield (t/ha)
2002	66,400	64,800	99,500	1.5
2003	95,400	94,100	181,200	1.9
2004	83,100	44,800	70,500	1.6
2005	85,100	85,000	188,800	2.2
2006	109,100	106,000	245,200	2.3
2007	109,100	109,100	266,400	2.4

Source: NIS (2008)

In the province, total dry rice cultivated areas varied from 100 ha to 1,000 ha during 2002-2008. There was no big change, regarding the dry rice cultivated areas. This could be due to the stagnated irrigation rehabilitation and construction and unreliable rainfall.

4.1.1.3 Chbar Mon and Samraong Tong Districts of Kampong Speu

Chbar Mon city and Samraong Tong district are 2 of the 8 districts in the Kampong Speu province. Both districts share the same borders. Chbar Mon city is located as the heart of the Samraong Tong district. In Chbar Mon city, NCDD_Chbar Mon (2009) recorded that 50.76% of the farmers in 2008 possessing land with the area less than 1 ha. Then, 3.79% was landless. Chbar Mon city is known as the irrigated areas because 54.5% of total rice areas was wet season irrigated rice areas in 2008 (NCDD_Chbar Mon, 2009).

Samraong Tong district was different from Chbar Mon city. In 2008 there were 7.29% of the farmers having no possession to any land but 55% of them holding land with the area less than 1 ha. About 79.7% of total rice areas in this district were the wet season rain-fed rice area (NCDD_Samraong Tong, 2009). Therefore, Samraong Tong District is classified as the rain-fed area where rainfall is the main source for farming activities.

4.1.2 Takeo Province

Takeo province is situated in the Southern part of Cambodia; sharing borders with Kampong Speu province to the North, Kandal province to the East, Kampot province to the West, and Vietnam to the South. Plain areas cover the most part of this province with slope eastwards to the Bassac River. Soils from the floodplain are black cracking clay; composing with high organic matter resulted from the annual flooding. However, higher land consists of red soils causing the low organic matter (Smout, 1996). Owing to USAID (2010), Soils are alluvial lithosols in most parts of the province, particularly at the East; Cultural hydromorphic and red-yellow podzols through the center and the West; and Alumisols on Southern border with Vietnam.

Since the broad belt of lowland paddy fields occupying much, the topography of this province is adjustable from the Bassac River floodplains at the East to smaller areas of lowland/upland mosic on parts of the Western and Southern borders (Retrieved on October 05, 2012 from http://www.foodsecurityatlas.org/khm/country/provincial-Profile/Takeo#section-4).

Takeo province is mixed up with 10 districts sharing different sizes of areas in terms of forest land, cultivation land, construction land and others (see the table 14). Agricultural farming, fishery, rice and fruit cropping are the basic sources of farmers' economy (Retrieved on April 19, 2013 from www.tourismcambodia.com/travelguides/provinces/takeo/economy.htm).

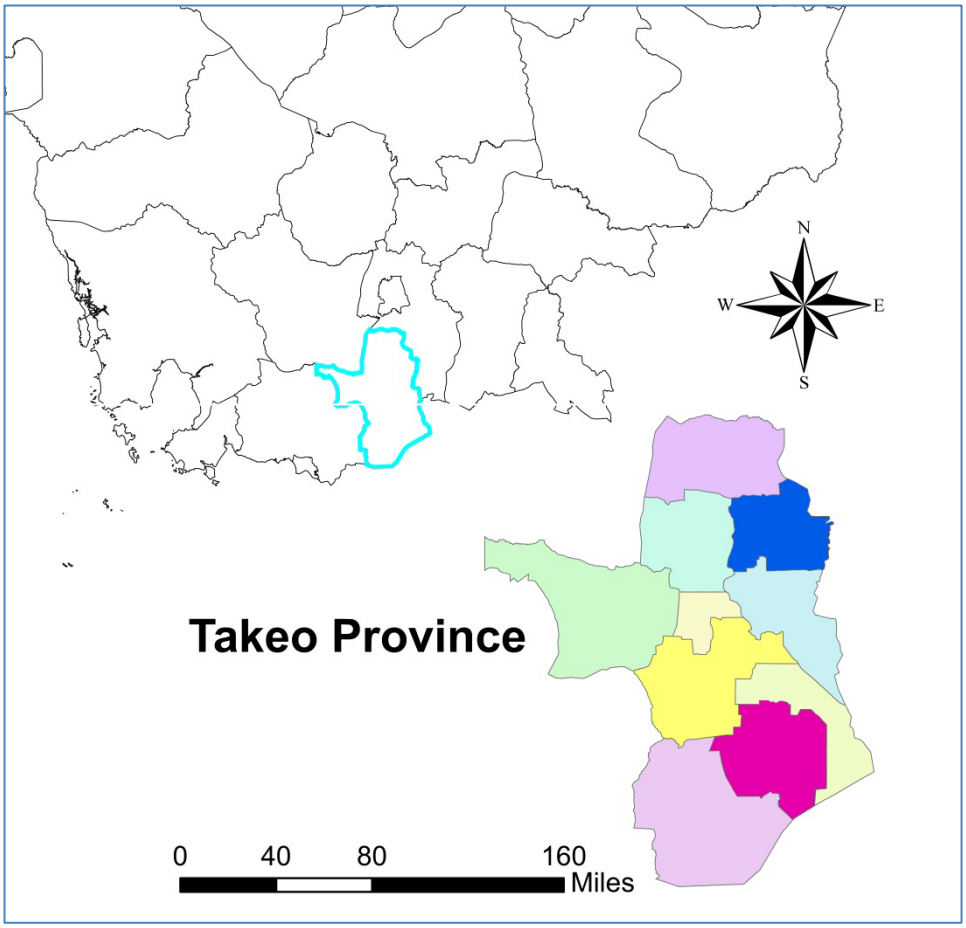


Figure 23: Map of Takeo Province

Table 14: Land Area (ha) by District in Takeo Province by Mid-2009

District	Total land area	Forest land area	Cultivation land area	Construction land area	other land areas
Angkor Borei	30,368	2,523	19,217	1,958	6,670
Bati	36,126	2,659	21,375	5,633	6,458
Borei Cholsar	24,000	2,000	19,879	978	1,143
Kiri Vong	61,670	14,809	36,890	6,613	3,359
Kaoh Andaet	35,680	41	30,992	1,446	3,201
Prey Kabbas	26,910	-	20,737	3,109	3,064
Samraong	30,513	-	22,846	4,298	3,369
Doun Kaev	9,469	146	6,682	1,275	1,366
Tram Kak	54,694	2,160	35,677	6,618	20,239
Treang	40,277	1,773	33,933	3,097	1,474
Total	**349,707**	**26,111**	**248,228**	**35,025**	**40,343**

Source: NCDD_Takeo (2009) from District Information System of DoLA

4.1.2.1 Rainfall in Takeo

Sharing the border with Kampong Speu province, the rainfall pattern in Takeo is not much different. Owing to World Weather Online, during June to November, rainfall starts from minimum level of 16.1mm to the maximum level of 65.8mm, with the average rainfall days range from 2 to 5 days. December to May provides less rainfall with the maximum of 11.3mm

and the average rainfall day is only 1 day. During January and April, there is no rain at all (www.worldweatheronline.com/Takeo-weather-averages/Takeo?KH.aspx). April is the hottest month with the temperature of 35^0C. The coldest months are December and January with temperature of 23^0C. According to the figure shown below, in this province rainfall is high from May to October. During this period, farmers start to prepare land for sowing and transplanting. In rain-fed areas, farmers harvest rainfall by storing in the ponds near their houses for irrigating the field and in big clay pots for housework. Rainfall starts to diminish from December till April. During this time, farmers cannot grow anything. Only some households with remaining water in the ponds or in their plots located near small stream can grow other crops.

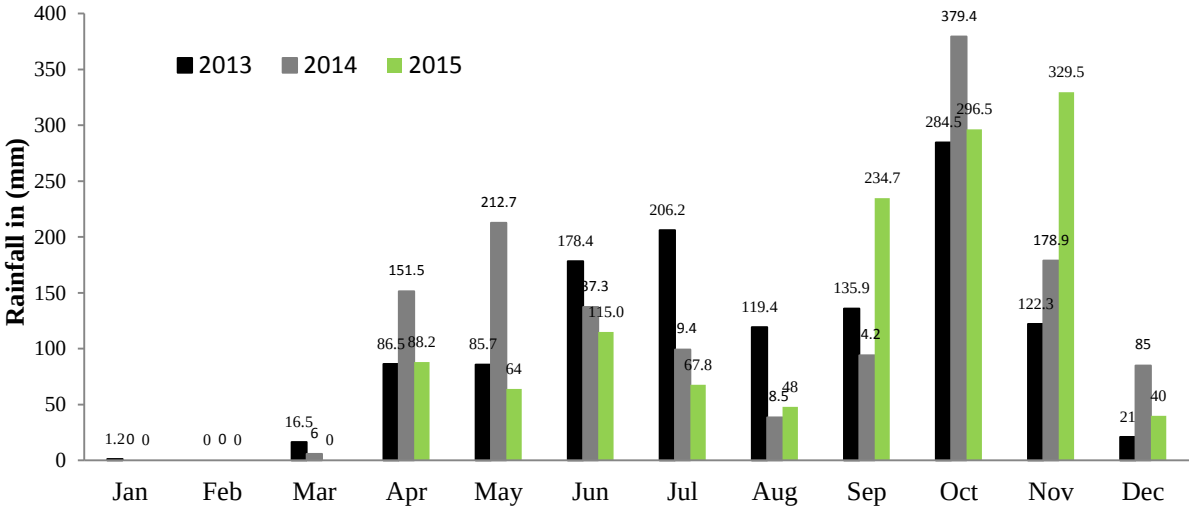


Figure 24: Rainfall Data in Takeo Province for 2013 to 2015

Source: Department of Meteorology, Ministry of Water Resources and Meteorology

4.1.2.2 Rice Cultivation in Takeo

Not different from where else in Cambodia, rice has become the main crop for people in this province as well as for the whole country. Although Takeo is not a big province, nearly 70% of total areas have been used for agriculture (USAID, 2010). More importantly, Takeo is also one of the major rice producing provinces of Cambodia.

Table 15: Rice Growing Data in Takeo Province 2002-2007

Year	Rice Cultivated Area (ha)	Rice Harvested Area (ha)	Rice Production (ton)	Average Yield (t/ha)
2002	222,500	207,600	488,000	2.4
2003	234,000	232,900	616,800	2.6
2004	233,400	224,400	633,900	2.8
2005	251,700	250,800	781,900	3.1
2006	247,300	246,700	787,300	3.2
2007	246,400	246,400	810,200	3.3

Source: NIS (2008)

Based on the data from NIS (2008), the total rice cultivated areas in the province in 2007 were 246,400 ha with the all-out production of 810,200 tons with the average rice yield of 3.3tons/ha.

Unlike Kampong Speu province in terms of total rice cultivation areas, harvested areas and production, Takeo had larger areas and higher average rice yield (3.3 tons/ha in 2007) than Kampong Speu (2.4 tons/ha in 2007). More than that, the dry rice cultivated areas in Takeo were larger than those of Kampong Speu. The average areas were 58,900 ha up to 76,600 ha during 2002-2007. This was due to the better irrigation system in Takeo province. However, it is just the case of being better than other worse provinces; Takeo is still facing some difficulties in irrigation in some areas. Again, the data on dry rice growing activities is still limited. Therefore, table above shares only the total areas from 2002-2007.

4.1.2.3 Samraong District of Takeo

One of the ten districts in Takeo province is hereby called Samraong District where wet rice areas shared about 14,517 ha in 2008 and dry rice areas covered over 3,207 ha of total areas. Furthermore, the average rice yields were 2.1t/ha and 2.7t/ha during wet rice growing and dry rice growing periods, respectively (NCDD_Samraong, 2009).

Regarding to the water availability for irrigation in this district, NCDD_Samraong (2009) reported that in 2008, 94.8% of total wet rice cultivated areas were rain-fed areas totally depending on rainfall, while 5.2% were irrigated areas in the same year. Added on the aforementioned information, in Samraong district, there were up to 79.57% of total farmers holding land with less than 1 ha in 2008. The remaining of 3.31% possessed nothing (NCDD_Samraong, 2009). It generally happens in other places in Cambodia as well. Most of farmers are holding land with less than 1 ha. Due to the small land, production is still low.

4.1.3 Prey Veng Province

Being located in the South of Cambodia and sharing borders with Kampong Cham province to the North, Kandal province to the West, Svay Rieng province to the East and Vietnam, Prey Veng province is also crossed by two main rivers Mekong and Tonle Bassac ideally providing the water and fertile soil for agriculture and a transport route as well. This province, with total area of 4,883 km^2, consists of the typical plain wet area, covering rice fields and other agricultural plantations (USAID_Prey Veng, 2008; NIS, 2013).

Rice farming covers the largest area of the province. Due to its agricultural base, the rate of people living below the poverty line is high. This causes the huge migration from the province to find other means to support their living.

The name of province literally means “Long Forest” in Cambodian language. The total forestry area is about 7,893 ha including 813 ha with green bush forest, 78 ha with dry bush forest, approximate 1,041 ha with planted forest and the remaining 5,962 ha with other forest (http://www.cambodiainvestment.gov.kh/content/uploads/2014/03/Prey-Veng-Province_eng.pdf retrieved on December 03, 2014). Although economy of Prey Veng province primarily depends on agricultural farming, fishing, and fruit cropping; currently some manufacturing industries such as sand production and garment have been introduced to the province.

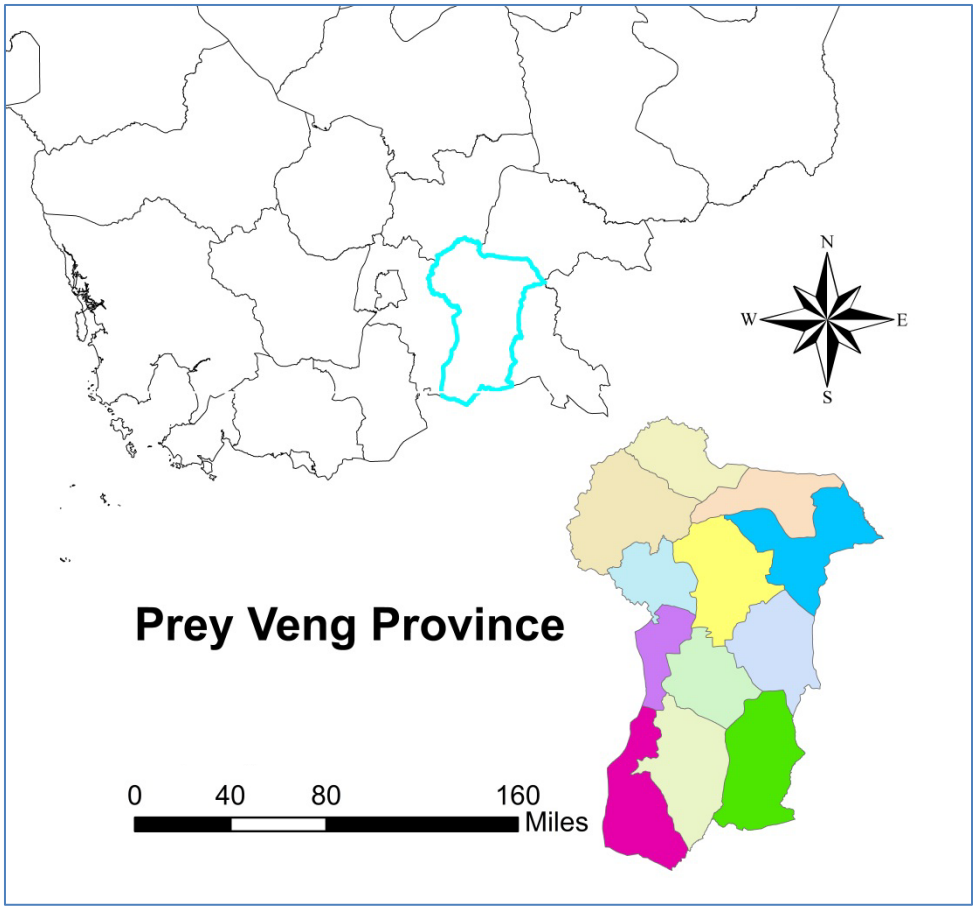


Figure 25: Map of Prey Veng Province

Table 16: Land Area (ha) by District in Prey Veng Province by Mid-2009

District	Total land area	Forest land area	Cultivation land area	Construction land area	other land areas
Ba Phnum	248,668	32,877	20,732	228	461
Kamchay Mear	35,183	555	23,060	5,308	5,259
Kampong Trabaek	46,236	-	36,466	9,770	-
Kanhchriech	32,872	-	22,000	3,488	7,384
Me Sang	41,810	-	22,441	3,110	16,259
Peam Chor	39,497	-	24,000	5,109	10,388
Peam Ro	20,390	798	14,300	2,846	2,446
Pea Reang	52,000	4,017	30,890	3,621	13,472
Preah Sdach	45,073	-	39,373	2,003	3,697
Prey Veng	32,765	-	29,520	3,079	166
Kampong Leav	18,330	372	12,459	1,050	4,459
Sithor Kandal	30,765	2,731	21,493	2,646	3,895
Svay Antor	6.577	23	4,645	1,684	225
Total	**650,166**	**41,373**	**301,379**	**43,942**	**68,110**

Source: NCDD_Prey Veng (2009) from District Information System of DoLA

4.1.3.1 Rainfall in Prey Veng

Wet and dry condition applies almost over the country. Prey Veng province is also affected. Therefore, during the whole year, the temperature of province is warm. The temperature ranges from 23.7°C to 32.9°C with the average of 28.36°C. The annual rainfall is about 1,350mm.

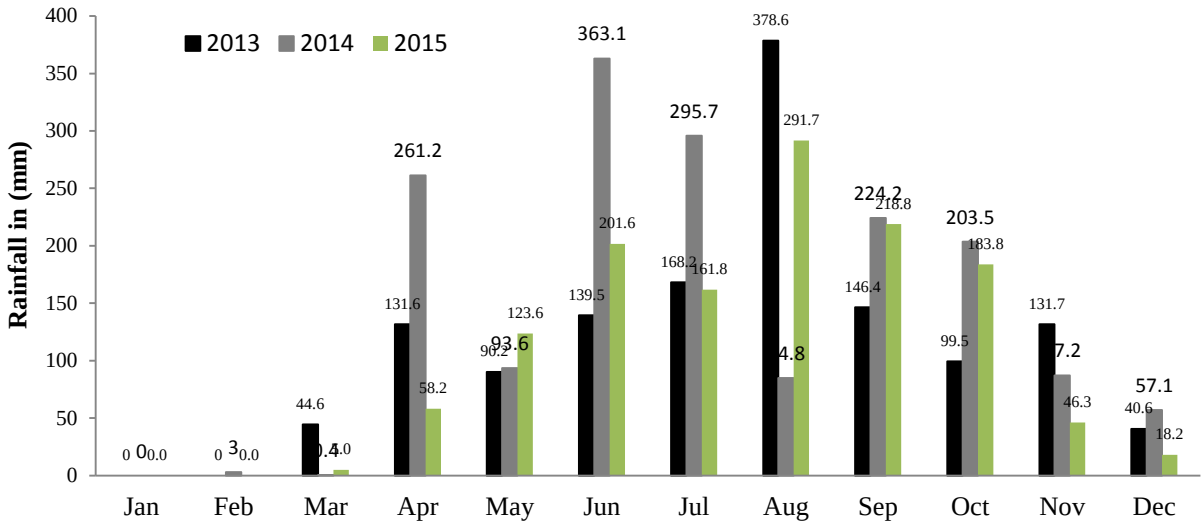


Figure 26: Rainfall Data in Prey Veng Province for 2013 to 2015
Source: Department of Meteorology, Ministry of Water Resources and Meteorology

It is difficult to say whether amount of rainfall is enough for irrigation. However, it is reported that there are 110 reservoirs providing a total net of the storage capacity of 319,860,000m^3 ((http://www.cambodiainvestment.gov.kh/content/uploads/2014/03/Prey-Veng-Province_eng.pdf retrieved on December 03, 2014). Still it does not mean that it is enough for the irrigation. Same as Takeo province, high season of rainfall begins from June to October, and starts to fall from November to April (see the figure 26).

4.1.3.2 Rice Cultivation in Prey Veng

Prey Veng province produces both wet and dry paddy rice. The recorded annual average of rice is about 1 million ton if there is no serious disturbance such as rainfall shortage and natural disaster. Over the province, rice field covers for 66.65% of the total provincial cultivated lands of 327,000 ha which is believed as a great potential for rice export industry.

Table 17: Rice Growing Data in Prey Veng Province 2002-2007

Year	Rice Cultivated Area (ha)	Rice Harvested Area (ha)	Rice Production (ton)	Average Yield (t/ha)
2002	244,900	232,100	519,700	2.2
2003	295,300	287,000	639,500	2.2
2004	276,900	248,200	517,400	2.1
2005	310,000	299,300	897,900	3.0
2006	317,900	314,000	820,500	2.6
2007	325,700	325,700	991,500	3.0

Source: NIS (2008)

The productivity of paddy during wet season was about 2.9t/ha; while it was up to 4.6t/ha for dry paddy probably in 2013 according to the article accessible with the given link here http://www.cambodiainvestment.gov.kh/content/uploads/2014/03/Prey-Veng-Province_eng.pdf, retrieved on December 03, 2014.

4.1.3.3 Kampong Trabaek District of Prey Veng

Being the 3rd biggest district in Prey Veng province, in 2008 Kampong Trabaek district covered by the dry rice land area of 9,016 ha increased from 6,925 ha in 2006. Not only the area was expanded, but also the average rice yield went from 2t/ha to 2.7t/ha in 2006 and 2008, respectively. However, remarkably, total area of wet rice land area slightly decreased from 29,527 ha in 2006 to 29,461 ha in 2008. In return, there was a slight increase in yield from 1.1t/ha to 1.6t/ha in 2006 and 2008, respectively. To increase the yield, better irrigation is the best solution. In this district, the availability of irrigation is very high compared to other districts. Fifty percent of wet rice cultivation was irrigated; while the other half completely depends on the rainfall or it is called rain-fed area, according to the district data book (NCDD_Kampong Trabaek, 2009). Although agriculture is very important for rural people, the size of land possession can be a problem for farmers. In Kampong Trabaek district in 2008, 32.91% of total population possessed land less than 1 ha per family; meanwhile, other 15.43% was landless (NCDD_Kampong Trabaek, 2009).

4.1.4 Kampot Province

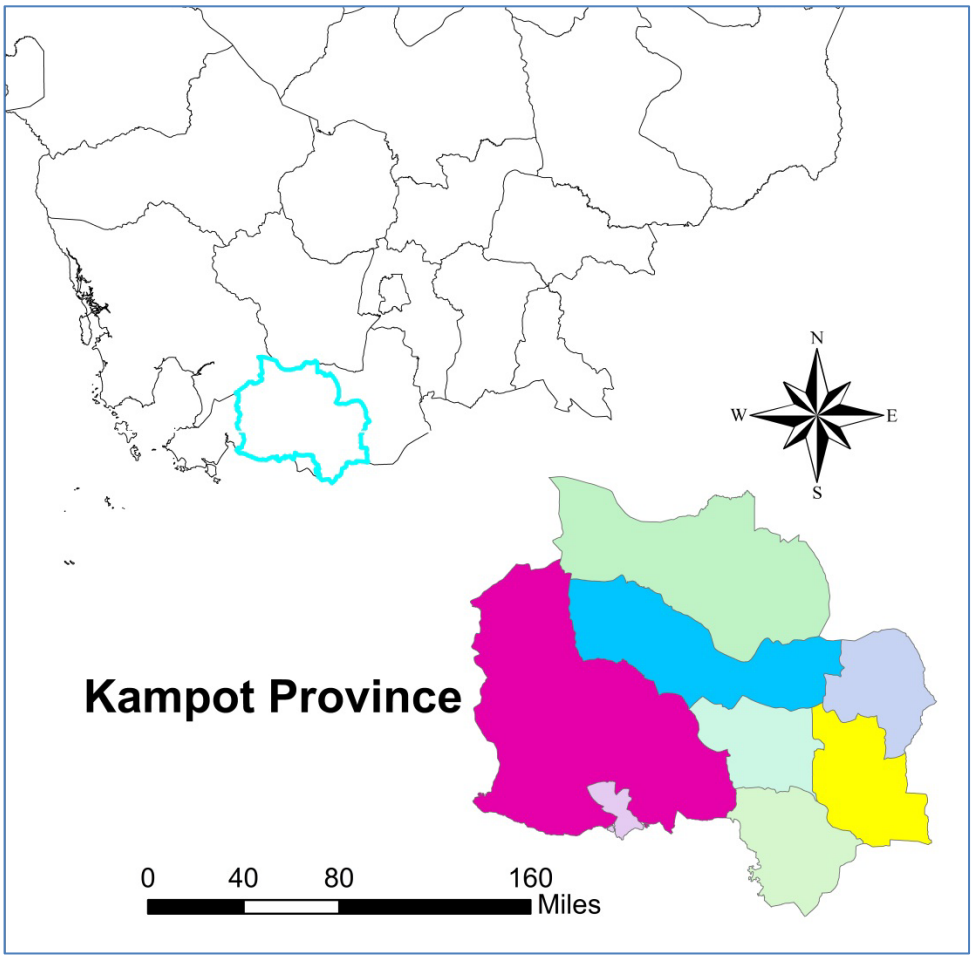


Figure 27: Map of Kampot Province

Located in the coastal region of the country, Kampot province is one of the most beautiful provinces of Cambodia; sharing a border with Vietnam to the East and Gulf of Thailand to the South. This province is rich of natural attractions, plentiful historical and natural wonders, and many tourist sites such as waterfalls, rivers, beautiful beaches, offshore islands, and picturesque mountains. Kampot consists of 8 districts with one city called Kampot (retrieved on December 04, 2014 from http://www.cambodiancommunityday.org/index.php/en/provinces/south-west-region/kampot,).

Two-third of total area of the province is covered by mountains and plain areas which are good for agricultural activities. The Southwest of the province is occupied by the coastline that has abundant natural resources, fisheries, agricultural farms and salt farms. Besides agricultural land, Kampot also has wildlife sanctuary and protected areas of 217 ha. With both potential of marine and agricultural resources, local government tries to promote food and beverage processing industries such as fish sauce, soy sauce, chili sauce, wine, bread, noodles, and bottled drinking water, etc. (Retrieved from www.cambodiainvestment.gov.kh./content/uploads/2014/03/Kampot-Province_eng.pdf, on December 04, 2014).

Table 18: Land Area (ha) by District in Kampot Province by Mid-2009

District	Total land area	Forest land area	Cultivation land area	Construction land area	other land areas
Angkor Chey	22,237	34	16,146	4,041	2,016
Banteay Meas	40,106	-	29,048	2,008	9,050
Chhuk	126,248	99,924	18,015	8,309	-
Chum Kiri	31,557	9,390	11,505	10,662	-
Dang Tong	34,500	14,693	15,809	3,635	363
Kampong Trach	35,300	11,935	19,826	3,124	415
Tuek Chhou	151,400	42,703	35,150	14,594	58,953
Kampot	5,400	2,390	652	1,358	1,000
Total	**446,748**	**181,069**	**146,151**	**47,731**	**71,797**

Source: NCDD_Kampot (2009) from District Information System of DoLA

4.1.4.1 Rainfall in Kampot

Being located along the coastline, Kampot province receives a lot of rain. This makes the amount of annual rainfall up to 1,729.5 mm more than other provinces in some inland ones. Although the amount of rainfall is high, due to the effect of coastline and mountainous areas, it is difficult to assume that irrigation of this province is better than other places. However, it is reported that there are 45 reservoirs with the total storage capacity of 182,973,500m^3 for irrigation. The temperature ranges from 24.1^{o}C to 31.9^{o}C. It is a bit hotter than other places due to the evaporation from the sea in the dry season (Retrieved on December 04, 2014 from www.cambodiainvestment.gov.kh/content/uploads/2014/03/Kampot-Province_eng.pdf).

As usual, much rain falls during June till October; then amount of rainfall in this province is more than one in other provinces. Amount of rain starts to decrease during the dry season, November to April (see the Figure 28 below).

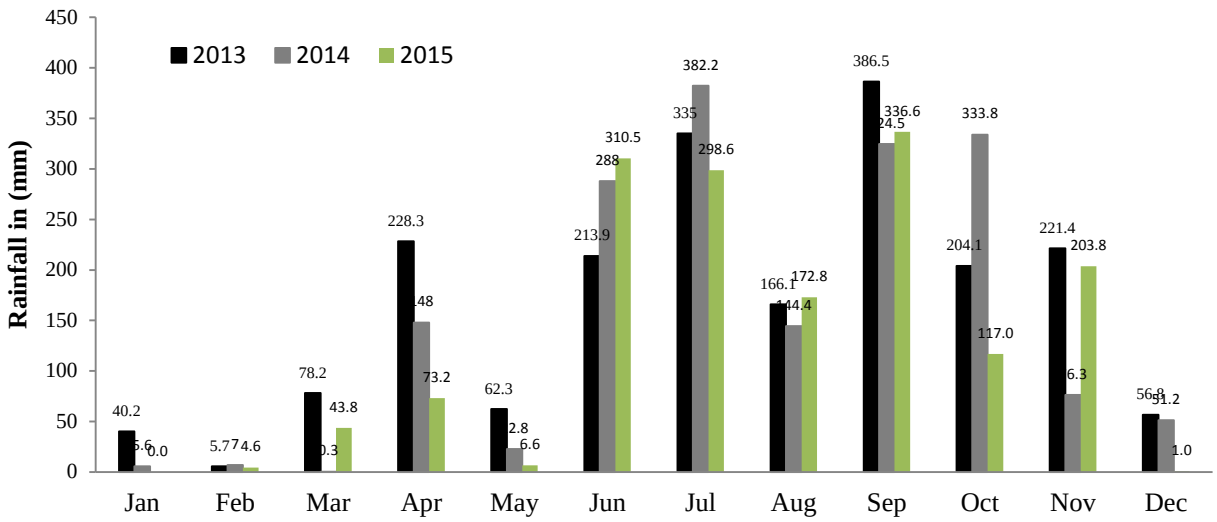


Figure 28: Rainfall Data in Kampot Province for 2013 to 2015
Source: Department of Meteorology, Ministry of Water Resources and Meteorology

4.1.4.2 Rice Cultivation in Kampot

Rice cultivated area is not big in this province because large areas are already occupied by mountains, plantations and other industrial areas. Provincial specialized fruit and products are durian, pepper and salt. Due to the red soil condition, rubber plantations occupy areas about 56.36 ha (based on the Provincial investment information retrieved on December 03, 2014 from http://www.cambodiainvestment.gov.kh/content/uploads/2014/03/Prey-Veng-Province_eng.pdf). Still, farmers are growing both dry and wet rice.

Table 19: Rice Growing Data in Kampot Province 2002-2007

Year	Rice Cultivated Area (ha)	Rice Harvested Area (ha)	Rice Production (ton)	Average Yield (t/ha)
2002	119,600	107,900	189,700	1.8
2003	124,000	124,000	286,000	2.3
2004	121,900	108,400	172,400	1.6
2005	121,600	121,600	292,800	2.4
2006	128,800	128,500	310,400	2.4
2007	124,600	124,600	319,700	2.6

Source: NIS (2008)

4.1.4.3 Dang Tong District of Kampot

According to the district data in 2008, it showed that in Dang Tong district there was no area for dry rice growing; while it used to be about 460 ha in 2006. There was a slight increase of wet rice growing area from 10,424 ha to 10,462 ha in 2006 and 2008, respectively. Therefore, rice cultivated area in this district were 100 percent rain-fed areas in 2008 with the average wet rice yield about 1.8t/ha (NCDD_Dang Tong, 2009). About 49.79% of total population in the district had cultivated area less than 1 ha per household. Meanwhile, 1.19% were landless (NCDD_Dang Tong, 2009).

4.2 Data Collection Methods

For the methodology of this research, various data collection methods had been applied such as field observation, household survey, follow-up activity, daily activity record and software application and document review. Primary data collection was conducted in the same eight villages in five districts and four provinces as described above. From all selected farmers, three from Kampong Speu and another three from Takeo provinces were the main farmers for the detailed study on labor consumption, rice contribution to the markets, water application and SRI practices; while other farmers in Kampong Speu, Kampot and Prey Veng provinces were the supporting farmers for the same objectives of this study, but they were not ask to record their daily farming activities.

The first data collection was done during February and March in 2014 in Kampong Speu, Kampot and Takeo provinces after Late Ripening Varieties (LRV) harvested; 2nd one was conducted in May, 2014 in Kampong Speu and Takeo provinces during the Early Ripening Varieties (ERV) transplanted; 3rd was carried on during September and October in 2014 in Kampong Speu, Takeo, and Prey Veng provinces after the harvest of ERV and the end of LRV transplanted; 4th data collection was conducted in March, 2015 in Kampong Speu and Takeo provinces after the LRV harvested; 5th one was done during August and September, 2015 in Kampong Speu and Takeo provinces after the harvest of ERV and the end of LRV transplanted; and the last one was conducted in December, 2015 in Kampong Speu and Takeo provinces after the LRV harvested. All interviews were conducted in Khmer—the native language. SRI Farmers (SF) and Non-SRI Farmers (NSF) were introduced by the village chiefs or community leaders upon the request from the author for the household survey (see the details in Table 20).

4.2.1 Field Observation

Besides household survey and follow-up activities explained below, field observation was done to get not only the real image on farmers' living styles but also the better understanding and knowledge on the community life and other activities. Additionally, author could visit the paddy fields directly; building up the intimate relationship with the targeted farmers and producing more comfortable and interactive environment. This field observation was also used for checking up the responses from the farmers during the household survey with the real practice.

4.2.2 Household Survey

Thirty-one farmers, 6 main farmers and 25 supporting farmers, were selected from each village to be interviewed and asked for the detailed farming activities with the designed questionnaire and daily farming activity sheet (see APPENDIX I and II). Among the selected farmers, some were NSF and the rest are SF who used to be the NSF. The questionnaire was designed with five different parts. Part A is a kind of baseline survey examining the household-level information such as occupations, family members, and livelihood and income-generation activities. Part B focuses on agricultural information covering the information about other crop cultivation, rice varieties, agricultural tools and animal raising. Part C talks about SRI practices by comparing with traditional practices such as SRI principle adoption, amount of used seeds, fertilizers (both chemical and compost), reasons why farmers decided to practice SRI, and yield; irrigation

condition and SRI promotion done by the authority or development partners. Part D aims at checking the consumption and markets after harvesting. The last part E covers the details of labor consumption during the farming season and some other points that could be found accidentally and noticed during the interview process.

Besides the in-depth interviews with the selected farmers, the quick-check interview with each village chief was also conducted. The main purposes of this interview was to get the general information on villages such as total areas, agricultural land, agricultural activities supported by other NGOs or Government, number of household, number of SRI farmers and occupations of villagers, etc.

4.2.3 Follow-up Activities

Added up to the designed questionnaire for the household survey, another daily farming activity record (see APPENDIX II) was designed and used to record the main farmers' daily farming activities. The main purpose of these follow-up activities was to collect the daily farming records from main selected farmers in Kampong Speu and Takeo provinces. These data were used to analyze the details of labor consumption and expenditure. This activity was done during every field work.

Table 20: Number of Key-Informants

Province	District	Village	Area	Number of Selected Farmers	
Kampot	Dang Tong	Trapaing Russey	Rain-fed (a)	3 (A1-A3)	Supporting Farmers to be checked with main farmers
		KhnheayKhang Lech	Rain-fed (b)	3 (B1-B3)	
Kampong Speu	Samraong Tong	Mohaleap	Rain-fed (c)	***3 (C1-C3)****	***Main Farmers for Daily Activity Records (*only C1 is a main farmer)***
Takeo	Samrong	Romon	Rain-fed (d)	***3 (D1-D3)***	
Prey Veng	Kampong Trabaek	Tbaeng	Rain-fed (e)	3 (E1-E3)	Supporting Farmers
		Ansaung	Rain-fed (f)	3 (F1-F3)	
Kampong Speu	Chbar Mon	Srae Thnal	Irrigated Upstream (g)	***5 (G1-G5)****	***G1 and H1 are Main Farmers***
		Romlong	Irrigated Downstream (h)	***8 (H1-H8)****	

4.2.4 Document Review

Papers and journals on agricultural development especially on irrigation, SRI practices and rice markets were reviewed and discussed critically for introduction, literature review and discussion parts of the dissertation. Moreover, other recently published papers and Government or NGOs' reports on irrigation application, rice markets, SRI practices and promotion were also reviewed in order to understand the current SRI practices in Cambodia as well as in other countries.

4.2.5 Data Analysis of Household Interviews and Daily Activity Records

In order to answer the research questions as well as to fulfill the research objectives, collected data were analyzed in both qualitative and quantitative ways. For the quantitative ways, some simple functions of MS Excel and Simple Linear Regression in SPSS (Statistical Package for Social Science) were employed. The qualitative ways were based on the discussion and evaluation of the results from the interviews, field observation and analyzed quantitative data. In addition, this study also explained how much SRI farmers can sell their products to rice markets after and before practicing SRI, and obstacles and solutions to farmers who are not able to sell their products**.** The study also looked at the characteristics of those farmers as follows:

- Are they the net buyers, whose rice production is less than rice consumption?
- Or the net sellers, whose rice production is more than rice consumption?
- Or Is there a possibly that they are both consumers and producers due to the price set in the market and other possible influences?

4.2.6 Software Application

To give clear images of location of study areas, GPS device was used to take points of the main farmers' plots then those points were analyzed by Google Earth Pro to create the maps of farmers' location. Moreover, all the maps in the Chapter 2 and maps of all provinces displayed in the early part of this chapter were recreated by author using ArcMap 10.2.1.

For Simple Linear Regression by SPSS, author employed it to find the correlation between the degree of SRI adoption with the other factors such as education, age, sex, distance from home to plot, and number of family, etc.

$$\mathbf{Y = \beta x + \alpha;}$$

Where:
- y is the degree of SRI adoption and x other factors as mentioned above.
- β is the slope
- α is Y intercept (Y value can be changed based on other factors)

4.3 Conceptual Framework of Sustainable Agricultural System

As discussed in the chapter 3 on the sustainable agricultural system and the concept of sustainability, here the concept of framework for the study was established to elaborate and prove the sustainability of SRI that can improve the farmers' livelihood and maintain the ecological system (see Figure 29).

Agricultural Sustainability responds to the each component of sustainable agricultural system and concept of sustainability. Therefore, the SRI practices and results of this research were analyzed and discussed to firstly respond to the each component of sustainable agricultural system and concept of sustainability. Finally, SRI was concluded as one of agricultural systems that meet all the criteria of Sustainability.

Again, sustainable agricultural systems tend to have a positive effect on natural, social and human capital, while unsustainable ones feedback to deplete these assets, leaving fewer for future generation (Pretty, 2008). Therefore, SRI also should have effects on three main factors of capitals including natural, social and human. Additionally, to ensure the sustainability in agricultural systems, those systems not only have positive effects on three main assets, but also possess strong concepts of resilience and persistence, and wisely take care of economic, social and environmental outcomes (Pretty, 2008).

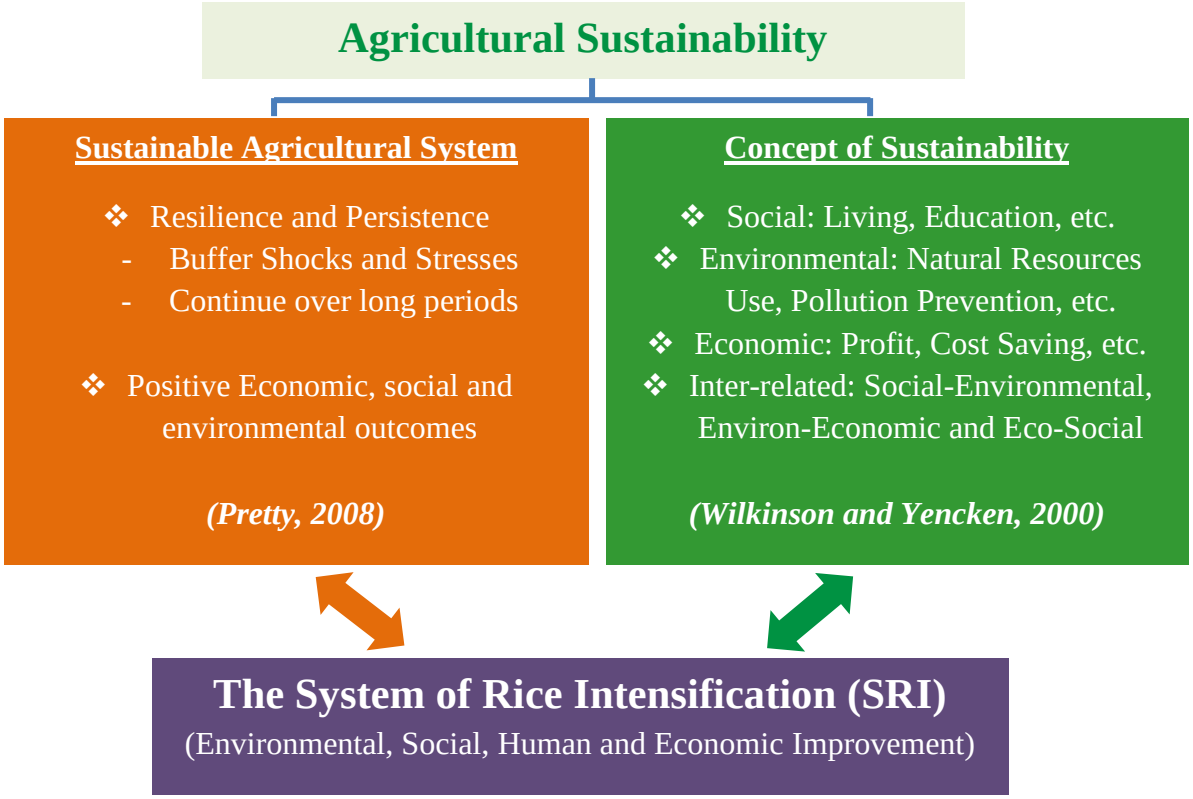


Figure 29: Conceptual Framework for the Research

4.4 Analytical Framework

The analytical framework was established in order to give the logical and concise ways to answer the research questions. This analytical framework provides the clear indicators of each research question. Detailed information about each indicator was very important because they could help answering all the research questions as well as responding to the research objectives mentioned in the Chapter 1.

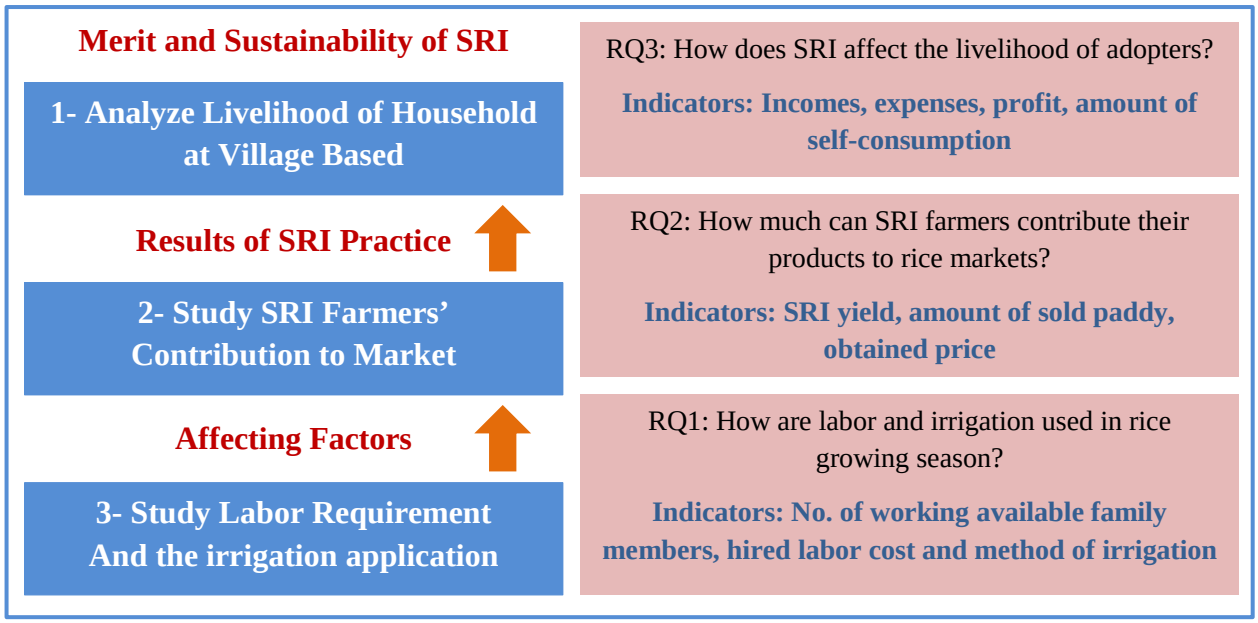


Figure 30: Analytical Framework for the Research

CHAPTER 5 FINDINGS

This Chapter presents the detailed findings found during the household interviews, field observation included the use of software ArcMap 10.2.1, Google Earth Pro, records of the main selected farmers' daily activity; followed by sub-sections including information on targeted villages, labor distribution during the rice growing period, irrigation application and its condition in the study areas, challenges on irrigation, information on paddy varieties, plantation and livestock in the study areas, rice farming and its production, SRI practices, rice farming expenditure, incomes and profits, market accessibility, calculation of labor requirement, and the changes of farmers' livelihood.

5.1 Village based Information

Firstly, this part displays the location of districts where selected villages are located in. The first two targeted villages in this research consist of Trapaing Russey and KhnheayKhang Lech Villages, represented rain-fed area (a) and (b) located in Damnak Sokram Commune in Dang Tong district of Kampot province as shown in Figure 31 (A). Then the third Mohaleap village, called as rain-fed area (c) located in Roleang Chak commune in Samraong Tong district of Kampong Speu province as shown in Figure 31 (B).

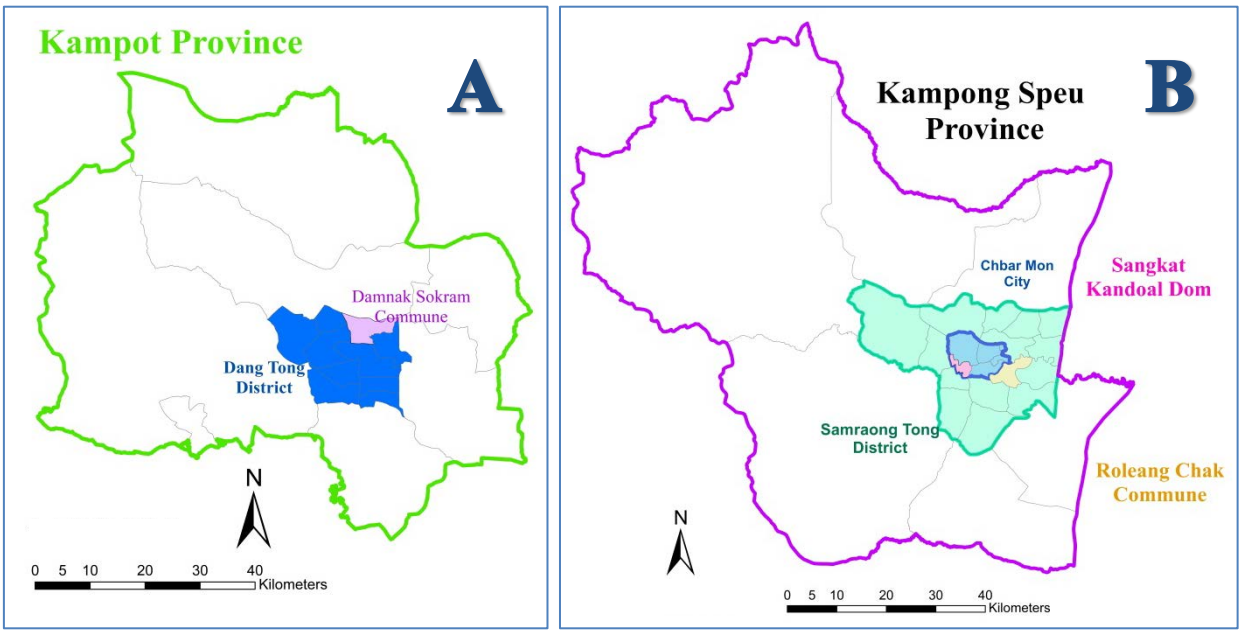


Figure 31: (A) Location of Commune and District of Rain-fed (a), (b) in Kampot province; (B) Location of Commune and District of Rain-fed (c) in Kampong Speu province

Romon village, called rain-fed area (d) based in Boeung Tranh Khang Chheung Commune in Samraong district of Takeo province as shown in Figure 32 (A); then Tbaeng and Ansaung villages, known as rain-fed area (e) and (f) in Prey Chhor and Ansong communes, respectively, in Kampong Trabaek district of Prey Veng province as shown in Figure 32 (B). While, Srae Thnal village known as irrigated upstream area (g) and Romlong village known as Irrigated downstream (h) are located in Sangkat Kandoal Dom in Chbar Mon city of Kampong Speu province as shown in Figure 31 (B).

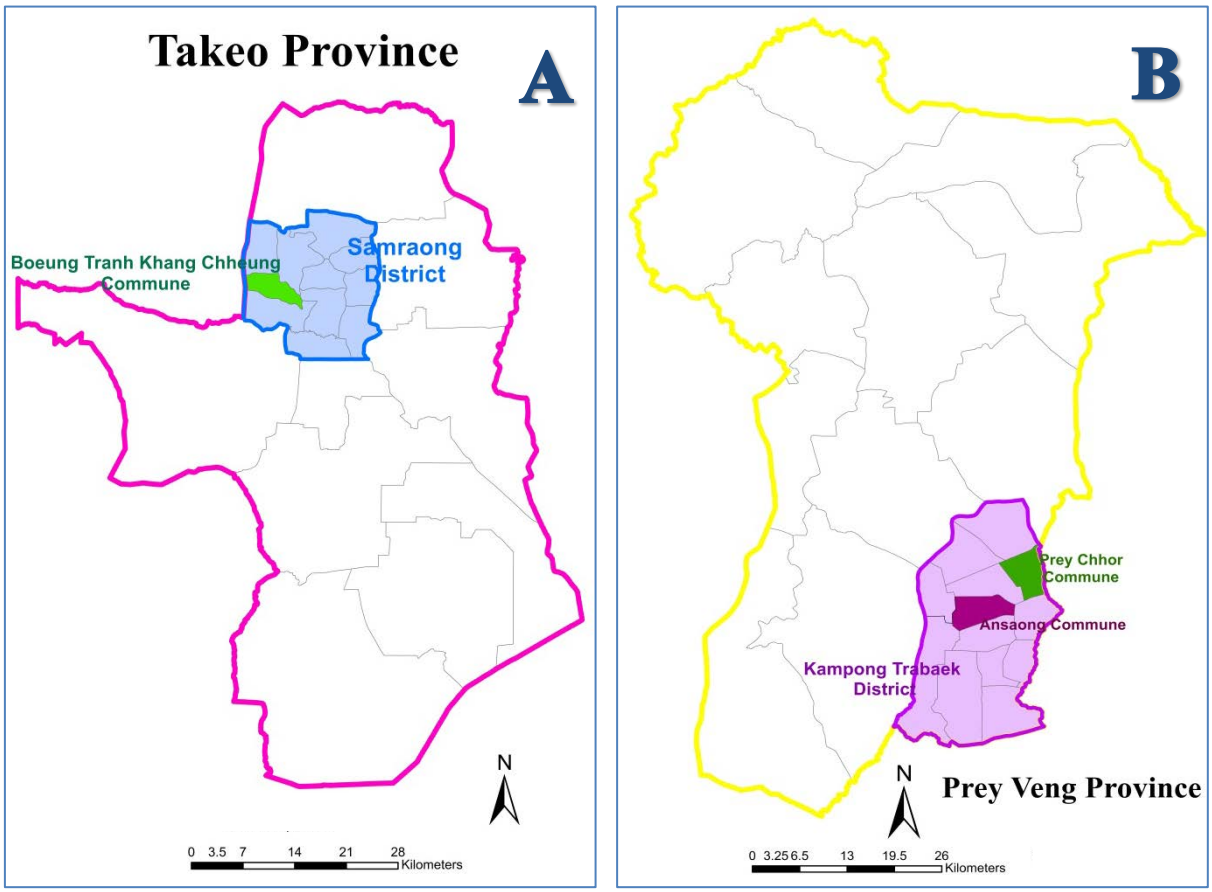


Figure 32: (A) Location of Commune and District of Rain-fed (d) in Takeo province; (B) Location of Commune and District of Rain-fed (e) and (f) in Prey Veng province

Secondly, general information on each targeted village is given here based on the results of conducted field observation and household interviews.

In rain-fed (a), there are 6 SRI households and total area of village is 216.9 ha; while agricultural area shares about 132.9ha. Although located in the same district as rain-fed (a), rain-fed (b) has no data on total area and agricultural area. Village chief in rain-fed (b) said he could not get data from the upper level. Number of SRI household in the village is 86 out of 198 farmer households. In rain-fed (c) village, according to data in 2013, only 2 out of 86 household had no farming land. In 2015, there are two new coming households, and then total number of household is 88. Village chief said number of SRI household is about 30 to 40. In rain-fed (d) village, village chief said about 120 farmer households are practicing SRI; however, based on the interviews with the main selected farmers and field observation, number of farmers still practicing is less than 10 households. On another hand, most of young people have migrated to work in Korea as workers; this causes the labor shortage in the village. No household is landless in rain-fed (e) village, according to the village chief. There are 6 farmer households practicing SRI in this village. In rain-fed (f) village, 14 farmers are still practicing SRI. However, there is no data available on the number of farmer households.

There is no reliable data on the number of SRI farmers in most of villages. For example, the number of SRI farmers in the village (b) is still high; it is possibly because some projects are still going-on. On another hand, in rain-fed (c) village where there is no project going on, although village said there are about 30 to 40 SRI farmers, it is contradictable with the real situation.

Irrigated upstream village (g) covers area of only 49 ha included 7 ha of agricultural area. There are 51 farmer households out of 133 based on the interview with village chief in 2015. Village chief also said there is only one SRI farmer. However, based on the interviews with farmers in the village, 5 farmers are still practicing SRI. Besides being farmers, village people are also identified as non-farming workers. Some of them are working in the village as teachers or village staff. Others are working outside village as factory workers or provincial staff. In irrigated downstream village (h), total area of village is 55 ha; while agricultural area shares about 50 ha of total area (interview with village chief in 2015). People are working inside the village as farmers or Khmer noodle makers. Others are working outside as construction and factory workers. Same to some rain-fed villages and irrigated upstream village, the number of SRI farmers is not clear even in irrigated downstream village. Village chief said there are 80 SRI farmers; while based on the farmers' confirmation, there are only 6 farmers still practicing SRI.

Table 21: Information on Each Selected Village

Village	No. of Total Household	No. of Farmer Household	No. of SRI Household	Total Area (ha)	Agricultural Area (ha)	Available Jobs
1- Rain-fed (a)	181 (2013)	181	6	216.9	132.9	Farmers, sellers, factory & construction workers, NGO staff, etc.
2- Rain-fed (b)	200 (2013)	198	86	-	-	Farmers, sellers, factory & construction workers, NGO staff, etc.
3- Rain-fed (c)	88 (2015)	84	*40 (village chief's observation)	193.86	145	Factory workers, teachers, farmers, tailors, handmade craft makers, etc.
4- Rain-fed (d)	337 (2015)	245	*120 (village chief's observation)	225	135	Farmers, workers, tailors, barbers, sellers, etc.
5- Rain-fed (e)	274 (2014)	268	6	1380.3	1350.3	Farmers, rice wine producers, rice pounding makers, etc.
6- Rain-fed (f)	225 (2014)	-	14	214	184.58	Farmers, sellers, Gov't staff, vegetable growers, etc.
7- Irrigated Upstream (g)	133 (2015)	51	* 1 (village chief's observation) ** 5(farmers' confirmation)	49	40	Gov't staff, farmers, teachers, factory workers, etc.
8- Irrigated Downstream (h)	177 (2015)	165	*80 (village chief's observation) ** 6 (farmers' confirmation)	55	50	Khmer noodle makers, construction & factory workers, farmers, etc.

***: Number of SRI farmers in the villages has not yet officially recorded by the village chiefs. Confirmation from farmers is different from village chief's observation as explained above. **: Farmers' Confirmation**

Although some village chiefs have their own data book records, those data are not updated. Strangely, village area and agricultural area are not recorded in the book. Some village chiefs got to know the data on the area due to the project intervention or own estimated measurement. It can say that administrative works at the grass-root level (village level) are still limited. There are no village offices or enough village documents.

5.2 Situation inside the Each Selected Village

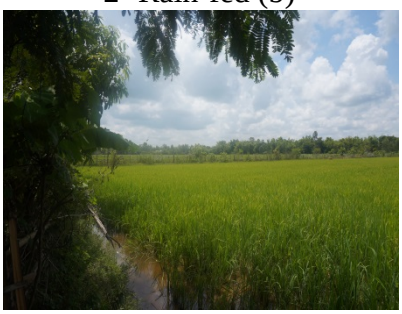
In rain-fed (a) and (b) villages, farmers totally depend on rainfall for both agricultural activities and household use. Small ponds located near farmers' houses or paddy fields are used to store rainfall for farming; whereas, farmers store rainfall in the big cemented containers for household use. Houses are scattered far from one to another. There is a long distance between one house and another due to innumerable paddy fields in between. Although located in the same province as irrigated upstream (g) and downstream (h), rain-fed (c) village has no canals along the paddy fields. However, there is a big reservoir storing the rainfall for irrigation and animal rearing. There is a limited use of reservoir due to the limited rain. Only some paddy fields next to the reservoir can be irrigated by gravity; while others by pumping. In rain-fed (d) village, there is no reservoir but many small ponds found in the village. In both villages (c) and (d), most residential houses are gathered in one place; while paddy fields are outside the residential areas. Pumping well and rainfall stored in big cemented containers are for household use. In rain-fed (e) and (f) villages, not so many ponds are seen but farmers have their own small dikes around house or paddy field for irrigation and animal rearing. Also, farmers said rainfall pattern in their villages is regular. But still, rainfall is stored for the household use.


1- Rain-fed (a)


2- Rain-fed (b)


3- Rain-fed (c)


4- Rain-fed (d)


5- Rain-fed (e)


6- Rain-fed (f)


7- Irrigated Upstream (g)


8- Irrigated Downstream (h)

Figure 33: Situation on Each Selected Village

(All photos taken by author during the fieldwork)

Small canals along the paddy fields can be found in irrigated upstream village (g) where many newly small canals had been built. Farmers did not complain much as before for the irrigation. However, water distribution and canals maintenance are still their concerns. There is no regular

water distribution in the village though Ou Veang FWUC exits. Due to the different elevation of canal and the paddy fields, some farmers need to pump water from or cut the canals into their plots. In irrigated downstream village (h), some parts of the canal are cut or blocked; therefore, water cannot flow to the downstream plots. Same conditions applied, farmers need to pump water from canal to plot due to different elevation. In both villages, rainfall, stream, pumping wells and bought water are the main sources for household consumption. Resident areas are gathered in one place; while paddy fields surround the village.

5.3 Irrigation Application and Its Condition in Study Areas

Practicing SRI requires the best water management as one of its principles. However, it is impossible for rain-fed farmers to manage their water condition in paddy field well due to the lack of irrigation system and unreliable rainfall. As explained above, rain-fed farmers still heavily depend on the rainfall. Delayed or less rain will not only disturb their farming activities, but also their living condition. The common methods of irrigation found in both rain-fed and irrigated area are: (1) by gravity from one plot to another or from nearby stream or pond to the plot based on the condition of plot's elevation, and (2) by pumping from stream or pond to the plot. The cost of irrigation is mainly for the fuel consumption to run the small mobile pumping machine.

(1) Plot-to-plot Irrigation
Photo taken in September, 2015 in Rain-fed (d) of Takeo Province

(1) Pumping Irrigation
Photo taken in March, 2014 in Irrigated Downstream (h) of Kampong Speu Province

Figure 34: Irrigation Methods in Study Areas

In irrigated areas water is more reliable and stable. The main constraints to irrigation are poor condition of existing canals and lack of maintenance. Based on the field observation and household interview, although there is an Ou Veang FWUC existing in the areas but their operation is lacking due to the poor participation from members on the water fee payment, limited budgets and capacity of members on the operation and maintenance works. On the other hand, in 2014 and 2015, some rain-fed study areas faced the delayed rainfall. In 2014, one farmer in rain-fed (c) village in Kampong Speu province delayed his LRV transplanting due to less rain. According to rainfall data in 2004 (see Figure 22); rainfall was 87.3mm and 135.4mm in July and August, respectively. These data was lower than 130.8mm and 161.9mm in July and August, 2013; respectively. More serious case happened in rain-fed (d) village in Takeo province, one

selected farmer failed to harvest ERV in 2014 due to the drought at the end of season. Owing to the rainfall data (see Figure 24); rainfall was only 99.4mm and 38.5mm in July and August; respectively. These data was so low compared to the data in 2013 with 206.2mm and 119.4mm in July and August; respectively.

To clearly visualize the differences between irrigated areas and rain-fed areas in Cambodia; especially in the study areas, the following maps will be illustrated the irrigation situation and plot location of some selected farmers, mainly only main farmers by using the Google Earth Pro and GPS points taken during the fieldworks.

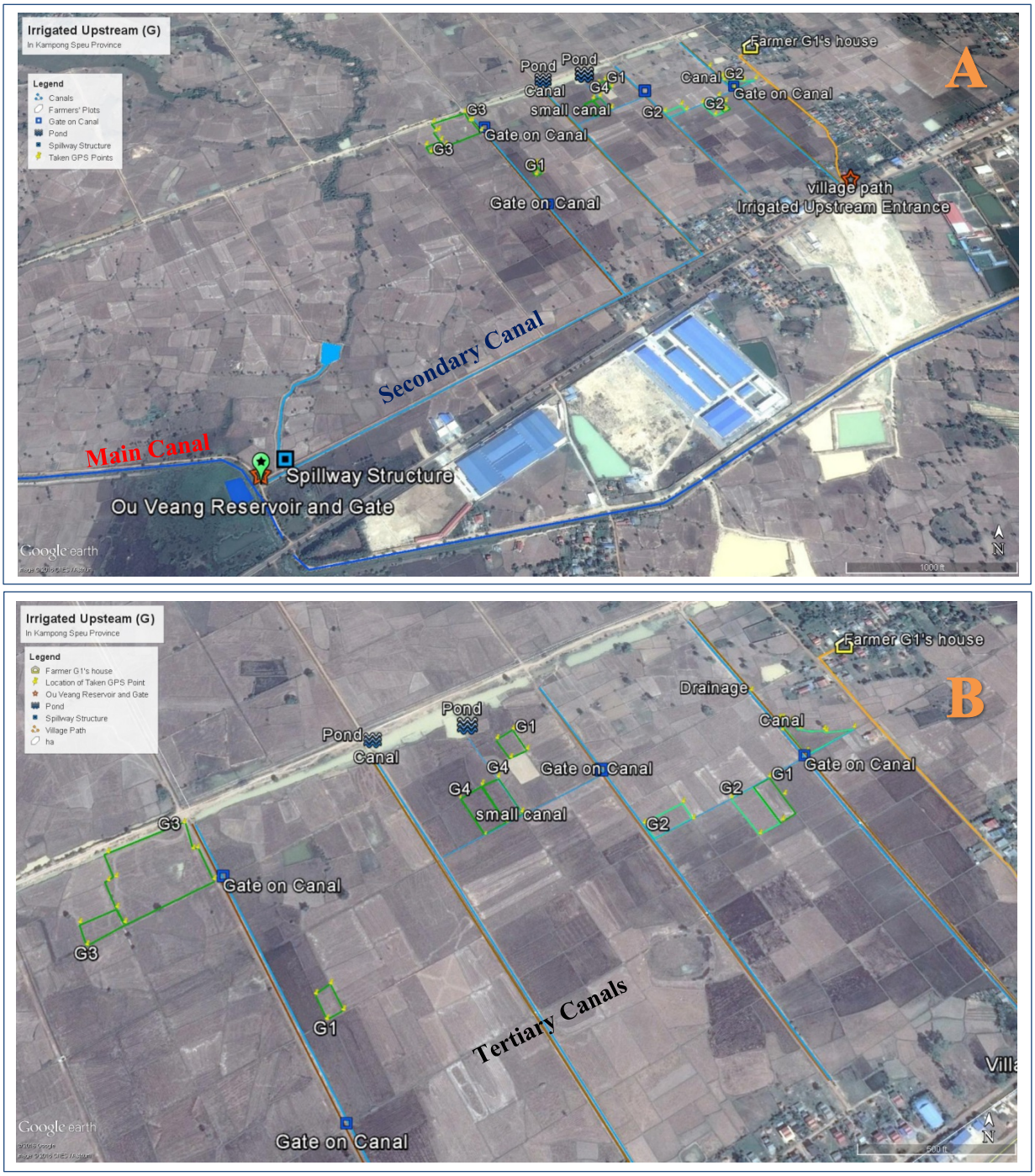


Figure 35: (A) Irrigated Upstream (g) in Full View; (B) Farmer's Plots and Canal Systems

Figure 35 (A) shows the full irrigation system in the Irrigated Upstream (g) village. Main source of water is from main canal. Water is stored in the Ou Veang reservoir and distributed to plots by secondary canal. According to irrigation systems and plot locations shown in this figure, it can be assumed that this area is fully irrigated with good plot allocation. However, water distribution and management and canal maintenance are still lacking due to the limited functions of FWUC. In Figure 35 (B), from the secondary canal, there are many tertiary canals. Water is distributed to plots based on the Gate on those canals. Plots located near the canal can be irrigated directly from canal. Further plots can get irrigated by plot-to-plot method. However, pumping irrigation is needed when less water is in canal.

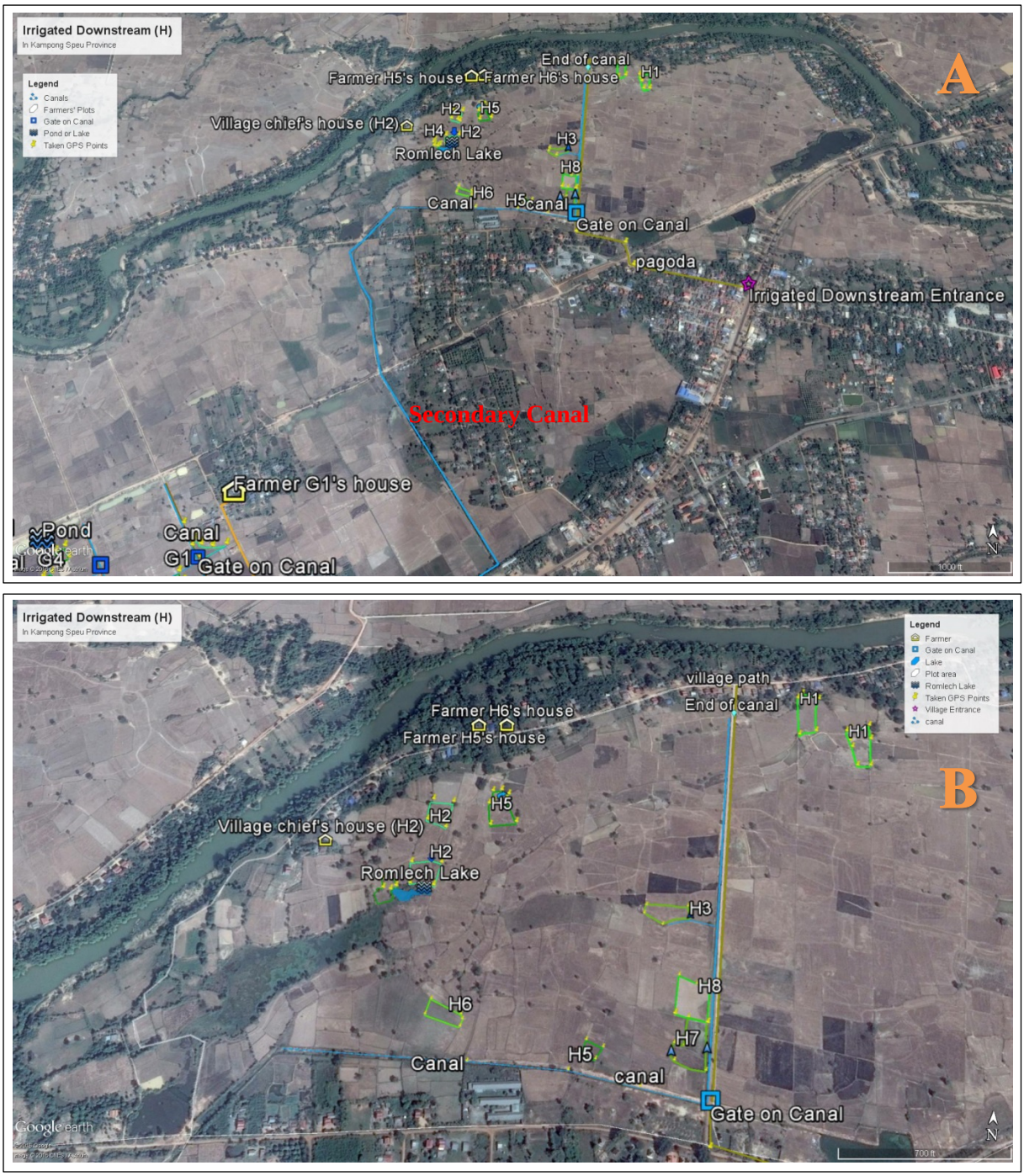


Figure 36: (A) Irrigated Downstream (h) in Full View; (B) Location of Farmers' Plots

Figure 36 (A) visualizes the irrigated downstream (h) village receiving water from irrigated upstream (h) village through the secondary canal. Behind the village, there is a river called Prek Thnoat. Based on the field observation, the condition of secondary canal is not good; while the gate on the connection between secondary canal and tertiary canal is not in use. In Figure 36 (B), there is only one tertiary canal connected from secondary canal. Most of farmers' plots are not connected to the canals. According to the interviews, plots far from canal and river are only irrigated by the rain. For plots next to the canal, gravity irrigation is impossible. Pumping irrigation is needed due to the different elevation. Compared with upstream (g), downstream (h) village is still facing the water problem due to the lack of canal systems, and bad existing canals. Most of plots located far from canals are like rain-fed plots strongly depending on rainfall.

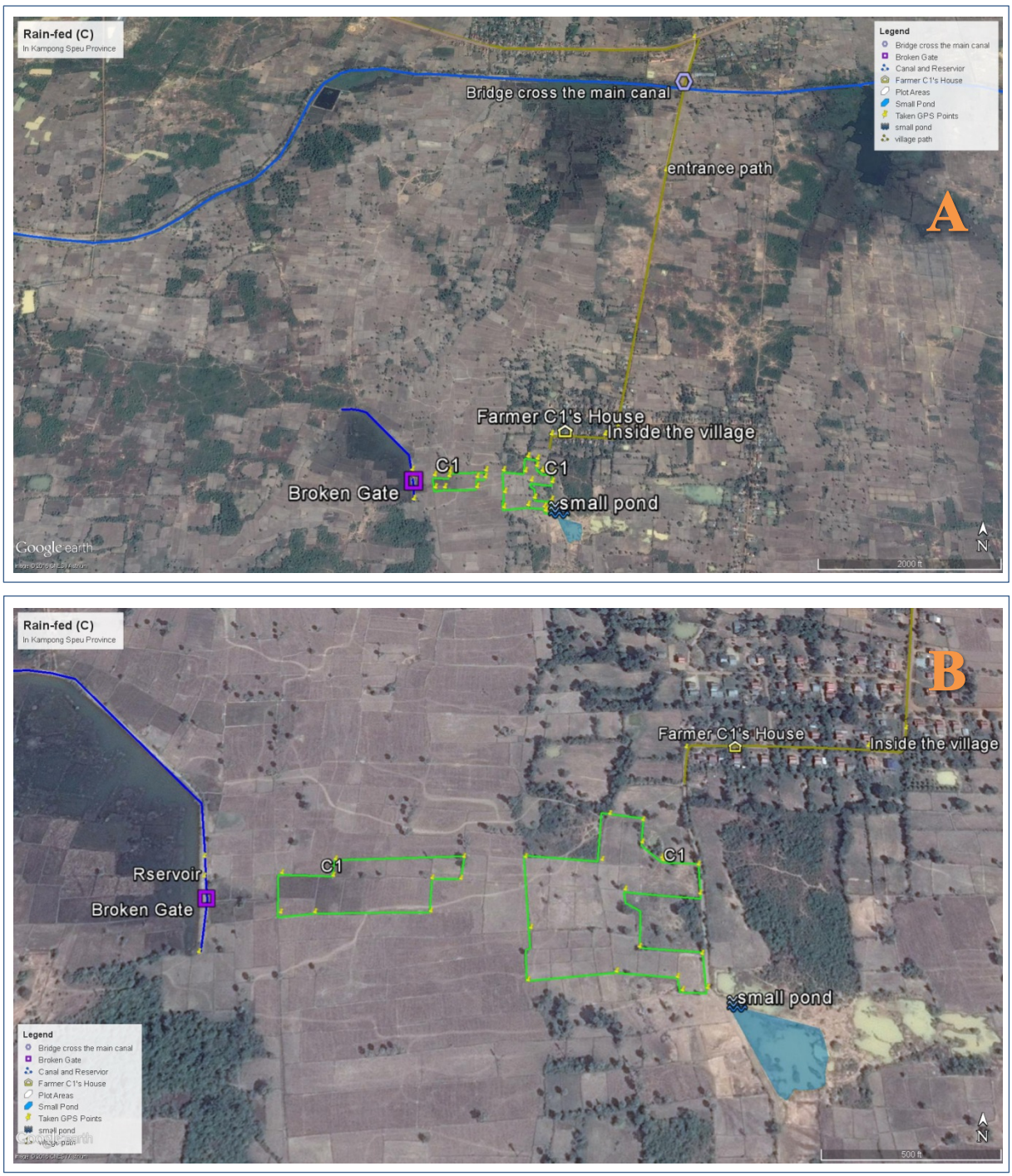


Figure 37: (A) Rain-fed (c) in Full View; (B) Location of farmer's Plots

From the Figure 37 (A), the rain-fed (c) has no any irrigation canal; except a main canal. However, it is not connected to any secondary canal. Rain-fed (c) totally depends on rainfall for agricultural activities. Main canal is so deep; it cannot irrigate nearby plots by gravity; but by pumping. Irrigation development is so far behind in this area. Figure 37 (B) illustrates deeper into the village and farmer's plots. There is no any tertiary canal or small canal existing in the area. However, there is a reservoir where rain is stored in during the rainy season. In the reservoir, farmers can grow crops or early rice varieties during the dry season. Plots near the reservoir are irrigated by pumping.

Figure 38: (A) Rain-fed (d) in Full View; (B) Location of Farmers' Plots

Unlike rain-fed (c) in Kampong Speu province, rain-fed (d) in Takeo province has no reservoir. According to the Figure 38 (A), village is located a bit far away from the urban areas on the national road No.3. Along the way to the village there is a canal crossing the road; however, this canal seems to be far away from the populated place and cannot be used to irrigate the selected farmers' plots in the village. In Figure 38 (B), there is a stream flowing along the village. However, the accessibility to that stream is limited. Due to the depth of the stream; nearby plots can be only irrigated from there by pumping. In the rainy season with enough rain, water from the stream will flow to plots located at another side of village through the underground pipe. In case of insufficient water or during the dry season, farmers totally depend on the rainfall or stored water in their personal ponds.

Due to some constraints, GPS points of all plots of selected farmers in other villages in Prey Veng province and Kampot province were not taken. Therefore, find the details of each village situation regarding the irrigation condition in the table below, based on the field observation and household interviews.

Table 22: Irrigation Application, Methods, and Its Conditions

Areas	Water Source and Irrigation Methods	Conditions
 Rain-fed (a) and (b)	Depend on Rainfall; water is stored in the individual ponds or small streams in the village. Irrigation is done by gravity and pumping.	Most of farmers can grow rice (LRV: Late Ripening Varieties) only once on the same plot. Gravity irrigation is also difficult since the elevation between plot and pond is different. Farmers are planning to build the check structure to store water in the village.
 Rain-fed (c)	Depend on Rainfall; water is stored in the big reservoir. Irrigation is done by gravity and pumping.	Farmers faced the delayed rainfall in September 2014; therefore their transplanting of LRV was also delayed. Water in reservoir is limited since it is also used for animal rearing.
 Rain-fed (d)	Depend on Rainfall; same as Rain-fed (a) and (b), water is stored in the individual ponds or small stream in the village. Irrigation is done by gravity and pumping.	Short-term drought or delayed rainfall occurred during the September 2014; it caused the failure in the harvesting of ERV (Early Ripening Varieties). Farmers delayed their LRV transplanting.
 Rain-fed (e) and (f)	Depend on Rainfall; unlike other rain-fed areas, this area seems to receive the regular rain. Water is stored in individual dike or stream in the village. Irrigation is also done by gravity and pumping.	During the same year of 2014, this area did not face the delayed rainfall. Farmers were told to build the small dike around their house or available space to keep the water. Pumping is applied with the plot far from the water source.

 Irrigated Upstream (g)	Unlike rain-fed areas, irrigated upstream area has the irrigation facilities. Water is available from the upstream reservoir. In case of less rain, there is also limited water in the canal. Irrigation is mostly done by gravity.	Most of farmers in this area can grow rice twice per year because of the high available of water. However, water conflict happens between upstream and downstream farmers. Irrigation facilities and canal maintenance are still poor.
 Irrigated Downstream (h)	Irrigation system is available. Limited water results from the less rain or over use from upstream farmers. Irrigation is mostly done by pumping due to the different elevation between the plots and canals.	Downstream farmers face poor water distribution from upstream areas. Poor canal management and maintenance in this area cause the ineffective way of water distribution because some parts of canal were cut or blocked.

5.4 Challenges on and Accessibilities to Irrigation in Study Areas

As discussed in Chapter 2 on the constraints to irrigation development in Cambodia, collection of water fee is still doubtful to farmers since water is everyone's resources. This issue is also happening in the study areas; particularly in irrigated upstream (g) where FWUC exists. During the interview with the village chief, he said that it is very difficult for him to collect the water fee since farmers said they have not used water from canal. Actually, farmers seem to ignore this duty due to their limited awareness of the roles of FWUC.

Table 23: Irrigation Challenges and Accessibilities in the Study Areas

Areas	Challenges	Accessibilities
Irrigated Areas	***1- In General:*** - No collective works on canal maintenance; - Limited awareness of necessity of FWUC; - Lack of small canals (water courses); and - Conflicts between upstream farmers and downstream farmers ***2- For FWUC:*** - Lack of cooperation from members on fee payment; and - Poor operations in distributing the water and maintaining canals.	- Different elevation, plot-to-plot irrigation is impossible; - No other water source available; still depend on rainfall; and - Irrigation cost (pumping) becomes higher expense for poor households.
Rain-fed Areas	- No FWUC in the areas; - No canal systems; - Dilemma: water for plot or for daily uses? - Total dependence on rain; - Although no water conflicts, farmers without their personal ponds are suffering; and - No ponds or lakes for public use.	- Only plots located near streams or ponds can be irrigated; - Irrigation cost (pumping) becomes higher for poor households; - Limited access to reservoir in some areas such as rain-fed (c)

There is no FWUC in rain-fed areas since there is no irrigation system. Water becomes the dilemma for farmers in rain-fed areas during the drought: whether water is for crops or for

animals and people. Again, water is important for farmers who depend on agriculture as the main incomes; then their better accessibilities to water should be taken into account. Through this study, different elevation between plots and canals cause the difficulty in irrigating the plots; then irrigation cost by pumping becomes higher expense for poor farmers. From this study, it can be assumed that most of other rain-fed areas and irrigated areas where irrigation systems are not functioning well are facing the same challenges and accessibilities.

5.5 Information on Selected Farmers

In rural areas of Cambodia, most of people are living as the extended family. Everyone is sharing the incomes and expenditures. Besides doing farming, some members of family are working for non-agricultural jobs. Those jobs are available in and outside the villages. Some farmers are running a small business or doing handmade craft at home; while young people are working outside as construction and factory workers. Outside working people come back to the village in the evening or at the weekend, based on the distance of their workplaces.

The average family members are 4 persons in each household (ranging from 2 to 10 members). Farming (rice growing) and livestock are the main sources of food and incomes for farmers in the study areas. Some farmers produce enough only for self-consumption; others can sell to the markets for incomes. This issue will be elaborated and discussed in the next chapter. On the other hand, farming and daily consumption become the main expenditure; followed by social activities, education, others and medicines.

5.6 Paddy Varieties, Plantation, Livestock and Agricultural Tools

The growing period of rice varies according to the varieties. Late ripening varieties (LRV) need about 6 months from the nursery stage till the harvest time. Based on the household interviews with selected farmers, LRV called “car 51” required 6 months from the middle of May (nursery stage) till the middle of November (harvest time). However, early ripening varieties (ERV) demand only 4 months. For example, from the early of July till the end of October Jasmine variety, one of the most popular varieties, could be harvested. In some areas, farmers are also growing MRV (Medium Ripening Varieties). MRV requires less time than LRV but longer time than ERV. All varieties farmers have used in the study area are local ones. Seeds of paddy were exchanged among farmers inside and outside the villages.

Besides growing rice, farmers also raise some domestic livestock such as cow, chicken, pig and duck for their extra foods, incomes and labors. These animals are raised ecologically without industrial feed provided due to the extra cost to farmers. Cows are normally used as the extra power for the land and nursery preparation works and their manure is used for making compost. Based on the field observation, some families have their own compost huts. Animal wastes, kitchen wastes and leaves are combined together in the compost hut. Chicken, duck and pig meats are for sale and self-consumption.

Agricultural tools are also main inputs for farmers to get higher outputs and help to reduce the labor cost. However, not all farmers have all needed tools. What most of farmers have in common is sickle. Generally, number of sickles depends on the number of family members who can help and helping people. With less agricultural machines such as tractor, harvesting machine

or threshing machine, farmers mainly depend on the animal powers and hired labors. Only seven farmers have their own tractors; two have threshing machines; and one has a harvesting machine.

5.7 Labor Distribution during the Rice Growing Period

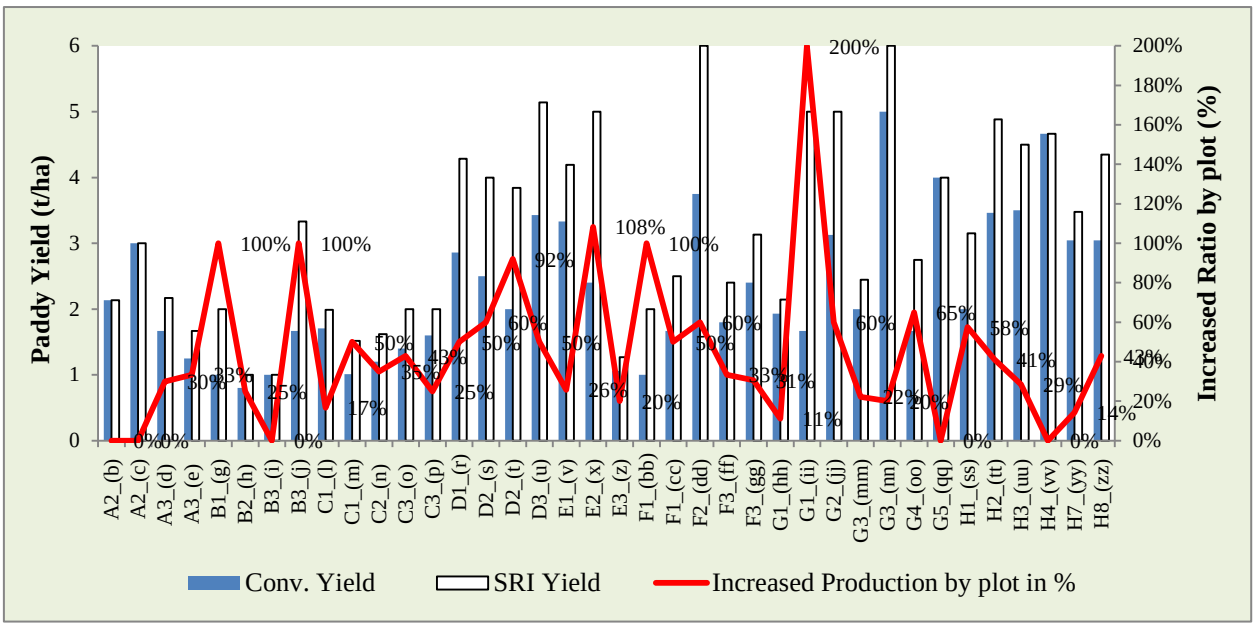
Available labor of each household in average is about 2.20 persons (see Table 24). However, elder people or parents work every day in the field. Other family members can help only during weekend when they are free from schools or workplaces. Regarding the labor distribution during the farming period, farmers hire people or work very hard during land preparation, nursery preparation and transplanting and harvesting.

In that case, during the tillering and panicle stages, farmers leave the plots free from labor. They go to the plots every two or three days to check the water and weed. According to the household survey as well as field observation, young family members are sent to work outside as the factory workers, construction workers and other intensive labor works. This causes the labor shortage when the labor is urgently needed. Moreover, the entire villages are quiet during weekday.

5.8 Rice Farming and Paddy Production

Most of selected farmers have more than one farming plots. Therefore, some farmers can grow rice twice per year. It is impossible for a farmer possessing one plot to grow rice twice on the same plot; especially in rain-fed areas since water is available only in the rainy season. Normally, the main source of water is rainfall. Even in irrigated areas, growing rice twice on the same plot is still difficult for some farmers due to the limited function of irrigation system.

To easily interpret the data, data on production in Table 24 was re-established in the Figure 39. Majority of SRI farmers are able to increase their productions after practicing SRI although some still get the same amount. The highest increased ratio is 200%; it means farmer can increase the production more than double; while the lowest increase ratio ranges from 0 to 11%. With these ratios, it can assume that other factors might influence the practices; resulting in different increased ratios. Poor water management and different water accessibility might be one of main constraints causing SRI yield having no significant different from the conventional yield. Proper water management is difficult to be conducted in these rain-fed areas where rainfall is unstable and there is no irrigation system. Still, at least SRI can help farmers increase their yields with their own adaptive conditions.



***Excluded Conv. Plots: A1 (a), B1 (f), E1 (w), E2 (y), E3 (aa), G4 (pp), H1 (rr), H5 (ww), and H6 (xx).**
****1st SRI Practice on new plot: B3 (k), F2 (ee), and G2 (kk) & (ll)**
*****Drought: D1 (q), Farmer could not harvest in 2014**

Figure 39: Conventional Production versus SRI Production

Table 24: Information on Family Members, Plantation, Livestock, Agricultural Tools, and Paddy Production of Selected Farmers

Farmer	Family members				Income ***	Expense ****	Plantation		Livestock				Agricultural Tools							Area (ha)	Practices	Production (t)		
	Total members	Full time *	Weekend **	Full Availability			Area (ha)	Crops *****	Cow	Chicken	Pig	Duck	Tractor	Animal drawn carts	Sickle	Plough	Harrow	Pumping Machine	Others			Conv.	SRI	Increased Ratio (%)
A1	5	2	0	2	(a), (d) and (f)	1, 2, 3, 4 and 6	-	-	2	10	0	9	0	1	3	1	1	1	-	(a) 0.70	Conv.	*2.50 (2013)*	-	-
A2	5	2	0.6	2.6	(a), (d) and (f)	1, 2 and 4	-	-	2	55	4	6	0	1	4	1	1	0	-	(b) 0.15	SRI	*0.32*	0.32 (2013)	0%
																				(c) 0.10		*0.30*	0.30 (2013)	0%
A3	5	2	0.3	2.3	(a), (c), (d) and (f)	1, 2, 3 and 4	-	-	4	11	0	0	0	1	3	1	1	0	-	(d) 0.60	SRI	*1.00*	1.30 (2013)	+30%
																				(e) 0.48		*0.60 (2013)*	0.80 (2013)	+33%
B1	4	1	0.6	1.6	(a), (c) and (d)	1, 2 and 6	-	-	2	10	20	0	0	0	4	1	1	0	-	(f) 1.00	Conv.	*1.30 (2013)*	-	-
																				(g) 1.00	SRI	*1.00*	2.00 (2013)	+100%
B2	4	1	0	1	(a) and (b)	1, 2, 4, 5 and 6	-	-	2	4	0	0	0	0	0	0	0	0	-	(h) 1.00	SRI	*0.80*	1.00 (2013)	+25%
B3	4	2	0	2	(a) and (d)	1, 2 and 3	-	-	2	20	1	5	0	1	3	1	1	0	-	(i) 2.00	SRI	*2.00*	2.00 (2013)	0%
																				(j) 0.06		*0.10*	0.20 (2013)	+100%
																				(k) 0.40		-	0.80 (2013)[a]	-
C1	6	2	0.9	2.9	(a), (b) and (d)	1, 2 and 3	0.50	(a), (b)	3	22	0	3	0	0	5	0	0	0	-	(l) 0.88	SRI	*1.50*	1.75 (2013)	+17%
																				(m) 1.98		*2.00*	3.00 (2013)	+50%
C2	7	2	0.3	2.3	(a) and (b)	1, 2 and 5	-	-	4	0	0	0	0	1	1	1	1	0	-	(n) 1.00	SRI	*1.20*	1.62 (2013)	+35%
C3	3	1	0.6	1.6	(a), (b) and (f)	1, 2, and 6	-	-	0	0	3	0	0	0	4	0	0	0	-	(o) 0.50	SRI	*0.70*	1.00 (2013)	+43%
																				(p) 0.50		*0.80*	1.00 (2013)	+25%
D1	4	1	0.6	1.6	(a), (d), (e) and (f)	1, 2, 4, 5 and 6	0.05	(c), (d)	0	7	2	0	0	1	3	1	1	1	1 threshing & 1 harvesting machine	(q) 0.25	SRI	1.20	- (2014)[b]	-
																				(r) 0.35		1.00	1.50 (2014)	+50%
D2	4	1	0.3	1.3	(a) and (b)	1, 2, 4, 5 and 6	0.05	(e), (b)	0	4	0	0	0	0	2	0	0	0	-	(s) 0.20	SRI	0.50	0.80 (2014)	+60%
																				(t) 0.25		0.50	0.96 (2015)	+92%
D3	4	3	0.3	3.3	(a), (b) and (d)	1, 2, 3, 4 and 5	0.20	(e), (f)	2	20	0	0	0	0	2	0	0	0	-	(u) 0.35	SRI	1.20	1.80 (2014)	+50%
E1	2	1	0	1	(a), (d), (e) and (f)	1, 2, 4 and 6	0.03	(g), (h)	8	30	2	12	1	1	2	0	0	1	-	(v) 0.21	SRI	0.70	0.88 (2014)	+26%
																				(w) 1.50	Conv._DS	2.50 (2013)	-	-
E2	5	1	0.9	1.9	(a), (b), (d) and (e)	1, 2, 4 and 6	0.02	(d), (e)	3	35	0	14	0	0	2	1	1	1	-	(x) 0.25	SRI	0.60	1.25 (2013)	+108%
																				(y) 0.30	Conv._DS	0.60 (2014)	-	-
E3	5	2	0.3	2.3	(a), (d), and (f)	1, 2, 3 and 6	0.03	(d), (e)	3	40	12	0	1	0	3	1	1	1	-	(z) 1.70	SRI	1.80	2.16 (2014)	+20%
																				(aa) 0.25	Conv._DS	0.90 (2014)	-	-
F1	5	1	0.6	1.6	(a), (d), and (f)	1, 2, 3 and 6	-	-	2	40	1	0	0	0	2	1	1	1	-	(bb) 0.15	SRI	0.15	0.30 (2014)	+100%
																				(cc) 0.60		1.00	1.50 (2013)	+50%

F2	4	1	0.3	1.3	(a), (d), (e) and (f)	1, 2, 3 and 6	-	-	4	10	10	0	1	0	6	1	1	1	-	(dd) 0.20	SRI	0.75	1.20 (2013)	+60%
																				(ee) 0.15		-	0.30 (2014)[a]	-
F3	4	2	0.6	2.6	(a), (d) and (e)	1, 2, 3, 4 and 6	0.03	(c), (d)	3	15	1	0	0	1	5	1	1	1	-	(ff) 0.15	SRI	0.27	0.36 (2013)	+33%
																				(gg) 0.15		0.36	0.47 (2013)	+31%
G1	2	1	0.3	1.3	(a) and (b)	1, 2, 3, 4 and 5	-	-	3	0	0	22	0	0	2	0	0	0	-	(hh) 0.14	SRI	0.27	0.30 (2014)	+11%
																				(ii) 0.12		0.20	0.60 (2015)	+200%
G2	10	3	1.5	4.5	(a), (d) and (f)	1, 2, 3 and 6	-	-	2	45	1	100	1	1	4	1	1	1	1 Threshing machine	(jj) 0.16	SRI	0.50	0.80 (2015)	+60%
																				(kk) 0.12		-	0.90 (2014)[a]	-
																				(ll) 0.15		-	0.56 (2014)[a]	-
G3	7	1	1.8	2.8	(a) and (f)	1, 2, 3, 5 and 6	-	-	4	11	0	0	1	0	6	0	0	1	-	(mm) 0.90	SRI	1.80	2.20 (2014)	+22%
																				(nn) 0.10		0.50	0.60 (2015)	+20%
G4	3	2	0.3	2.3	(a) and (f)	1, 2, 4 and 5	-	-	1	3	0	3	0	0	2	0	0	0	-	(oo) 0.12	SRI	0.20	0.33 (2014)	+65%
																				(pp) 0.16	Conv.	0.50 (2015)	-	-
G5	3	1	0.6	1.6	(a) and (f)	1, 2 and 3	-	-	3	23	0	10	0	1	5	0	0	0	-	(qq) 0.50	SRI	2.00	2.00 (2014)	0%
H1	3	1	0.6	1.6	(a) and (c)	1, 2, 3, 4 and 5	-	-	0	40	3	0	0	0	2	0	0	0	-	(rr) 0.20	Conv._DS	0.30 (2014)	-	-
																				(ss) 00.20	SRI	0.40	0.63 (2014)	+58%
H2	7	4	0.9	4.9	(a), (e) and (f)	1, 2, 3 and 5	0.10	(c), (e), (f)	4	20	0	30	1	1	6	1	1	1	-	(tt) 0.26	SRI	0.90	1.27 (2014)	+40%
H3	3	1	0.6	1.6	(a) and (b)	1, 2, 3 and 4	-	-	3	0	0	0	0	0	2	0	0	0	-	(uu) 0.14	SRI	0.49	0.63 (2014)	+29%
H4	4	2	0.6	2.6	(a), (b), (c) and (f)	1, 2, 4 and 5	-	-	4	0	0	0	0	1	4	1	1	1	-	(vv) 0.09	SRI	0.42	0.42 (2014)	0%
H5	4	2	0.6	2.6	(a), (e) and (f)	1, 2, 4 and 5	0.20	(b), (e), (i)	0	20	0	0	0	0	4	0	0	1	-	(ww) 0.20	Conv.	0.70 (2014)	-	-
H6	5	2	0.9	2.9	(a) and (f)	1, 2, 3, 4 and 5	-	-	0	0	2	0	0	0	2	0	0	0	-	(xx) 0.10	Conv.	0.15 (2014)	-	-
H7	4	1	0.9	1.9	(a), (b) and (f)	1, 2, 3, 4 and 5	-	-	0	0	2	0	0	1	4	1	1	0	-	(yy) 0.23	SRI	0.70	0.80 (2014)	+14%
H8	4	2	0.3	2.3	(a), (e) and (f)	1, 2 and 5	0.50	(d), (f), (j)	2	9	1	0	1	1	12	1	1	1	-	(zz) 0.23	SRI	0.70	1.00 (2014)	+43%
Average	***4.48***			***2.20***																				

**: 1 point for 1 person working full day;*
***: 0.3 point (2days/week) for 1 person working at weekend*
******:*** *Source of Incomes (a): Farming; (b): Factory Salary; (c) Construction Wage; (d) Livestock; (e): Vegetable Selling; (f): Others such as Small business at home, handmade craft, NGO salary and Gov't Salary, etc.*
*******:*** *Expenditure (1): Farming; (2) Daily Food Consumption; (3) Education; (4) Social Activities; (5) Medicines; and (6) Others such as clothes, utilities, etc.*
******: (a) soybean; (b) pumpkin; (c) cucumber; (d) water spinach; (e) long guard; (f) lemon grass; (g) sugar cane; (h) banana; (i) corn and (j) others*
[a]*:No past data available because just started applying SRI in 2013 and in 2014*
[b]*:Could not harvest due to drought in 2014*

5.9 SRI Promotion Activities in the Study Areas

Although SRI has been mentioned in NSDP for 2009-2013 as one of methods to raise the rice productivity, SRI promotion and dissemination activities are limited or there are no follow-up activities on SRI promotion. In rain-fed (a) and (b) in Kampot Province, farmers learnt about the SRI practices during 2004 or 2005 from NGOs; well-known one of them is CEDAC. Other farmers started practicing during 2010, learning from their neighbors. According to the village chiefs, on-going activities in the villages are related to the Farmer Associations mainly focusing on saving groups and other projects on drinking water and hygiene. In rain-fed (e) and (f) in Prey Veng Province, most farmers also learnt SRI practices from CEDAC during 2004 and 2005. Influenced by the same concept, Farmer Associations have been also established by CEDAC; mainly focusing on saving groups. While, other NGOs are working on infrastructure improvement such as construction or rehabilitation of village paths, drainages and canals, etc. In rain-fed (d) in Takeo Province, CEDAC also introduced SRI practices during 2004. Then, the next step was to establish Farmer Association; however, so far only saving groups are still active. No other on-going projects or activities in the village. In rain-fed (c) and irrigated upstream (g) and downstream (h) in Kampong Speu Province, farmers also got to know about SRI from CEDAC during 2006. In irrigated downstream (h), saving group used to exist but now it is inactive. While, in rain-fed (c), saving group established by microfinance institute is in the village. Currently, there is no on-going activity or project related to SRI promotion in the villages.

Based on the current situation in the study areas, SRI promotion activities are inactive after the first attempt was completed. There is no follow-up activity or continuous ones from NGOs or involving government institutes. There are some possible reasons: (1) NGOs or local authorities have no budget to continue their projects; (2) they thought their first attempts were successful without follow-up assessment; (3) NGOs turn their interests in other fields such as infrastructures, drinking water, hygiene and micro-finance.

5.10 Degree of SRI Adoption

SRI is still believed to increase the yields with good water management and young seedling transplantation. For the good and regular water management, it is not easy for farmers in rain-fed areas and also farmers in irrigated areas where irrigation systems do not function properly. Due to water shortage, some farmers could not keep water less in the paddy field.

The degree of SRI adoption of selected farmers is based on the 12 SRI principles introduced by local NGO called CEDAC. Here 1 point is given to farmers applying one principle. Although presently there are many revisions and updates on the SRI principles, here mainly discussed on the 12 SRI principles which farmers firstly started adopting. Moreover, currently there are no any SRI dissemination projects in the study areas.

According to Table 25 as well as the responses during the household interviews, farmers could not transplant seedling younger than 15 days old because they were waiting for the rain. This prolonged the transplanting time then seedlings became older. Another notice is that almost of selected farmers used only one seedling for transplanting. This is a big change from the conventional practices that normally require farmers to use about 5 seedlings per hill. Regarding

the fertilizer application, all farmers have applied organic fertilizers or compost; but some farmers have also used chemical fertilizers. All in all, degree of SRI adoption was from 58% to 100% among selected farmers (see Table 25).

The adoption of SRI is still dependent on other factors. To increase the degree of SRI adoption as well as to increase the yields, other influencing factors are indeed taken into consideration. In case of farmers A1, B1(f), E1(w), E2(y), E3(aa) and H1(oo), they are practicing conventional methods; however, Table 25 shows that there is a low adopting rate of SRI about 16-23%. This indicates that these farmers have learnt and applied one or two SRI principles on the conventional plot. The principles adopted by non-SRI farmers are “apply natural fertilizer as much as possible”, “select purified and dense seedlings for transplanting”, or “weed at least 2-4 times a season”. It can say that conventional farmers understand the bad impacts of chemical fertilizer, and try to increase the amount of natural fertilizer. Additionally, some farmers did not know how to keep seeds well for their next harvesting, and then they possibly mixed different seeds together for sowing and did not select good seedlings for transplanting. These can cause the yield decrease. Important notice is that although conventional farmers do not dare to use one seedling for transplanting but they try to reduce from 5-6 plants to 2-3 plants per hill.

Besides the water constraints, distance from home to plot can be a matter to the SRI adoption. Plots located far away from farmers’ homes are believed to be not preferred for SRI practices because of the traveling time consumption on water management, weeding and fertilizer application. Table 25 shows the distance from farmers’ house to their plot. In order to see the connection between these issues, the relationship between the degree of SRI adoption (see Table 25) with the distance from home to plot will be discussed in the next chapter.

Table 25: Degree of SRI Adoption and Distance from Home to Plot

Area	Rain-fed (a)					Rain-fed (b)						Rain-fed (c)					Rain-fed (d)					Rain-fed (e)					
Farmer	**A1**	**A2**		**A3**		**B1**		**B2**	**B3**			**C1**		**C2**	**C3**		**D1**		**D2**		**D3**	**E1**		**E2**		**E3**	
Plot*	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**	**n**	**o**	**p**	**q**	**r**	**s**	**t**	**u**	**v**	**w**	**x**	**y**	**z**	**aa**
Distance from home to plot (m)	**0**	**0**	**250**	**100**	**1250**	**2500**	**80**	**80**	**300**	**0**	**200**	**70**	**350**	**2500**	**420**	**420**	**20**	**30**	**30**	**30**	**0**	**0**	**10**	**30**	**150**	**200**	**0**
SRI Principles																											
1- Level the paddy field and provide drainage	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0
2- Keep water less in the paddy field	0	1	1	1	1	0	1	1	0	0	0	0	0	0	1	1	1	1	0	0	0	1	0	1	0	1	0
3- Raise nursery beds or use dry nursery beds	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0
4- Select purified and dense seedlings for transplanting	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5- Transplant seedlings younger than 15 days	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- Transplant big seedlings immediately	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0
7- Transplant one plant per hill	0	1	1	1	1	0	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0
8- Transplant seedlings shallowly with roots horizontal	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	0
9- Transplant seedlings with square pattern or in line	0	0	0	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0
10- Transplant seedlings 25-40cn apart	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0
11- Apply natural fertilizer as much as possible	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
12- Weed at least 2-4 times a season	0	0	0	1	1	0	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	1	1	1	1
Total	**2****	**8**	**8**	**10**	**10**	**2****	**10**	**10**	**7**	**7**	**7**	**8**	**8**	**7**	**10**	**10**	**11**	**11**	**8**	**8**	**8**	**9**	**2****	**9**	**2****	**9**	**3****
Percentage (%)	***16***	***67***	***67***	***83***	***83***	***16***	***83***	***83***	***58***	***58***	***58***	***67***	***67***	***58***	***83***	***83***	***92***	***92***	***67***	***67***	***67***	***75***	***16***	***75***	***16***	***75***	***25***

Area	Rain-fed (f)						Irrigated Upstream (g)										Irrigated Downstream (h)								
Farmer	**F1**		**F2**		**F3**		**G1**		**G2**			**G3**		**G4**		**G5**	**H1**		**H2**	**H3**	**H4**	**H5**	**H6**	**H7**	**H8**
Plot*	**bb**	**cc**	**dd**	**ee**	**ff**	**gg**	**hh**	**ii**	**jj**	**kk**	**ll**	**mm**	**nn**	**oo**	**pp**	**qq**	**rr**	**ss**	**tt**	**uu**	**vv**	**ww**	**xx**	**yy**	**zz**
Distance from home to plot (m)	**20**	**300**	**0**	**0**	**50**	**350**	**1000**	**300**	**300**	**350**	**150**	**1000**	**1200**	**500**	**500**	**1500**	**20**	**120**	**150**	**1000**	**500**	**1200**	**600**	**800**	**1000**
SRI Principles																									
1- Level the paddy field and provide drainage	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	0	0	1	1
2- Keep water less in the paddy field	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	0	0	1	0
3- Raise nursery beds or use dry nursery beds	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	1	0	1	1	1	1	0	0	0	1
4- Select purified and dense seedlings for transplanting	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5- Transplant seedlings younger than 15 days	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
6- Transplant big seedlings immediately	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	1	1	0	0	0	1	1	0
7- Transplant one plant per hill	1	1	1	1	10	10	0	0	1	1	1	0	0	1	0	1	0	1	1	0	0	0	0	1	1
8- Transplant seedlings shallowly with roots horizontal	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	0	1	1
9- Transplant seedlings with square pattern or in line	0	0	1	1	1	1	0	0	1	1	1	1	1	1	0	1	0	1	0	0	1	0	0	1	0
10- Transplant seedlings 25-40cn apart	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	1
11- Apply natural fertilizer as much as possible	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
12- Weed at least 2-4 times a season	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	0	1
Total	**9**	**9**	**12**	**12**	**9**	**9**	**7**	**7**	**9**	**9**	**9**	**7**	**7**	**9**	**3****	**8**	**2****	**10**	**10**	**8**	**8**	**3****	**3****	**9**	**8**
Percentage (%)	***75***	***75***	***100***	***100***	***75***	***75***	***58***	***58***	***75***	***75***	***75***	***58***	***58***	***75***	***25***	***67***	***16***	***83***	***83***	***67***	***67***	***25***	***25***	***75***	***67***

: "all" represents the plot (s) that each selected farmers have.

****: Degree of SRI applied in Conventional plots***

5.11 Challenges on SRI Practices

Acceptance and adoption of SRI are still challenging to farmers due to some constraints. As discussed in the Chapter 3.9 on the adoption and adaptation on SRI, discouraging factors for some farmers deciding not to practice SRI are found as encouraging factors for some farmers to practice SRI. Then, it is very difficult to promote the SRI; while farmers have perceived the constraints differently. In this study, some big challenges on SRI practices are divided into two types.

a. Direct Challenges:
    - Insufficient water for irrigating the plots or for practicing alternative drying and wetting (AWD) irrigation;
    - Poor land management and preparation for transplanting due to lack of machinery or animal power; and
    - More cost on irrigation; especially for pumping irrigation.

b. Indirect Challenges:
    - Low interest in applying new agricultural techniques due to uncertain outputs;
    - Lack of pushing factors such as promotion and dissemination activities; and
    - Quick and certain incomes from non-farming activities.

Irrigation still plays an important role in increasing rice productions as well as to increase the acceptance of SRI; while promotion and dissemination activities help farmers change their perception on SRI. Although adoption is difficult; adaptation of SRI is still strongly recommended for farmers based on their situation.

5.12 Total Expenditure on Rice Growing in 2013, 2014 and 2015

The main items of expenditure include seed, fertilizer, irrigation and hired labors. Seeds, local varieties exchanged among inside or outside villagers, have been stored from previous harvesting. Then, farmers do not spend on seeds. However, farmers spend the most on hired labor; followed by chemical fertilizer and irrigation (as shown in Table 26). The cost of hired labor varies based on the working condition. The land preparation work costs about 20,000Riel to 30,000Riel and transplanting work costs from 10,000Riel to 15,000Riel per day per person. Harvesting work is paid based on the amount of the harvest. During the household survey, farmers stated that the costs keep increasing due to less labor in the village. People leave the village for other non-farming jobs inside and outside the country. Still, the costs of hired labor can be negotiated. However, some farmers did not spend or spent less on hired labor cost because they could get help from neighbors or worked with their family members.

Table 26: Total Expenditures on Rice Growing in 2013, 2014 and 2015

Farmer	Plot (ha)		Items (Riel)				Total Expenditure	
			Seed	Chemical Fertilizer	Irrigation	Hired Labor	Riel	USD (Calculation)
A1	(a) 0.70		0	90,000	10,000	438,000	538,000	134.50
A2	(b) 0.15		0	15,800	0	138,000	153,800	38.45
	(c) 0.10		0	19,400	0	138,000	157,400	39.35
A3	(d) 0.60		0	0	0	0	0	0
	(e) 0.48		0	70,000	0	0	70,000	17.50
B1	(f) 1.00		0	155,000	0	0	155,000	38.75
	(g) 1.00		0	0	0	0	0	0
B2	(h) 1.00	2013	0	0	0	50,000	50,000	12.50
B3	(i) 2.00		0	495,000	0	459,000	954,000	238.50
	(j) 0.06		0	0	10,000	88,000	98,000	24.50
	(k) 0.40		0	80,000	0	0	80,000	20.00
C1	(l) 0.88		0	174,000	45,000	257,000	476,000	119.00
	(m) 1.98		0	240,000	45,000	370,000	655,000	163.75
C2	(n) 1.00		0	360,000	0	255,000	615,000	153.75
C3	(o) 0.50		0	10,000	0	75,000	85,000	21.25
	(p) 0.50		0	0	0	75,000	75,000	18.75
D1	(q) 0.25		0	0	20,000	0	20,000	5.00
	(r) 0.35	2014	0	0	30,000	0	30,000	7.50
D2	(s) 0.20		0	150,000	35,000	128,000	313,000	78.25
	(t) 0.25	2015	0	34,500	100,000	230,000	364,500	91.12
D3	(u) 0.35	2014	0	60,000	25,000	80,000	165,000	41.25
E1	(v) 0.21		0	0	4,500	160,000	164,500	41.13
	(w) 1.50	2013		360,000	40,500	450,000	850,500	212.63
E2	(x) 0.25		0	60,000	0	70,000	130,000	32.50
	(y) 0.30			120,000	0	150,000	270,000	67.50
E3	(z) 1.70	2014	0	288,000	27,000	500,000	815,000	203.75
	(aa) 0.25			120,000	0	0	120,000	30.00
F1	(bb) 0.15		0	60,000	0	160,000	220,000	55.00
	(cc) 0.60			120,000	0	580,000	700,000	175.00
F2	(dd) 0.20		0	0	22,500	0	22,500	5.63
	(ee) 0.15	2013		0	13,500	0	13,500	3.38
F3	(ff) 015		0	14,000	0	15,000	29,000	7.25
	(gg) 0.15			14,000	0	18,000	32,000	8.00
G1	(hh) 0.14	2014	0	9,600	30,000	80,000	119,600	29.90
	(ii) 0.12	2015		64,000	15,500	113,000	192,500	48.12
G2	(jj) 0.16		0	57,500	0	160,000	217,500	54.37
	(kk) 0.12	2014	0	57,500	0	160,000	217,500	54.37
	(ll) 0.15		0	79,500	0	160,000	239,500	59.87
G3	(mm) 0.90		0	260,000	0	1,244,000	1,504,000	376.00
	(nn) 0.10	2015	0	82,000	0	120,000	202,000	50.50
G4	(oo) 0.12	2014	0	21,600	0	50,000	71,600	17.90
	(pp) 0.16	2015	0	21,600	0	114,000	135,600	33.90
G5	(qq) 0.50		0	620,000	36,000	384,000	1,040,000	260.00
H1	(rr) 0.20		0	30,000	30,000	50,000	110,000	27.50
	(ss) 0.20		0	35,200	20,000	50,000	105,200	26.30
H2	(tt) 0.26		0	60,000	45,000	180,000	285,00	71.25
H3	(uu) 0.14	2014	0	42,000	30,000	60,000	132,000	33.00
H4	(vv) 0.09		0	23,000	22,500	0	45,500	11.37
H5	(ww) 0.20		0	54,000	100,000	325,000	479,000	119.75
H6	(xx) 0.10		0	0	0	110,000	110,000	27.50
H7	(yy) 0.23		0	75,000	27,000	684,000	786,000	196.50
H8	(zz) 0.23		0	22,500	0	84,000	106,500	26.62

Source: Household Interview; 1USD=4,000Riel (basic estimation)

Although water is important, most of the farmers did not spend money on it; they strongly depend on rainfall. The cost of irrigation was the expenditure on fuel for pumping machines or on the pumping machine rental fee. Water was pumped from small streams, reservoirs or from ponds nearby their farms or houses. In case of Farmers C1-C3 in rain-fed (c), acquiring water from the reservoir is limited because the same water source is also used for raising animals.

Most of the farmers spent a lot of money on chemical fertilizers to add up on amount of the organic ones. Normally, chemical fertilizers are used during the land and nursery preparation. Some farmers did not spend on them because they used only organic fertilizers or their compost or some farmers just collected and applied the animal wastes and leaves to the field directly. However, farmers have tried to reduce or kept the same amount of chemical fertilizers. They have understood the bad impacts of chemical fertilizers on the soil quality and on their health or family members'.

5.13 Amount of Sold Paddy and Its Price

Even farmers possessing single plot are able to sell some to the market such as Farmer B2 in rain-fed (b), and farmers C3 and D3 in rain-fed (c) and (d), respectively. Farmers prefer to sell total amount of popular and high-price paddies such as Jasmine and Somali varieties to the markets and keep the LRV paddy for consumption.

Table 27: Paddy Selling Prices and Selected Farmers' Incomes

Farmer	Plot (ha)	Varieties	Year	Production (t)	Sold amount (Kg)	Price (Riel/Kg)	Total Income	
							Riel	USD (Calculation)
A1	(a) 0.70	LRV	2013	2.50		*Self-Consumption*		
A2	(b) 0.15	LRV		0.32	300	1,200	360,000	90.00
	(c) 0.10	LRV		0.30		*Self-Consumption*		
A3	(d) 0.60	LRV		1.30	1000	1,000	1,000,000	250.00
	(e) 0.48	LRV		0.80		*Self-Consumption*		
B1	(f) 1.00	LRV		1.30	1000	1,000	1,000,000	250.00
	(g) 1.00	ERV		2.00	1000	1,350	1,350,000	337.50
B2	(h) 1.00	ERV		1.00	500	1,350	675,000	168.75
B3	(i) 2.00	LRV		2.00	1700	1,000	1,700,000	425.00
	(j) 0.06	LRV		0.20		*Self-Consumption*		
	(k) 0.40	ERV		0.80	800	1,600	1,280,000	320.00
C1	(l) 0.88	LRV		1.75		*Self-Consumption*		
	(m) 1.98	ERV		3.00	2400	1,200	2,880,000	720.00
C2	(n) 1.00	LRV		1.62	1000	930	930,000	232.50
C3	(o) 0.50	LRV		1.00		*Self-Consumption*		
	(p) 0.50	ERV		1.00	1000	1,400	1,400,000	350.00
D1	(q) 0.25	ERV		***Drought: rice plans sold as grass***			1,000,000	***250.00****
	(r) 0.35	LRV	2014	1.50		*Self-Consumption*		
D2	(s) 0.20	LRV		0.80		*Self-Consumption*		
	(t) 0.25	ERV	2015	0.96	960	1100	1,056,000	264.00
D3	(u) 0.35	LRV	2014	1.80	800	1,000	800,000	200.00
E1	(v) 0.21	ERV		0.88	880	1,500	1,320,000	330.00
	(w) 1.50	LRV	2013	2.50		*Self-Consumption*		
E2	(x) 0.25	LRV		1.25		*Self-Consumption*		
	(y) 0.30	ERV	2014	0.60	300	1,500	450,00	112.50
E3	(z) 1.70	MRV		2.16		*Self-Consumption*		
	(aa) 0.25	ERV		0.90	750	1,500	1,125,000	281.25
F1	(bb) 0.15	ERV		0.30	300	1,500	450,000	112.50

	(cc) 0.60	LRV		1.50		*Self-Consumption*		
F2	(dd) 0.20	LRV		1.20		*Self-Consumption*		
	(ee) 0.15	MRV	2013	0.30	***pounded rice***		1,200,000	***300.00*****
F3	(ff) 015	LRV		0.36	***pounded rice***		1,440,000	***360.00*****
	(gg) 0.15	LRV		0.47		*Self-Consumption*		
G1	(hh) 0.14	LRV	2014	0.30		*Self-Consumption*		
	(ii) 0.12	ERV	2015	0.60	600	700	420,000	105.00
G2	(jj) 0.16	ERV		0.80		*Self-Consumption*		
	(kk) 0.12	LRV		0.90	500	1100	550,000	137.50
	(ll) 0.15	MRV	2014	0.56	560	900	504,000	126.00
G3	(mm) 0.90	MRV		2.20	1500	1050	1,575,000	393.75
	(nn) 0.10	ERV	2015	0.60		*Self-Consumption*		
G4	(oo) 0.12	MRV	2014	0.33	200	1000	200,000	50.00
	(pp) 0.16	ERV	2015	0.50	200	800	160,000	40.00
G5	(qq) 0.50	LRV		2.00		*Self-Consumption*		
H1	(rr) 0.20	ERV		0.30	300	750	225,000	56.25
	(ss) 0.20	LRV		0.63		*Self-Consumption*		
H2	(tt) 0.26	LRV		1.27	500	800	400,000	100.00
H3	(uu) 0.14	LRV	2014	0.63		*Self-Consumption*		
H4	(vv) 0.09	MRV		0.42		*Self-Consumption*		
H5	(ww) 0.20	LRV		0.70		*Self-Consumption*		
H6	(xx) 0.10	LRV		0.15		***Not Enough for self-consumption***		
H7	(yy) 0.23	LRV		0.80		***Not Enough for self-consumption***		
H8	(zz) 0.23	LRV		1.00	400	900	360,000	90.00

****: Due to drought farmer failed to harvest but sold the rice plants as grass. That is assumed to be incomes.***
*****: Farmers said 1kg of paddy can produce 4 cans of pounded rice (1 can=1,000Riel). Therefore, it is assumed those as incomes.***

Most of selected farmers have harvests that can cover all for their self-consumption and sale. Owing to the household interview, farmers said that the remaining paddies are always enough for one year consumption. They sometimes sell some of them for urgent money. This can be early assumed evidence showing that practicing SRI can help farmers contribute their harvest to the markets. In case of Farmers H6, and H7 in irrigated downstream (h), their harvests are not enough for their self-consumption. Farmer H6 said that during about 3 months, her family has to buy 150kg of rice (50kg=110,000Riel); equaled to 234kg of paddies (milling ratio is 64%) for extra consumption. For farmer H7, only for 2 months equaled to 100kg of rice and 156kg of paddies, her consumption is not enough. Assumedly, their productions are low due to the conventional practices.

5.14 Market Accessibility and Farmers' Concerns

Owing to the household interviews, during the harvesting season, normally middle men come to the village and buy the paddies from farmers directly. Farmers just prepare and put all paddies in the plastic bags in advance; then middle men will come with trucks and some laborers to carry the paddies to the trucks. Price is always offered by the middle men and is agreed by the farmers. Although buying price offered by the middle men is low, farmers seem to be satisfied since they do not need to do all the works such as transporting the harvests to markets and carrying and lifting paddies up and down from truck by themselves.

Importantly, in rain-fed (a) and (b), farmers said with big amount of paddies, they can get the higher prices since middle men just come once time and they can collect big amounts. However, it is hard when farmers grow different varieties and harvest in different times.

Regarding the sale to commercial mills directly, farmers did not mention anything during the interviews. However, in order to sell paddies to commercial mills; farmers need to have contract with them or can produce in the large amount. In the study areas, especially selected farmers have only small land.

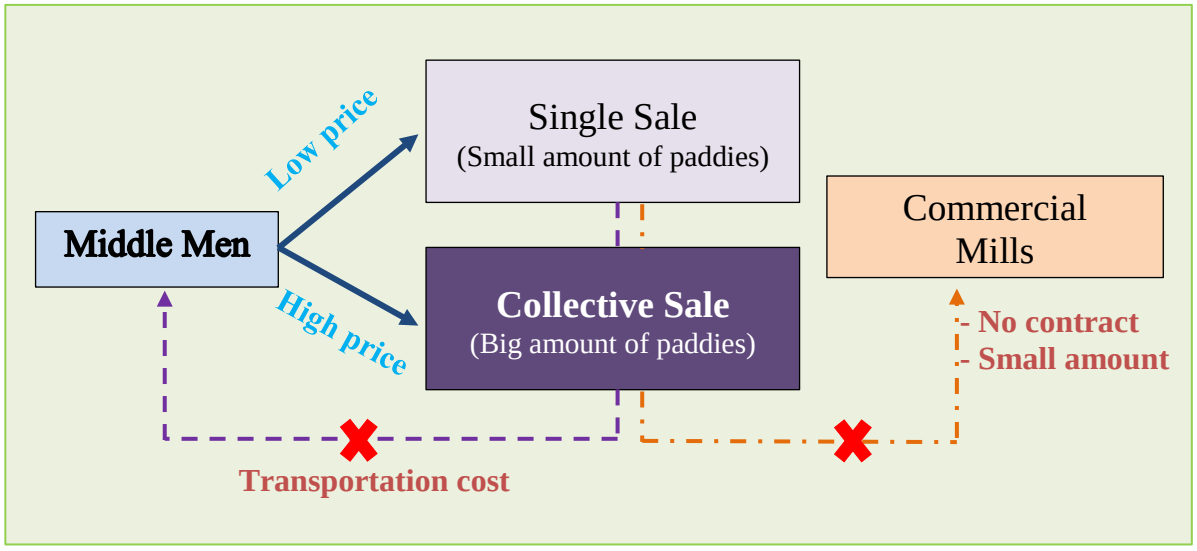


Figure 40: Farmers' Market Accessibility

5.15 Calculation on Labor Requirements for Rice Growing

In order to get the precise information on the labor requirement, six main farmers among the selected farmers were asked to write down their daily farming activities on the provided sheets (see the appendix II) for the rice growing 2014-2015 and 2015-2016. Those farmers are farmer C1 from rain-fed (c) in Kampong Speu province, farmers D1, D2, D3 from rain-fed (d) in Takeo province, G1 from Irrigated Upstream (g), and farmer H1 from Irrigated Downstream (h) in Kampong Speu province. The calculation on labor requirement was done based on the different stages of rice growing cycle including (1) land preparation, (2) nursery preparation, (3) sowing, (4) uprooting, (5) transplanting, (6) irrigation and water and plot management, (7) fertilizing, (8) weeding, and (9) harvesting and transporting. The calculation here does not include the threshing, drying and storage time. The unit of the labor requirement is an hour/ha.

Before jumping to the results of labor requirements, Table 28 explains the rice growing history of each main selected farmer from 2013 to 2015. Even in the irrigated areas, growing ERV and LRV on the same plot is difficult due to the limited water from the rain. And it becomes more serious in rain-fed areas when there is less rain or drought. Owing to the household interview and field observation; plus the strong evidence form the rainfall data (see Figure 22 and 24), during the dry season in 2014, most of areas in Kampong Speu province received less rain and some areas faced the drought with the rainfall of 52.2mm, 117.8mm and 87.3mm in May, June and July; respectively. These data were lower than ones in 2013. Due to these, farmers could grow rice only once time on same plots. In Takeo province, in 2014 it was much rain (212.7mm in May) at the end of dry season; therefore, farmers decided to grow ERV, as example as farmer D1. Unfortunately, amount of rain dropped sharply in July and August with 99.4mm and 38.5mm; respectively. Then, farmer decided to cut and sell the rice plants as grasses. In 2015, there was enough rain from the mid of the dry season and much rain in October and November (see Figure

22 and 24); therefore, some irrigated farmers could grow twice on the same plots and rain-fed farmers also could grow both ERV and LRV. Finally, most of plots were harvested; while much water was still standing inside.

On another hand, due to the unstable rainfall or less rain and lack of labors, farmers normally do not grow other crops on the rice plots during the off- farm season (from end of December or early of January till mind of April). According to the rainfall data from all selected areas during 2013-2015 (shown in Figure 22, 24, 26 and 28), amount of rainfall ranges from 0mm to78.2mm from January to March.

Table 28: Rice Growing History of Main Farmers from 2013 to 2015

Farmer	Plot (ha)	2013		2014		2015	
		Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season
G1	(hh) 0.14	-	LRV	-	LRV	-	LRV
	(ii) 0.12	-	LRV	ERV	-	ERV	LRV
H1	(rr) 0.20	ERV	-	ERV	-	ERV	LRV
	(ss) 0.20	-	LRV	-	LRV	-	LRV
C1	(l) 0.88	-	LRV	-	LRV	-	LRV
	(m) 1.98	ERV	-	ERV	-	ERV	-
D1	(q) 0.25	*ERV (no harvest due to drought)*	*LRV*	*ERV (no harvest due to drought)*	-	ERV	LRV
	(r) 0.35	*ERV (no harvest due to drought)*	*LRV*	*ERV (no harvest due to drought)*	LRV	-	
D2	(s) 0.20	-	LRV	-	LRV	-	LRV
	(t) 0.25	-		-	-	ERV	
D3	(u) 0.35	-	LRV	-	LRV	-	LRV

Based on the rice growing calendar shown in Table 28, the following Table 29 will show the details of 2014 and 2015 rice growing information extracted from the farmers' records. For the 2013, only data of farmer C1 was shown in the all previous tables as well as figure because 2013 data for farmer G1, H1, D1, D2, and D3 were not collected during the fieldworks. The data shown in table below here will be utilized only in the case study in the discussion part. For Farmer D3, only 2014 data is shown due to insufficient record.

Table 29: Rice Growing Information for Main Farmers during 2014 and 2015

Farmer	Plot (ha)	Year of Practice	Production (t)		Expenditure (Riel)			
			Con.	SRI	Seed	Chemical Fertilizer	Irrigation	Hired Labor
C1	(l) 0.88	2014 (LRV)	1.50	0.72*	0	174,000	15,000	115,000
		2015 (LRV)	1.50	1.80	0	0	0	267,000
	(m) 1.98	2014 (ERV)	2.00	0.80**	0	240,000	15,000	150,000
		2015 (ERV)	2.00	4.00	0	0	0	486,000
D1	(q) 0.25	2014 (ERV)	1.20	-***	0	0	20,000	0
	Only 0.20	2015 (ERV)	1.20	1.30	0	0	17,500	91,000
	(r) 0.35	2014 (LRV)	1.00	1.50	0	0	25,000	0
	With 0.40	2015 (LRV)	1.00	1.70	0	0	14,000	182,000
D2	(s) 0.20	LRV (2014)	0.50	0.80	0	150,000	35,000	128,000
	(t) 0.25	ERV (2015)	0.50	0.96	0	34,500	100,000	230,000
	0.20+0.25	LRV (2015)	1.00	1.80	0	325,000	30,000	590,000
D3	(u) 0.35	LRV (2014)	1.20	1.80	0	60,000	25,000	80,000
G1	(hh) 0.14	LRV (2014)	0.27	0.30	0	9,600	30,000	80,000
	0.14+0.12	LRV (2015)	-	0.90	0	0	80,000	192,000
	(ii) 0.12	ERV (2014)	0.20	0.25	0	25,600	0	120,000
		ERV (2015)	0.20	0.60	0	64,000	16,500	113,000
H1	(rr) 0.20	ERV (2014)	0.30	-	0	30,000	30,000	50,000
	(ss) 0.20	LRV (2014)	0.40	0.63	0	35,200	20,000	50,000
	0.20+0.20	LRV (2015)	-	1.24	0	0	0	250,000

****: Only partial land was cultivated, old seedlings were used and drought occurred during October to December, 2014***

*****: Only partial land was cultivated, old seedlings were used and drought occurred during September to November, 2014***

******: No harvest due to Drought***

For the activity records of the rice growing during 2014-2015, only four farmers including G1, H1, C1 and D2 could record their full farming activities for a year. For farmer D1, he failed to record the complete activities due to the drought occurring in the mid of dry season (as explained earlier). So, he decided to harvest the rice plants and sold as grasses. For farmer D3, he could write up to the transplanting works; and stopped writing the remaining works. Up on the first request, farmers were reluctant to write down, so during the follow-up fieldwork, farmers were asked to recall and write down; although some farmers could write down from the beginning. Other found problems for recording activities regularly are (1) only head family or children can write and read; so when they are away for their non-farming activities and schools, no one can write down and (2) they find this kind of activities are useless or profitless to them.

According to Table 30 (a) below, farmer H1 applied the direct-seeding (DS) method; therefore there was no data on the uprooting and transplanting time. Practicing SRI requires farmers to do immediate transplanting after the uprooting. However, with the small plot, farmers could finish uprooting the seedlings during the very short period then the uprooting time is included in the transplanting time. With the large area in case of farmers C1, uprooting seedlings required some times. As results, uprooting and transplanting times were divided. Moreover, in some cases like farmer C1, with large area the time for land preparation was small due to own labor. Farmer C1

prepared the land daftly by himself. It can happen to other cases even with hired labor. Hired land preparing people just tried to finish their works as soon as possible to save time for other business. For irrigated upstream (g), irrigation and water management and weeding times are higher than ones in irrigated downstream (h), rain-fed (c) and rain-fed (d). Although it was a short drought and delayed rainfall, farmer G1 still spent more time on water management because regular field visits can prevent the remaining water from being drained out by other farmers. Farmers in irrigated downstream (h), rain-fed (c) and (d) spent less time because no weed grew and water was not sufficient. All in all, farmers spent in the field form 190 to 725 hours/ha, 320 to 871 hours/ha, and 410 hours/ha for ERV, LRV and ERV Direct Sowing; respectively. Detailed labor consumption for each plot can be referred to Table 30 below in addition with the detailed record of farmers' activity attached in appendix IV and V.

In 2015, same six farmers were asked to record their farming activities again. However, farmer D3 in rain-fed (d) in Takeo province again failed to record his farming activities. Therefore, there is no data shown in Table 30 (b).

Table 30: Labor Requirements for Rice Growing in (a) 2014 and (b) 2015

(a) Rice Growing Cycle in 2014 (in hours)	**Farmer G1**		**Farmer H1**	**Farmer C1**		**Farmer D2**
	0.14 ha	0.12 ha	0.20 ha	1.98 ha	0.88 ha	0.20 ha
	LRV (SRI)	ERV (SRI)	ERV (DS)	ERV (SRI)	LRV (SRI)	LRV (SRI)
Land Preparation	3 ***(3)****	2 ***(2)****	8 ***(8)****	22	14	4 ***(4)****
Nursery Preparation	4	1 ***(1)****	0	12	12	6 ***(6)****
Sowing	2	2	2	4	4	4 ***(2)*****
Uprooting	0	0	0	84 ***(42)*****	46	0
Transplanting	32 ***(24)*****	24 ***(16)*****	0	78 ***(36)*****	66	45 ***(39)*****
Irrigation and water management	34	16	23	16	12	28
Fertilizing	9	2	2	16	8	4
Weeding	12	4	9	0	0	10
Harvesting and Transporting	26 ***(12)*****	36 ***(12)*****	38	144	120	48 ***(32)*****
Total (hours)	***122***	***87***	***82***	***376***	***282***	***149***
Hours/ha	***871***	***725***	***410***	***190***	***320***	***745***

(b) Rice Growing Cycle in 2015 (in hours)	**Farmer G1**		**Farmer H1**	**Farmer C1**		**Farmer D1**		**Farmer D2**	
	0.14+0.12 ha	0.12 ha	0.20+0.20 ha	1.98 ha	0.88 ha	0.35+0.05 ha	0.20 ha	0.25 ha	0.25+0.20 ha
	LRV (SRI)	ERV (SRI)	LRV (SRI)	ERV (DS)	LRV (SRI)	LRV (SRI)	ERV (SRI)	ERV (SRI)	LRV (SRI)
Land Preparation	12 ***(8)****	8 ***(4)****	20 ***(8)****	70	70	25	3	12 ***(9)****	19 ***(12)****
Nursery Preparation	5 ***(2)****	2 ***(2)****	10 ***(6)****	12	10	6	4	3	8 ***(8)****
Sowing	1	2	2	4	2	0.5		1	1
Uprooting	9 ***(9)****	3	26 ***(15)*****	0	144 ***(121)*****	52 ***(10)*****	18	11 ***(4)****	10 ***(10)****
Transplanting	32 ***(32)****	16	86 ***(31)*****	0		110 ***(24)*; (42)*****	59 ***(27)****	24 ***(18)****	96 ***(96)****
Irrigation and water management	64	43	0***	0***	0***	14	10	12	3
Fertilizing	7	5	0	0	0	6	3	17	32
Weeding	14	12	0***	0***	0***	0	10	21	19
Harvesting and Transporting	62 ***(4)*****	11 ***(2)**** ***Harvest by machine***	93 ***(22)*****	289 ***(264)****	108 ***(96)****	112 ***(32)****	26 ***Harvest by machine***	62 ***(35)****	114 ***(96)****
Total (hours/person)	***206***	***102***	***237***	***375***	***334***	***325.50***	***133***	***163***	***302***
Hours/ha	***792***	***850***	***593***	***189***	***380***	***814***	***665***	***652***	***671***

(…)*: Hired labors in hour, mainly for land preparation by cows or tractor with ranging cost from 40,000 Riel to 80,000 Riel;
(…)**: Sharing-hand mostly happens during uprooting, transplanting and harvesting works;
: Data is Zero because it was enough rain after transplanting work. Water remained in the plots till harvesting time; therefore there was no activity for water management and weeding;
LRV: Late Ripening Variety, ERV: Early Ripening Variety, and DS: Direct-Seedling.

Based on the records and household interviews, there was a short drought before transplanting; then some farmers had prepared land for nursery or transplanting twice. For example, Farmer C1 spent 12 hours for nursery preparation due to the repetition of works and finally farmer decided to apply Direct Seedlings. Moreover, after transplanting, there was much rain; so some farmers did not spend time for water management and weeding. This also happened in case of Farmer C1 and H1. While other farmers spent less time on water management and weeding. Finally, most of plots in irrigated and rain-fed areas were harvested with much water standing. Based on the Table 30 (b), the labor requirements for one season 2015-2016 of ERV, LRV, and ERV Direct Sowing growing are from 652 to 850 hours/ha, 380 to 814 hours/ha and 189 hours/ha; respectively.

With these data collection from two years of farming activity records, Table 31 below indicates the statistical description showing the average labor requirement of LRV is 648hours/ha and the average one of ERV is 617hours/ha. With these numbers, there are only about 30hours different for labor requirement between practicing LRV (SRI) and ERV (SRI). Some reasons as follow:

- Regardless the ERV or LRV growing, land management, uprooting and transplanting require labors and time almost the same;
- In case of sufficient water or rain during rainy season, farmers would spend less time on water and weed management during the LRV growing;
- However, in dry season when there is a shortage of water, farmers would spend more time on water and weed management during the ERV growing.

Table 31: Statistical Description of Labor Requirement during LRV and ERV Growing

Growing	Data (hours/ha)	Maximum	Minimum	Average	Standard Deviation
LRV (SRI)	792, 593, 380, 814, 671, 871, 320, 745	871	320	***648.25***	203.67
ERV (SRI)	850, 665, 652, 725, 190	850	190	***616.60***	251.01
ERV (DS)	189, 410	410	189	***299.50***	156.27

5.16 The Changes of Farmers' Livelihood

In order to know the livelihood changes of farmers, especially SRI farmers and also the impacts of SRI on the farmers' livelihood improvement, the detailed histories of livelihood changes including changes of assets and loan situation of six main selected farmers are explained below.

5.16.1 Changes of General Properties before and after Practicing SRI

All six main farmers (G1, H1, C1, D1, D2, and D3) were kindly asked to recall their assets they possessed before practicing SRI (or during the past 10 years) and report their current assets during practicing SRI. It is not convenient for them to report their properties; however, they were

happy to cooperate since the main purpose of this interview was just to know the merits of SRI and all the information will not be used for personal interest.

Table 32: General Assets before and after Practicing SRI

Farmers	TV		Motorbike		Bike		Others	
	Before	**Now**	Bef.	**Now**	Bef.	**Now**	Bef.	**Now**
G1	0	**1**	0	**1**	0	**1**	0	**1 (pumping well)**
H1	0	**1**	0	**1**	1	**1**	0	**1 (Radio)**
C1	0	**0**	0	**1**	4	**1**	1(small Battery)	**1 (bigger)**
D1	0	**1**	0	**1**	1	**1**	1 (Radio)	**1 (CD player)**
D2	0	**1**	0	**0**	1	**2**	1 (toilet)	**2 (toilets)**
D3	1 (b/w)	**1 (color)**	0	**1**	0	**2**	0	**1 (biogas)**

Table above indicates that in term of general assets farmers now can have a better access to information through possessing TV, and radio, better transporting methods with motorbikes while the number of bikes increased and other better facilities for their daily lives such as pumping well, toilets and biogas.

5.16.2 Changes of Agricultural Assets

According to the interview as well as Table 38, there is no much change regarding the agricultural tools. Only Farmer C1 now has a tractor and Farmer D1 has harvesting and threshing machines. Other farmers are still using their old tools or hiring people for some works. For animal rearing, farmers have not expanded their activities. Number of animals have increased or decreased slightly depending on family members who can take care of them. Some farmers had sold or bought more land; however most of them have not enlarged their farming plots.

Table 33: Changes of Agricultural Assets

Farmers	Plow		Harrow		Sickle		Tractor		Others	
	Bef.	**Now**	**Bef.**	**Now**	**Bef.**	**Now**	**Bef.**	**Now**	**Bef.**	**Now**
G1	0	0	0	0	2	2	0	0	-	-
H1	0	0	0	0	3	3	0	0	-	-
C1	1	0	1	0	7	7	0	1	-	1 Pumping Machine
D1	1	1	1	1	3	3	0	0	-	1 harvesting and threshing machine
D2	0	0	0	0	2	2	0	0	-	-
D3	0	0	0	0	2	2	0	0	-	-

Farmers	Farming Land (ha)		Cow		Chicken		Pig		Duck	
	Bef.	**Now**	**Bef.**	**Now**	**Bef.**	**Now**	**Bef.**	**Now**	**Bef.**	**Now**
G1	1	0.26 (sold some plots)	2	4	5-6	4	0	0	10	8
H1	1	0.40 (gave to sisters)	0	0	20	0	0	4	0	0
C1	≈ 2	Same	2	3	2	15-20	1	1	0	10-20
D1	0.60	Same	0	0	5	6-7	2	2	0	0
D2	0.45	Same	3	0	4	4	1	0	0	0
D3	0.35	Same	2	0	≈ 40	≈ 20	2	0	0	0

It can be interpreted that farmers have no intention to invest more in the farming activities; they are satisfied with their production. They can produce more without investing much in the agricultural tools.

5.16.3 Loan Situation in the Study Areas

From the last 10 years ago or before practicing SRI, most of farmers used to lend the money from local lenders or micro-finance to deal with the food shortage (due to low production), emergency needs, and children's education. Later on, farmers was/are able to pay back the loan and have better housing condition. Based on the farmers' narration as shown in Table 34, incomes from agriculture have helped farmers pay back the loan, deal with the shock, and improve their children's education. For example, in case of Farmer G1, she lived with her sister's family; gradually, she could buy the land and build her house and be able to pay back the loan. Farmer C1 has worked hard in the field to send his children to school. Finally, he gets good payoff from agricultural activities and remittances from his children to pay back the loan.

Table 34: Loan Situation based on the Main Selected Farmers' Narration

Farmer G1	In 2013, borrowed 1500USD from the local authority to build house. By September 2015, was able to pay all the loans. Incomes from construction (husband's job) are not stable. Every year at least 3 times get the loan from other people in the village. Incomes from the agriculture can pay back the loan. But cannot have much saving.
Farmer H1	Because there are only few family members, incomes and rice for consumption are enough. Just before the youngest sister was still studying; so there was no saving. But now, she is working; so we can have savings; plus we can sell paddies. We built a new kitchen with small warehouse to store our harvests. Then I start to raise some pigs again.
Farmer C1	During the past 10 years, incomes were small. I sold the paddy and worked as agricultural worker. Still I needed to get the loan from local banks by using land title as collateral. Gradually, daughter gets a job as factory worker and son works in Phnom Penh. Incomes from agriculture were the foundation for my family. Now, I am a motor taxi. Incomes are better. I could purchase tractor and build bigger house.
Farmer D1	During the past 10 years, paddy was not enough but we did not need loan because other family members have been doing other businesses such as a lender to other people in the village with small interest, a member of saving group and livestock seller. Later, practicing SRI, and producing more paddies. Now, paddy is more than enough. More incomes from selling the paddy. Farmer could buy more agricultural tools and renovated our house.
Farmer D2	During the past 10 years, we could produce enough and sold to the market. But incomes were not enough. Farmer got the loan from NGOs and villagers. Now, rice production is stable also family members are working. One is working as factor worker in Cambodia and one is working outside the country. More incomes we earn then we were able to pay back all the loans. With extra incomes, we could renovate their house.
Farmer D3	During last 10 years, practicing conventional provided low yield. It was not enough for eating about 2 to 3 months. Got the loan from Local banks construct house. Gradually, there is enough rice for eating by practicing SRI. Moreover, two family members are working as factory workers. We earn extra incomes from handmade craft and construction workers. Then we could pay back the loan.

Through these changes regarding the loan payment, agriculture plays an important role. Paddy production becomes stable or higher; then farmers can save money earned from other businesses to pay back the loan. With stable or higher paddy production, farmers can improve their living gradually.

CHATPER 6: DISCUSSIONS

Based on research findings, household interviews, and field observation, this part in essence notifies some key points as follows:

6.1 Irrigation and Recommended Water Saving Methods

Even in the irrigated areas, sometimes farmers also face the limitation of irrigation water due to less rain, according to the farmers' respond during the household interviews. Moreover, regular water distribution in the areas has not been operated well because of poor irrigation structure, poor land preparation, and lack of canal bank maintenance. Water cannot reach the paddy fields because of different elevation between the rice bank and canal bank. Farmers have no choice but to cut the banks to connect them. This kind of action disturbs the irrigation distribution in the area. On the other hand, in rain-fed areas, rainfall is only the main source of irrigation. Delayed rainfall will prolong the rice growing. For example, in rain-fed (c) and (d), in 2014 farmers could transplant their seedlings for LRV during the October due to the drought. Only some plots located near the stream or reservoir could be irrigated by pumping. Still, extracting water in the stream or reservoir is sometimes restricted such as the case of farmers in rain-fed (c).

To save water for irrigation, Guerra et al. (1998) has introduced three possible ways targeting at reducing SP (Seepage and Percolation). Those three methods include (1) reducing the depth of ponded water; (2) keeping the soil just saturated or (3) applying alternative wetting and drying (AWD). Among these three possible ways, the last one is mainly centered in this discussion since AWD is also recommended in SRI (Uphoff, 2003) and in this research selected farmers are practicing SRI. However, they are still applying continuous flooding although most of them are aware of that principle, less water application. To keep rice fields continuously flooded is to spend less time on weeding due to farmers' responses during the household interviews. This claim is also proved by Brown et al. (1978) having said that the primary purposes of the continuous flood are to control weeds and irrigate crop. However, their results show that to irrigate continuously is very wasteful of water. Although AWD method can save water, Bouman and Tuong (2001) had said that AWD can lead to yield reduction because of possible drought-stress effects on the crop. Although there is a practical solution to reduce water loss; however, this AWD method cannot be applied in these study areas. Farmers are still afraid of taking risk to keep water less in the paddy field. They said that if keeping water less or draining water out and if later drought occurs, this will spoil the rice grain after harvesting. They must have experienced it. Therefore, they do not want to take this risk. It is expected that this solution, AWD application, will be possible after irrigation systems have been improved and farmers are able to maintain and operate the irrigation systems well. Associated with the results from field observation and household interviews, to help farmers be able to deal with short-term drought and water shortage, some recommended water saving methods as follows:

1- Construction of small dike connected from one plot to another: doing so requires the commitment and contribution from the farmers. Farmers or village chief should initiate such kind of activity in the village rather than keep waiting for the development aid or project from the government or NGOs;

2- Construction of public reservoir, ponds or wells: in most of selected areas, some farmers have their ponds to store rainfall. However, other farmers who have no effort to dig ponds have no water for irrigation. To solve this problem, village chief, farmers or group of farmers should use the free land to dig the big ponds for common use;
3- Construction of small dike around their house compound: this kind of good samples was found in rain-fed (e) and (d). Therefore, other villages should learn from this practice. Small dike can store some water which can be used for animal feeding or vegetable watering; and
4- Installation of cement containers: since clean water supply system is not yet provided to rural areas, installation of cement containers can save rainfall for household use or animal rearing and vegetable watering. This kind of method has been practiced in rain-fed (a) and (b).

These proposed methods are not new but they were neglected by the local people because of the poor social network in the village (the details of this issue was discussed later in this chapter). People seem to ignore the benefit sharing but they prefer to fulfill the individual needs.

6.2 Correlation between Plot Distance and Available Labor with Degree of SRI Adoption

As discussed earlier, water management plays as one of the important factors influencing on the degree of SRI adoption. Since most of the selected areas in this study were conducted in rain-fed villages where water or rainfall is not stable, it was previously assumed that other factors might be taken into the consideration regarding the increase of degree of SRI adoption. Here analyzed the correlation between plot distance and labor availability of family members with the degree of SRI adoption among the SRI farmers because distance between the home and plot was assumed to be one of factors that can affect the farmers' practices. However, Figure 41 (A) shows that there is a very weak correlation with value of the R^2 only 0.14 between the distances from home to plot and degree of SRI adoption. Therefore, distances from home to plot have no significant influence on the degree of SRI adoption (see Table 35).

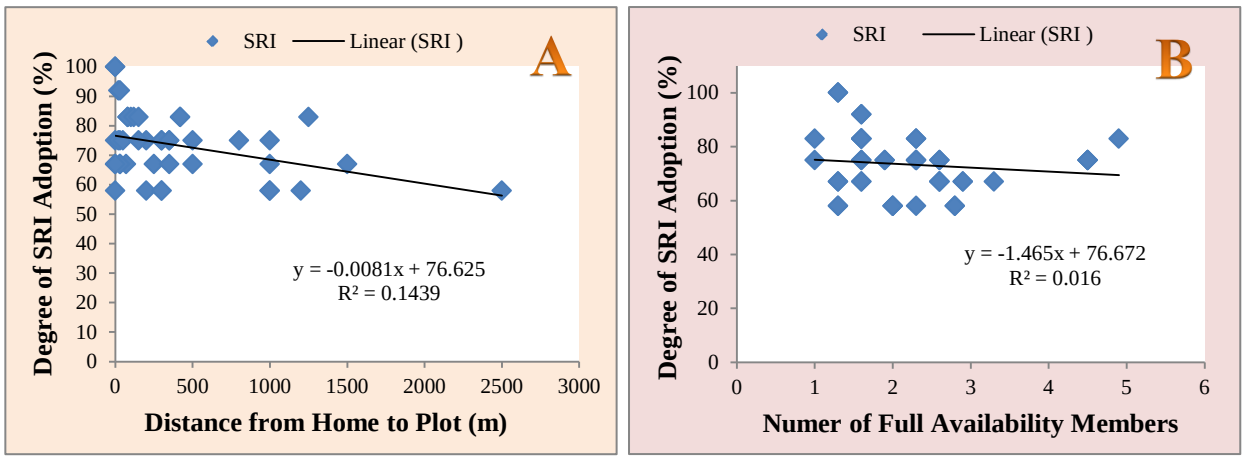


Figure 41: (A) Correlation between the Distances from home to paddy field and Degree of SRI Adoption; (B) Correlation between the Labor Availability of family members and the Degree of SRI Adoption

Figure 41 (B) also indicates that labor availability of family members does not have a significant connection with the degree of adoption, based on the value of R^2 only 0.016, a very weak correlation (see Table 35).

Regarding this, analyses, other factors such as number of family members, age of family head, education level of family head, plot areas, and sex of family head were also analyzed with the simple linear regression as explained in the Chapter 4.

Table 35: Correlation between the Degree of SRI Adoption with Other Factors

No.	X: Dependent Variable	No. of Sample	Std. Error	Y: Independent Variable Degree of SRI Adoption	
				R Square Value	P Value
1	Number of family members by plot	43	1.95	0.004	0.705
2	Age of family head by plot	43	12.05	0.078	0.07
3	Education level of family head by plot	43	3.23	0.000	0.962
4	Area of plot	43	0.48	0.020	0.366
5	Distance from home to plot	43	485.27	0.144	0.012
6	Sex of family head by plot	43	0.44	0.000	0.985
7	Full availability of family members by plot	43	0.96	0.016	0.420

This explains that besides the higher labor availability and the distance, other factor as shown in the Table 35 do not matter the increase or decrease of degree of SRI adoption. Education and Sex of family head have no correlation with the degree of SRI adoption.

However, there is a spillover effect of SRI adoption to non SRI farmers. As shown in Table 25, some non SRI farmers have adopted some principles of SRI. This study also analyzed their adoption with the distance from home to plot and full availability of family members.

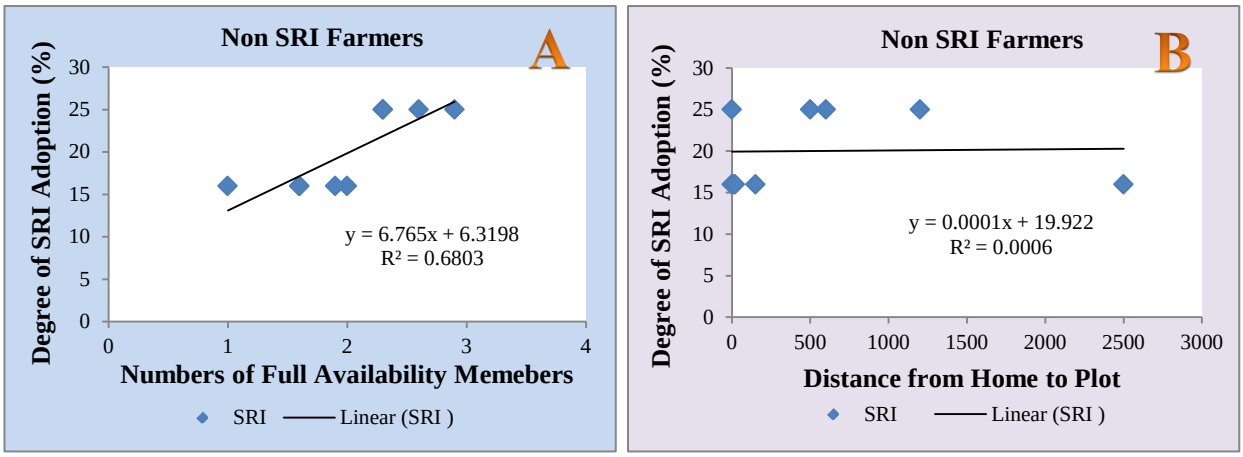


Figure 42: (A) Correlation between the Distances from home to paddy field and Degree of SRI Adoption; (B) Correlation between the Labor Availability of family members and the Degree of SRI Adoption for Non SRI Farmers

Unlike the SRI farmers, for non SRI farmers, there is a correlation between the numbers of full availability members with the degree of SRI adoption (Figure 42 (A)). However, numbers of non SRI farmers is smaller than one of SRI farmers. On another hand, there is no correlation between the distance from home to plot and the degree of SRI adoption (Figure 42 (B)).

In this sense, farmer's performance or willingness is considered to be the most important factor to increase the degree of adoption.

6.3 Comparison on Labor Requirement between SRI and Conventional Methods

Labor requirement of SRI has become the major constraint to the farmers to adapt this method, as Latif et al. (2009) reported that SRI needed about 18% labor more than the farmers' practices based on the experiments done at the Bangladesh Rice Research Institute in 2003 and 2004. However, Uphoff (2012) argued that the demand of labor will decrease when the SRI experiences are growing. A study done by Ly et al. (2012) in two districts of Cambodia found that labor requirement for LRV-SRI was from 680-864hrs/ha (772hrs/ha in average) higher than LRV-Conventional from 592-760hrs/ha (691hrs/ha in average) and DS for 336hrs/ha. These data excluded the threshing and storage time. However, different results were obtained from this research, according to the farmers' records as explained in the Finding part, labor requirements for LRV-SRI was from 320-871hrs/ha (average of 648hrs/ha), for ERV-SRI from 190-850hrs/ha (average of 617hrs/ha) and for ERV-DS from 189-410hrs/ha (average of 300hrs/ha) excluded threshing and storage time.

Besides the farmers' records, some randomly selected non-SRI farmers in rain-fed areas were interviews for their labor requirement during the LRV growing in 2015. Table below shows that working hours are from 587 to 714hrs/ha with the average of 650hrs/ha.

Table 36: Labor Requirement for LRV Growing with Conventional Method Applied

Rice Growing Cycle (2015-2016)	**Farmer A**	**Farmer C**	**Farmer D**
	Rain-fed (c)	Rain-fed (d)	Rain-fed (d)
	0.30 ha (LRV-Conventional)	*0.80 ha (LRV-Conventional)*	*0.80 ha (LRV-Conventional)*
Land Preparation	4	40	42
Nursery Preparation Sowing	4	4	5
Uprooting	16	32	28
Transplanting	40	160	160
Irrigation and Water Management	24	20	30
Fertilizing	4	14	10
Weeding	48	48	80
Harvesting and Transporting	36	200	216
Total (hours)	**176**	**518**	**571**
Hour/ha	***587***	***648***	***714***

To see the clear differences in both methods, all collected data (from Table 10 in the Literature Review Chapter 3.10, from Table 30 in the Finding Chapter 5.15, and from Table 36 mentioned above) are rewritten and taken the average value for the comparison (shown in Table 37 and Figure 43). All data are not included the Threshing and Storage time. Data on Nursery Preparation and data on Sowing are combined. Same is applied to data on Uprooting and Transplanting (see the table 37).

Data from the Literature Review (LR) are the labor requirement for LRV with conventional practices during 2009-2010 in both irrigated and rain-fed areas (read the details in Chapter 3.10); data from Interview Results (IR) are also about the labor requirement for LRV with conventional practices during 2015-2016 in rain-fed areas; and data from Recorded Results (RR) are about the

farmers' activity records for LRV during 2014-2015 and 2015-2016 in both irrigated and rain-fed areas. For Recorded Results (RR), only data on LRV from Farmer G1 (0.14ha in 2014 and 0.26ha in 2015), Farmer H1 (0.40ha in 2015), Farmer C1 (0.88ha in 2014 and 2015), Farmer D1 (0.40ha in 2015), and Farmer D2 (0.20ha in 2014 and 0.45ha in 2015) are used for the comparison on labor requirement between conventional and SRI practices. For this comparison, LR and RR include data from both irrigated and rain-fed areas; while, IR has only data of rain-fed areas. In that case, labor requirement for irrigation in both areas can be discussed.

Table 37: Labor Requirement on LRV from Literature Review, Interview Results and Recorded Results (in hours/ha)

Rice Growing Cycle (hours/ha)	Literature Review-LR (Conventional)			Interview Results-IR (Conventional)			Recorded Results-RR (SRI)		
	Data	Average	St. D	Data	Average	St. D	Data	Average	St. D
Land Preparation	72, 56	***64***	***11***	13, 50, 53	***39***	***22***	21, 16, 20, 46, 50, 80, 63, 42	***42***	***23***
Nursery Preparation and Sowing	32, 24	***28***	***6***	13, 5, 6	***8***	***4***	43, 19, 50, 23, 30, 13, 16, 20	***27***	***13***
Uprooting and Transplanting	216, 256	***236***	***28***	186, 240, 235	***220***	***30***	229, 127, 225, 158, 280, 164, 405, 235	***228***	***87***
Irrigation and Water Management	80, 32	***56***	***34***	80, 25, 38	***48***	***29***	243, 14, 140, 246, 0, 0, 35, 7	***86***	***108***
Fertilizing	32, 16	***24***	***11***	13, 18, 13	***15***	***3***	64, 9, 20, 27, 0, 0, 15, 71	***26***	***27***
Weeding	72, 0	***36***	***51***	160, 60, 100	***107***	***50***	86, 0, 50, 54, 0, 0, 0, 42	***29***	***33***
Harvesting and Transporting	256, 208	***232***	***34***	120, 250, 270	***213***	***81***	186, 136, 240, 238, 233, 123, 280, 253	***211***	***57***

The average labor requirement of each rice growing stage of each method is shown in the Figure 43 for the more precise comparison. Figure indicates that both SRI and conventional methods require almost same labors. Just, notably more labors are required for SRI method only during irrigation and water management. However, labor requirement during this stage is flexible and dependent; according to the availability of rainfall and irrigation and the farmers' attention on their farming. SRI farmers in both irrigated areas visited their plots so often to check the water situation (according to the results shown in Table 30). According to household interviews, farmers visited plot often to check the water because they are afraid that neighboring farmers or downstream farmers drain water out from their plots. This happens due to the poor water distribution in irrigated areas. With proper water distribution, labor requirement of water management can be reduced. While, in rain-fed areas, labor requirement of water management is low when there is enough rainfall. Since there is no canal system and drainage, water mostly stays in the plots. During 2015-2016, rain-fed farmers did their harvesting in water; so did the farmers in irrigated upstream area.

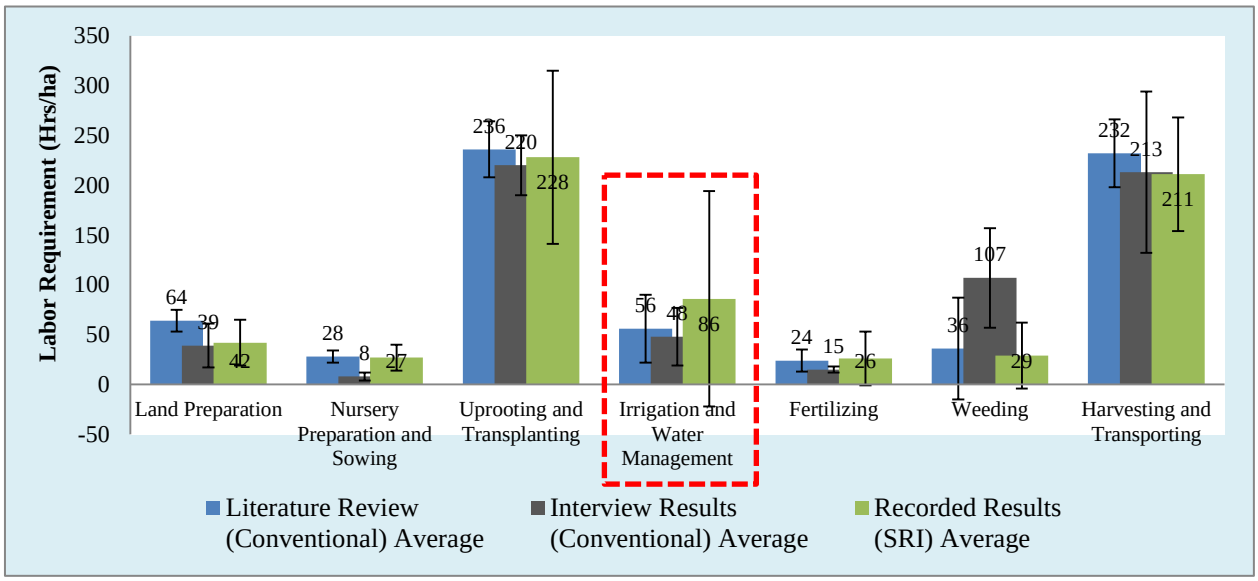


Figure 43: Comparison on Labor Requirements between SRI and Conventional Practices

All in all, based on the results of this study, labor requirement for LRV-SRI (320-871hrs/ha with the average of 648hrs/ha) is not much different from conventional ones from Interview Results (587-714hrs/ha with the average of 650hrs/ha) but it is a bit lower than the LRV conventional ones from the Literature Review (680-864hrs/ha with the average of 772hrs/ha). However, if the irrigation systems are functioning well, SRI farmers can spend less time in the field since water supply is stable; then the total labor requirements for both practices can be similar. Therefore, it can be concluded that labor requirements for SRI are not very different or higher than Conventional practices, if farmers can manage their practices well.

6.4 Promotion of "Sharing-hand" Concept for the Reduction of labor Expenditure

Owing to the household interview, the main sources of labor for farming are (1) available labor refers to the availability of family members who can help during the farming (see the calculation of full available labors in Table 24); (2) additional labor here is called "Sharing-hand"; (3) hired labor here refers to the extra labors farmers hire and pay as daily base. As discussed in the finding part, the cost of hired labor can be negotiated.

In rural areas, people are practicing "Sharing-hand" in farming activities. Normally, farmers give their hands to their neighbors and take turn to help each other during planting period. It is given to each other for free. Concept of "Sharing-hand" has passed from one generation to another. It has still been practicing until present time only in some areas. In rain-fed (e) and (f), most of farmers already stopped practicing due to two reasons. Firstly, farmers are busy with their non-farming activities inside or outside the villages. Secondly, the failure to return the help breaks the trust (based on the household interview).

Table 38: Hired Labor Cost per Hectare

Farmer	Are of Plot (ha)	Practices	Year of Cultivation	Available labor	Additional Labor	Hired Labor Cost	
						US Dollar	US Dollar/ha
A1	(a) 0.70	LRV	2013	2	-	109.50	156.43
A2	(b) 0.15	LRV	2013	2.6	-	34.50	230.00
	(c) 0.10	LRV	2013			34.50	345.00
A3	(d) 0.60	LRV	2013	2.3	-	0.00	0.00
	(e) 0.48	LRV	2013			0.00	0.00
B1	(f) 1.00	LRV	2013	1.6	*Sharing-hand*	0.00	0.00
	(g) 1.00	ERV	2013			0.00	0.00
B2	(h) 1.00	ERV	2013	1	*Sharing-hand*	12.50	12.50
B3	(i) 2.00	LRV	2013	2	-	114.75	57.38
	(j) 0.06	LRV	2013			22.00	366.67
	(k) 0.40	ERV	2013			0.00	0.00
C1	(l) 0.88	LRV	2013	2.9	-	64.25	73.01
	(m) 1.98	ERV	2013			92.50	46.72
C2	(n) 1.00	LRV	2013	2.3	*Sharing-hand*	63.75	63.75
C3	(o) 0.50	LRV	2013	1.6	-	18.75	37.50
	(p) 0.50	ERV	2013			18.75	37.50
D1	(q) 0.25	ERV	2014	1.6	*Sharing-hand*	0.00	0.00
	(r) 0.35	LRV	2014			0.00	0.00
D2	(s) 0.20	LRV	2014	1.3	*Sharing-hand*	32.00	160.00
	(t) 0.25	ERV	2015		-	57.50	230.00
D3	(u) 0.35	LRV	2014	3.3	-	20.00	57.14
E1	(v) 0.21	ERV	2014	1	-	40.00	190.48
	(w) 1.50	LRV	2013 2014		-	112.50	75.00
E2	(x) 0.25	LRV	2013 2014	1.9	-	17.50	70.00
	(y) 0.30	ERV	2013 2014		-	37.50	125.00
E3	(z) 1.70	MRV	2013 2014	2.3	-	125.00	73.53
	(aa) 0.25	ERV	2013		-	0.00	0.00
F1	(bb) 0.15	ERV	2013	1.6	-	40.00	266.67
	(cc) 0.60	LRV	2013		-	145.00	241.67
F2	(dd) 0.20	LRV	2013	1.3	-	0.00	0.00
	(ee) 0.15	MRV	2013		-	0.00	0.00
F3	(ff) 0.15	LRV	2014	2.6	*Sharing-hand*	3.75	25.00
	(gg) 0.15	LRV	2014			4.50	30.00
G1	(hh) 0.14	LRV	2014	1.6	*Sharing-hand*	20.00	142.86
	(ii) 0.12	ERV	2015			28.25	235.42
G2	(jj) 0.16	ERV	2014	4.5	-	40.00	250.00
	(kk) 0.12	LRV	2014			40.00	333.33
	(ll) 0.15	MRV	2014			40.00	266.67
G3	(mm) 0.90	MRV	2014	2.8	-	311.00	345.56
	(nn) 0.10	ERV	2015			30.00	300.00
G4	(oo) 0.12	MRV	2014	2.3	-	12.50	104.17
	(pp) 0.16	ERV	2015			28.50	178.13
G5	(qq) 0.50	LRV	2014	1.6	-	96.00	192.00
H1	(rr) 0.20	ERV	2014	1.6	-	12.50	62.50
	(ss) 0.20	LRV	2014			12.50	62.50
H2	(tt) 0.26	LRV	2014	4.9	-	45.00	173.08
H3	(uu) 0.14	LRV	2014	1.6	-	15.00	107.14
H4	(vv) 0.09	MRV	2014	2.6	-	0.00	0.00
H5	(ww) 0.20	LRV		2.6	-	81.25	406.25
H6	(xx) 0.10	LRV		2.9	-	27.50	275.00
H7	(yy) 0.23	LRV		1.9	-	171.00	743.48
H8	(zz) 0.23	LRV		2.3	-	21.00	91.30

Referring to Table 38 above, in case of farmers B1, B2,C2, D1, D2, F3 and G1 besides available labor, they could get the additional labor here-called Sharing-hand. Then, their total hired labor costs were lower than other farmers' cases. Therefore, the actual cost of hired labor depends on each household's condition. Low or high hired labor cost depends on the condition of Sharing-hand and availability of family members. If the available labor of family members is always in the needed time, farmers do not need much help from neighbors or hire many people. Then, hired labor cost can be reduced.

Detailed data from the main farmers' records also indicates that "Sharing-hand" really helps farmers reduce the hired labor cost as shown in Table 39. Generally, farmers share their hands during sowing, uprooting, transplanting and harvesting works. However, the cost of these works is a bit different from each other. Based on the household interview, sowing work costs about 10,000 Riel/day; uprooting 20,000 Riel/day; transplanting 20,000 Riel/day; and harvesting works also about 20,000 Riel/day. As discussed in the Finding part, the price of these works can be negotiated. Therefore, in order to make calculation easy to be understood, the average cost of these works is 2,200 Riel/hours (resulted from the sum-up of the cost of each work divided by four and then divided by 8 to get the cost per hour). The Calculation is based on the main farmers' records in 2014-2015 (refer to Table 30 (a) for the details).

Table 39: Contribution of "Sharing-hand" to the Total Hired Labor Cost

Farmer	Plots (ha)	2014-2015 Total Labor Requirement (Hours)	Total Hired Labor Cost (Riel)	"Sharing-hand" (Hour)	Saved Cost by "Sharing-hand" (Riel)
G1	0.14	122	80,000	**36** ***(29.5%)***	**79,200** ***(99.0%)***
	0.12	87	120,000	**28** ***(32.2%)***	**61,600** ***(51.3%)***
C1	1.98	376	150,000	**78** ***(20.7%)***	**171,600** ***(114.4%)***
D2	0.20	149	128,000	**73** ***(49.0%)***	**160,600** ***(125.5%)***

The important discussion here is "Sharing-hand" can help farmers save a lot on the hired labor cost. It can reduce the total cost and undoubtedly to increase the profits. Farmers who are not able to pay for hired labor cost when labor is needed; they can seek for another opportunity by depending on the neighbors' labor and family members in return with what they can pay with their own labor. If farmers do not have a good relationship with their neighbors, they have to hire people. Possibly, lack of the labor in the village due to the high numbers of elder people and immigration of young people can cause the high demand of hired people. The concept of Sharing-hand can help farmers not only deal with labor shortage in their family and reduce the hired labor cost but also reinforce their relationship with their neighbors. This concept is viewed as good practice that should be continued in the rural areas.

6.5 Comparison on Labor Cost between SRI and Conventional Practices

Based on the Table 38, it indicates that hired labor cost between traditional practices and SRI ones varies depending on the condition of availability of family member and the condition of "Sharing-hand". Moreover, as discussed in the previous part on the labor requirements between SRI and Conventional practices, there is no much different between both methods. With proper irrigation system, labor requirements of both methods can be similar. Importantly, as explained in the finding part on the labor distribution during the rice growing period, laborers are in high

demand when preparing land and nurseries, transplanting seedlings, and harvesting for both practices, SRI and conventional. Therefore, it can conclude that there is little or no difference on labor cost between SRI labor requirements and conventional practices. Hired labor costs depend on the supply of farmer-family labors and the efficacy of the sharing-hand system not on farming techniques.

6.6 Improvement of Market Situation through Social Capital Enhancement

Most of selected farmers grow Jasmine variety for early growing season due to its popularity. Importantly, collective sale (farmers put their products together in order to get a bigger amount of products) help farmers to get higher prices compared to an individual or one-time sale. Moreover, collective sale helps middle men to save the time to buy the large amount of paddy. That is why; middle men can set the higher price for farmers. For example, Jasmine variety (ERV) sells for 1,600R/kg if farmers can collect a big amount and sell. Otherwise, the price is only 1,350Riel to 1,400Riel per kg for single sale. The collective sale could happen due to two possible reasons: (1) the short distance between each farmer's house or plot where farmers easily gather their products and (2) good relationship with the neighboring household.

Here is going to discuss more on the important role of collective sale and other activities that can help to improve the market situation, directly or indirectly, from the grass-root level. While, other obstacles such as lack of market information, lack of agricultural input, poor technology, lack of credit service and poor infrastructure are being tackled by the government and NGOs as already discussed in the Chapter 3. Those issues are considered as the concerns over financial (credits, expensive, and markets, etc.), human (knowledge transfer, technology, etc.), natural (soil fertility, water management, etc.), and physical (construction of irrigation facilities, roads, etc.) views. However, social connection or here so-called "Social Capital" seems to be neglected.

Social capital can be also defined as social relations that facilitate a group of people who share the same common of interests or advantages by interacting each other with common norms, trust and network of association*. In Cambodia's context, among 5 livelihood capitals (financial, human, natural and physical) as mentioned earlier, social capital which is simply understood as relationship or networking among community people in society seemed to be neglected since other development projects or activities mainly focus on the economic term. For example, according to the report of GTZ, it said that the establishment of Farmer Associations in rural Cambodia trend to be economic based rather than social capital building (Ayres & Pellini, 2005).

In the study areas, collective sale is not happening in all places in the villages due to the poor relationship among the farmers based on the field observation. This causes some farmers cannot get better selling price. On the other hand, regarding the SRI dissemination, in most of selected areas, only small numbers of household are practicing; while majority are still practicing conventional one; for example there are only 6 SRI farmers out of 181 farmer household and 86 out of 198 in rain-fed villages (a) and (b); respectively (see the table 21).

**: Definition of Social Capital retrieved from http://www.hks.harvard.edu/saguaro/web%20docs/GarsonSK06syllabus.htm on June 19, 2015*

This is believed that information sharing and participation activity in the village are poor and the farmers' mindset is still strong to what they have believed from the past practices. Therefore, acceptance of new knowledge is still limited.

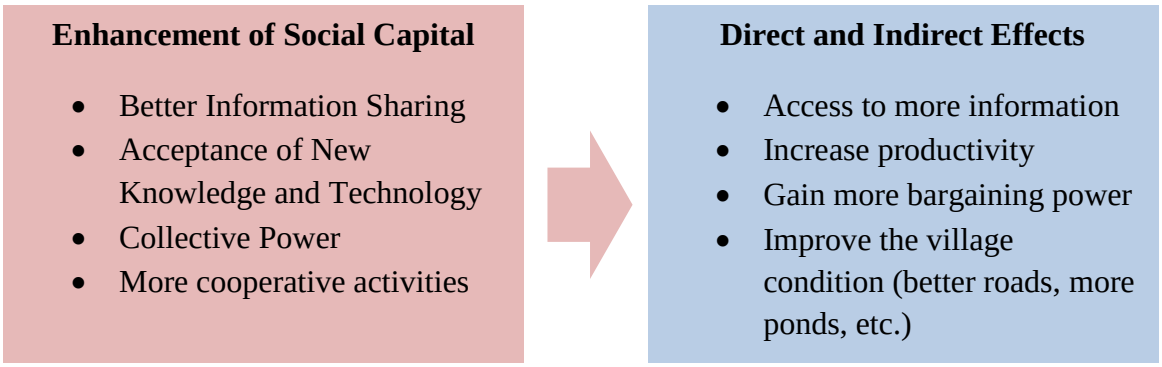


Figure 44: Effects of Social Capital to Market Access

Moreover, in some rain-fed villages, farmers prefer to have their own ponds to store rainfall for their individual usage but there is no common or public pond for all villagers. This causes some farmers have access to water but others who have less land or no budget to dig the pond don't have access. If village chief has initiative power or make the villagers work together, there will be more improvement in the village such as better roads, and more facilities. However, they prefer to wait for the projects from the upper level or NGOs. Therefore, it is recommended that NGOs or development projects should encourage the people to have collective activities. With better roads and better networks, farmers can improve their access to markets.

6.7 Characteristics of Selected Farmers based on their Amount of Sale to Rice Markets

Figure 45 below represents the total expenditure and incomes of each selected farmer (referred to Table 26 and Table 27 in the Finding Chapter). Figure also illustrates that besides the sufficiency for self-consumption, farmers also could earn the profit by selling their surplus. The negative income as shown in Fig. is the value of the paddy amount for self-consumption; except for Farmer H6 and H7, the negative values represent the insufficiency of self-consumption. Based on the agricultural household concept as already discussed in the Methodology Chapter, here is going to discuss and define the characteristics of selected farmers.

Based on the figure, it is concluded and defined that most of selected farmers are ***(1) the net sellers.*** Farmers once sell their large amount of paddies during the harvesting season; and occasionally, they keep selling small amount of the remaining paddies in case of urgent need of money. This case occurs when farmers don't get their other sources of incomes in time. Some farmers or their family members are working as salary-workers such as NGO staff, construction and factory workers. They can get them only once per month; therefore in case of urgent need or shocks they need to sell their paddies or if their paddies are limited, they will not sell but get the loan from other people.

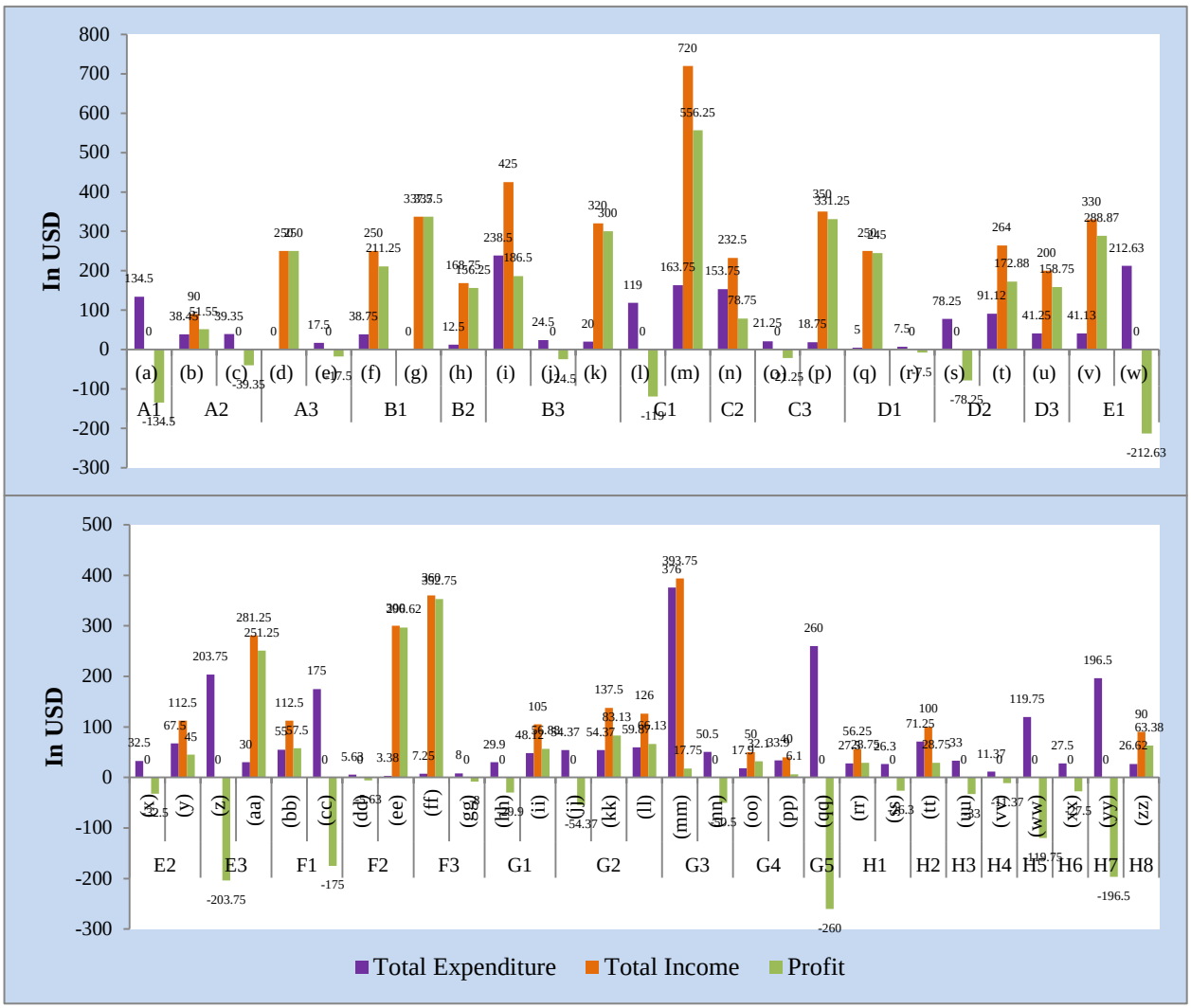


Figure 45: Expenditure, Incomes and Profits from Rice Growing in 2013, 2014 and 2015

Again, according to the Figure, other selected farmers in this study are defined as ***(2) neither net seller nor net buyer*** because they produced enough for their self-consumption. Based on the household interview, although they produced only for self-consumption, they rarely sell their stored paddies for extra income even in the urgent need because they have other sources of daily incomes such as being barbers or tailors, handcraft and incomes from their own shop selling some snacks or groceries at their homes in the village**.** However, only two farmers H6 and H7 are defined as ***(3) net buyers*** because they could not produce enough for self-consumption and needed to buy rice from markets.

6.8 Assessment on SRI Farmers' Sale to the Rice Markets

As discussed and shown in Table 27 in the Chapter above, most of selected farmers; especially SRI farmers could sell their productions to the markets, after being able to support enough for their consumption. Figure 46 below indicates the percentage of sold paddies to markets from each selected household or farmer.

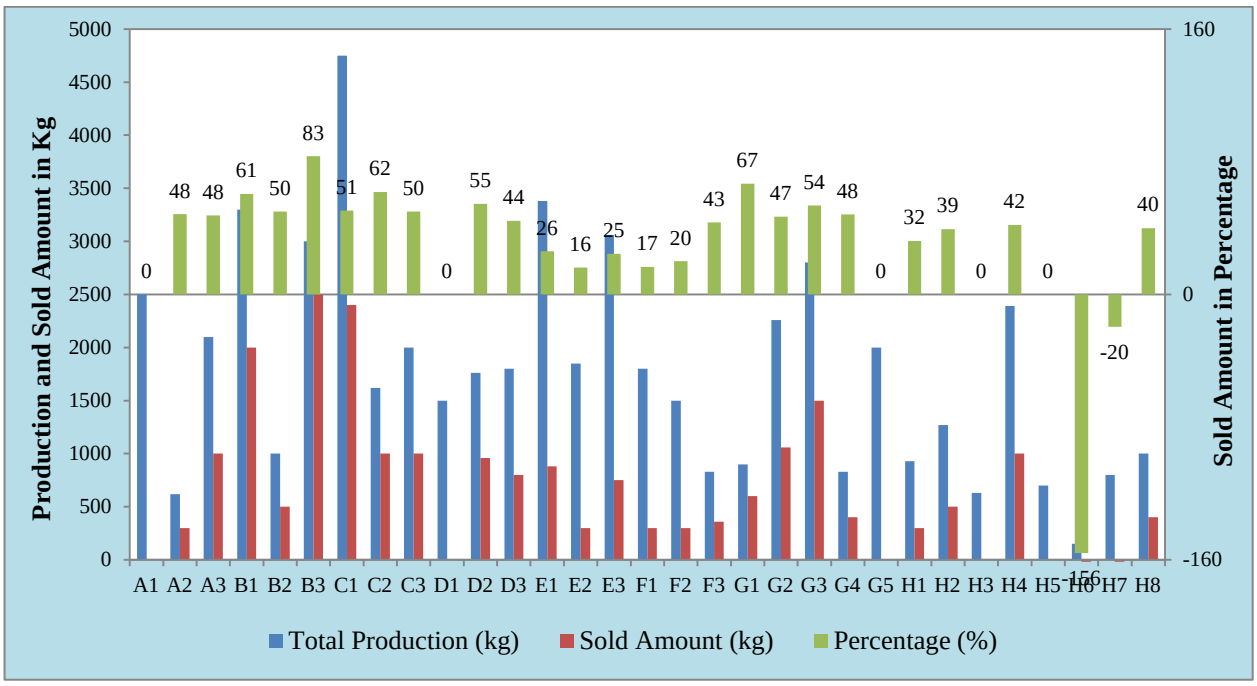


Figure 46: Amount of Paddies Sold to Market by Selected Farmers

Most of selected farmers have harvests that can cover all for their self-consumption and sale. They said that the remaining paddies are always enough for one year consumption and sometimes sell some of them for urgent money. Although buying price offered by the middle men is low, they seem to be satisfied since they do not need to do all the works such as transporting the harvests to markets and carrying and lifting paddies up and down from truck by themselves. This can be early assumed evidence showing that practicing SRI can help farmers contribute their harvest to the markets. In case of Farmers H6, and H7 in irrigated area (h), their harvests are not enough for their self-consumption. Farmer H6 said that during about 3 months, her family has to buy 150kg of rice; equaled 234kg of paddies for extra consumption. For farmer H7, only for 2 months; equaled to 156kg of paddies, her consumption is not enough. Assumedly, their productions are low due to the conventional practices.

The following part is going to discuss the bigger impact of SRI farmers in the market. Increasing production by practicing SRI and number of SRI farmers can increase the village production and possibly contribute to the bigger markets. The ratio of increased production in each village, derived from the increase of total production of selected families in Table 24 is 22.5%, 33.3%, 35.0%, 58.1%, 38.4%, 51.4%, 39.2%, and 31.6% in Rain-fed (a), Rain-fed (b), Rain-fed (c), Rain-fed (d), Rain-fed (e), Rain-fed (f), Irrigated Upstream (g) and Irrigated Downstream (h); respectively. As explained and shown in Table 24, most of the selected farmers are practicing SRI and it led to increase in their conventional yields. It can be deduced from the study that SRI farmers contributed to the increase in production in each village. Thus it can be explained that a village has more production to share to rice markets besides the sufficiency of self-consumption of each household in the village.

Table 40: Contribution of SRI Farmers to the Rice Markets

Village	Ratio of Increased Production in Village	Average No. of SRI Household	Surplus Produced by SRI Farmers
Rain-fed (a)	+22.5%	3%	+0.68%
Rain-fed (b)	+33.3%	43%	+14.3%
Rain-fed (c)	+35.0%	48%	+16.8%
Rain-fed (d)	+58.1%	49%	+28.5%
Rain-fed (e)	+38.4%	2%	+0.77%
Rain-fed (f)	+51.4%	6%*	+3.08%
Irrigated Upstream (g)	+39.2%	10%**	+3.92%
Irrigated Downstream (h)	+31.6%	5%**	+1.58%

*: No. of total of household was used; **: No. of SRI households from farmers' confirmation

Finally increase of the number of SRI farmers in each village will increase the village production. Possibly, increasing the number of SRI farmers also leads to the increase of national paddy production in Cambodia. Average of SRI yield in Cambodia was recorded as 3.48t/ha (ranging from 2.7 to 4.2t/ha) with SRI applied area of 59,785 ha in 2009 (Chhay, 2010). However, according to data from Ministry of Agriculture, Forestry and Fisheries (MAFF) the average national yields were 2.84 and 3.17t/ha in 2009 and 2011 respectively. With these data, at least within the rice growing area of 59,785 ha, only in 2009 SRI could increase the rice production about 24.28%. Therefore, it can be concluded that increase the number of SRI as well the SRI applied areas will increase not only the household production but also the country production. This will lead to the increase the paddy supply in the rice markets.

6.9 Analyses of Farmers' Incomes

Before jumping to the discussion of SRI merits and farmers' livelihood improvement, here is going to discuss the farmers' income improvement by practicing SRI. As explained and discussed on the selected farmers' expenditure, incomes and profits in the earlier parts on their farming, the detailed comparison between Conventional and SRI practices will be analyzed here with the two selected case studies (1) from Farmer G1 as representative of irrigated farmers; and (2) from Farmer D2 as representative of rain-fed farmers.

1st Case Study: Farmer G1 in Irrigated Upstream (g) village in Kampong Speu Province

According to the household interview, farmer has started practicing SRI since 2006 from CEDAC. Actually, farmer owns three plots; however, same variety was applied on two plots with area of 0.08 ha and 0.06 ha, then they were combined and symbolized as (hh) and the other area of 0.12 ha as (ii) (areas were circled in red in Figure 47).

Figure 47: Location of Farmers G1's Plots

Even being located in irrigated area, plot (hh) sometimes is irrigated by pumping in case there is less water in canal or when it cannot be irrigated by plot-to plot from upstream plot.

On the other hand, since farmer had been asked to record the farming activities from 2014 to 2015, Table 41 shows the compared calculations on expenditures and incomes of 2014 and 2015 farming with the past expenditures and incomes during conventional practice.

Here is assumed that the total expenditures on inputs (including labor, fertilizer, and irrigation cost) of both SRI and conventional practices are same; because firstly, farmer was hard to recall the exact amount of total expenditures on inputs during practicing conventional method. Secondly, farmer has not used so much chemical fertilizer or there is a little change in amount of fertilizer for both methods. While, labor and irrigation cost has depended on the availability of members or "Sharing-Hand", and the amount of rainfall. Therefore, the main comparison is on the incomes and amount of sold paddies to middle men.

Table 41: Total Expenditures for Farming during 2014 and 2015 of Farmer G1

Farmer G1	**Expenditure (Riel)**			
Plot	Labor	Fertilizer	Irrigation	Total in USD
0.14 ha (LRV)_2014	80,000	9,600	30,000	119,600 Riel **(29.90USD)**
0.12 ha (ERV)_2014	120,000	25,600	0	145,600 Riel **(36.40USD)**
0.12 ha (ERV)_2015	113,000	64,000	16,500	193,500 Riel **(48.37USD)**

1USD=4000Riel

Table 42: Comparison on Incomes between SRI and Conventional Practices of Farmer G1

Farmer G1	Income			Total Expenditure (USD)	Profits (USD)
Plot	Production (kg)	Unit Price (Riel/kg)	Total in USD		
0.14 ha (LRV)_2014	300 (SRI)	1300	390,000 Riel (97.50 USD)	**29.90**	**+67.60**
	270 (Conv.)	1300	351,000 Riel (87.75 USD)	**29.90**	**+57.85**
0.12 ha (ERV)_2014	250 (SRI)	850	212,500 Riel (53.12USD)	**36.40**	**+16.72**
	200 (Conv.)	850	170,000 Riel (42.50 USD)	**36.40**	**+6.10**
0.12 ha (ERV)_2015	600 (SRI)	850	510,000 Riel (127.50 USD)	**48.37**	**+79.13**
	200 (Conv.)	850	170,000 Riel (42.50 USD)	**48.37**	**-5.87**

According to Table 42, the production of ERV in 2014 was a bit higher than conventional one because of short drought after transplanting (during mid of April, based on the farming record), farmer said during the household interviews. Moreover, based on the rainfall data in 2014 (shown in Figure 26) of Kampong Speu province where the irrigated upstream (g) located in shows the amount of rainfall dropped sharply from 261.2mm to 93.6mm in April and May; respectively. The data represented the whole province; therefore, it can be concluded that some places might have received less or had no rain. Even during the LRV in the same year, amount of rainfall started to drop, after transplanting at the end of June, from 363.1mm to 295.5mm and to 84.8mm in June, July and August; respectively.

Although, farmer has been facing water problem for irrigation, he or she still has been able to increase their production by practicing SRI. Supposedly, those productions are sold to market; then farmer can earn more incomes due to larger amount of paddies. Therefore, it can say that SRI help farmer increase their productions and their incomes as well as increase the amount of paddies contributed to market.

2nd Case Study: Farmer D2 in Rain-fed (d) Village in Takeo province

Unlike farmer G1, farmer D2 has started practicing SRI since 2011 from the same NGO, CEDAC. Farmer also owns three plots (0.20ha, 0.05ha and 0.20ha). Farmer mentioned two plots as one since same variety was applied on them. Then total area of plot (s) is 0.26 ha (combination between 0.20ha and 0.05ha); and the plot (t) is 0.20ha as circled in the figure below. Farmer D2 also had asked to record two years of farming continuously.

Two plots (s) and (t) completely depend on the rainfall for the irrigation. In case of insufficient rainfall, saved water in the pond next the plots was used to irrigate the plots by pumping. Generally, it is difficult for farmers in rain-fed areas to grow rice twice on the same plot or even on different plots. For example, in 2014, farmer D2 could grow only LRV on plot (s). Because of less rain at the beginning of ERV growing season (in April and May with rainfall of 148mm and only 22.8mm; respectively, according to the Figure 28), farmer was hesitated to grow ERV. While, in 2015 there was also less rain in May (only 6.6mm, according to the Figure 28 again); however, farmer decided to grow ERV. Fortunately, there was much rain from June till end of

July (with the amount of rainfall from 288mm to 382mm). Finally, farmer could harvest ERV. Therefore, tables 43and 44 below will show the comparison of ERV in 2014 and LRV in 2015 with the conventional one.

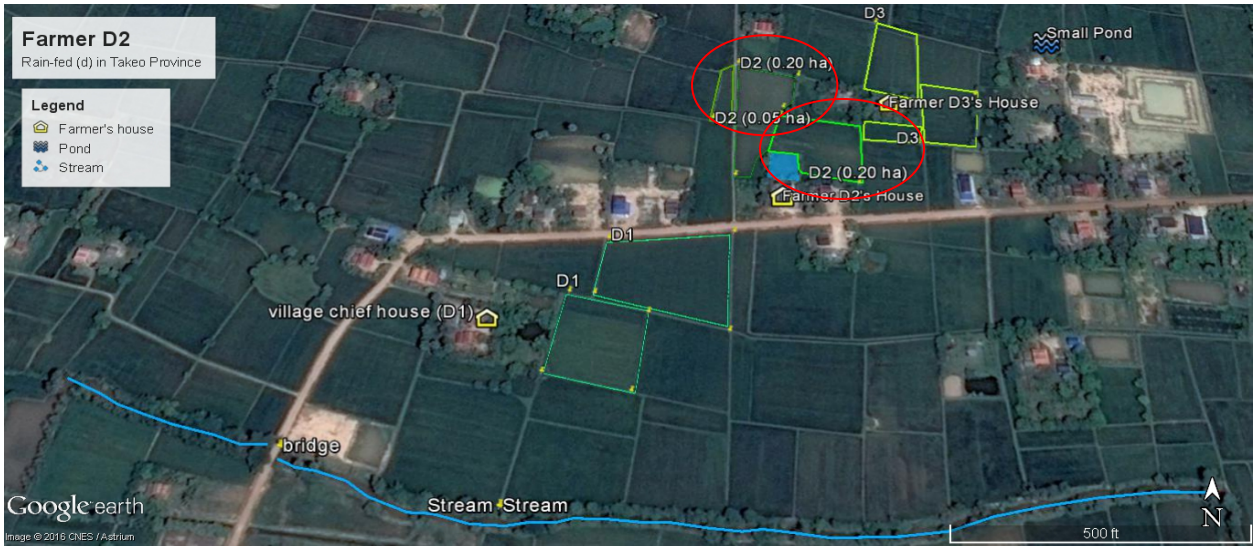


Figure 48: Location of Farmer D2's Plots

Expenditures on inputs of both SRI and conventional methods are assumed to be the same because farmer has tried to stabilize the amount of chemical fertilizer; while trying to increase the amount of organic fertilizer as much as possible. Irrigation and labor cost, as explained in the 1st case study, depend on the availability of members and on the amount of rainfall. It seems that farmer spent a lot on irrigation for ERV in 2015. It is because there was less rain during the beginning of ERV growing season as explained earlier.

Table 43: Total Expenditures for Farming during 2014 and 2015 of Farmer D2

Farmer D2	**Expenditure (Riel)**			
Plot	Labor	Fertilizer	Irrigation	Total in USD
0.20 ha (LRV)_2014	128,000	150,000	35,000	313,000 Riel **(78.25 USD)**
0.25 ha (ERV)_2015	230,000	34,500	100,000	364,500 Riel **(91.12 USD)**

Table 44: Comparison on Incomes between SRI and Conventional Practices of Farmer D2

Farmer D2	**Income**			**Total Expenditure (USD)**	**Profits (USD)**
Plot	Production (kg)	Unit Price (Riel/kg)	Total in USD		
0.20 ha (LRV)_2014	800 (SRI)	1000	800,000 Riel (200 USD)	**78.25**	**+121.75**
	500 (Conv.)	1000	500,000 Riel (125 USD)	**78.25**	**+46.75**
0.25 ha (ERV)_2015	960 (SRI)	1100	1,056,000 Riel (264 USD)	**91.12**	**+172.88**
	500 (Conv.)	1100	550,000 Riel (137.50 USD)	**91.12**	**+46.38**

1USD=4000Riel

Farmer could earn small profits during practicing conventional method; while profits go up sharply after practicing SRI method. Farmer could produce more; so they could sell more to markets.

Based on these two case studies, it can be concluded that practicing SRI can improve farmers' incomes by increasing their productions.

6.10 Transition of Livelihood Improvement

As discussed on the incomes from practicing SRI, it clearly indicated that farmers gradually can earn more incomes and also because of other sources of incomes farmers have been able to improve their livings by having more general assets such as vehicles, TVs and radios, etc. (as shown in Table 32). Moreover, some selected farmers were able to buy some machinery (as shown in Table 33). More importantly, farmers had been able to pay their past debts, according to the household interviews as explained and shown in table 35. Although, currently, farming is not the only income sources for farmers, it used to be the main source of incomes in the past 10 years. All in all, living condition is getting better because of better paddy production, non-farming incomes, and remittance. This transition is shown in the Figure below.

However, this trend can affect the agricultural development in the near future due to the labor shortage in agriculture since young people have migrated to work outside the villages. Since incomes from agriculture is no secured due to unstable water supply for irrigation, farmers have moved their attention to non-farming jobs which they can expect the fixed and regular incomes. It is important to equip farmers with better access for their agricultural practices such as better irrigation systems, better market systems, better credit services and better extension services on new technologies.

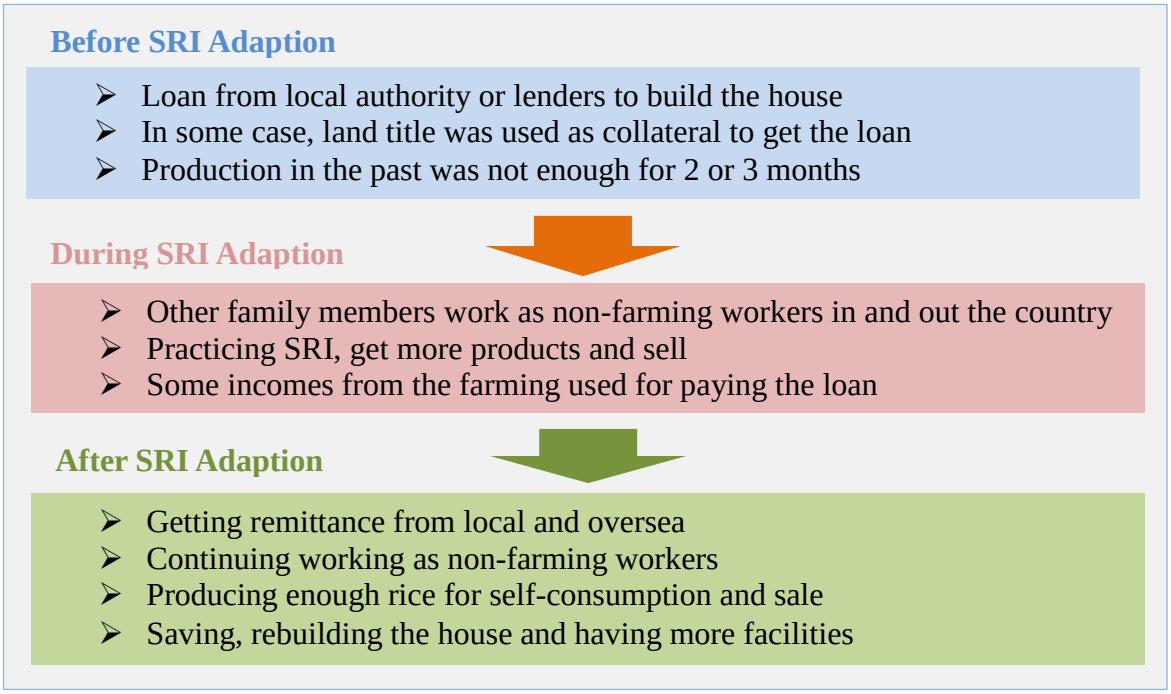


Figure 49: Transition of Livelihood Improvement

Importantly, in order to achieve the better livelihood condition, farmers need to change their farming systems, especially the conventional one. There are two fundamental types of changes to

their farming systems as Mak (2001) said. Firstly, there must be changes within the system. It means that farmers should adapt or add new elements, here mainly from SRI principles, to their original farming system, here meant Conventional practices. As discussed in the Chapter 3.11, farmers can make changes in their SRI practices based on their existing situation. Having old mind set will not improve anything. Secondly, in order to achieve the changes within the system, changes outside the system are needed. Those outside changes are called physical factors, according to Mak (2001). The changes in amount of rainfall, culture and society are the changes outside the system. As discussed so far, human cannot control the rain, but it is recommended that irrigation systems should be improved; and methods of saving water as discussed in very early of this Chapter should be applied; especially for rain-fed farmers. While, social network and collaboration are also crucial to make changes in farmers' villages, in order to share the knowledge, save the labor cost and increase the prices of the paddies. These kinds of changes are really needed in the rural areas of Cambodia for the better livelihood of farmers. Therefore, this research intentionally conveys these messages to local authorities, NGOs, development agencies as well as government need to take action in order to create those changes.

6.11 Merit of SRI and Its Sustainability

This part is the core of this research to discuss the merit of SRI and its sustainability based on the findings and the conceptual framework explained in the Chapter 4.3. To prove the SRI as the agricultural sustainability, here is going to explain and discuss how and in what conditions SRI meets the criteria of sustainability concept and responds to the each component of sustainable agricultural system.

Firstly, based on this research's results, it proves that SRI can improve the economic status of the practitioners' or farmers as discussed earlier in the 1st and 2nd case studies from the selected farmers.

Secondly, by practicing SRI, farmers are encouraged to apply organic fertilizers as much as possible. Although most of selected farmers are still using chemical fertilizer, the Figure 50 shows the decreased amount of chemical fertilizer. Only a few farmers have increased their amount of chemical fertilizer. According to the interviews, farmers said they have tried to stabilize or decrease the amount of chemical fertilizer because they have noticed that soil becomes harder and their family members who involve in fertilizer application got headache or dizzy. On the other hand, table 43 explains the amount of organic fertilizer that each selected farmer has applied. It is difficult to get the exact weight of organic fertilizers farmers applied, because most of farmers just collect and save the animal wastes and leaves and apply to the fields. Normally, farmers carry organic fertilizers in the ox carts. Again, according to the household interviews, farmers have understood the importance of organic fertilizer on the field; that is why most of them said they have tried to apply as much as they can collect the materials. However, only a few farmers have their own compost huts. All in all, concerning on the environmental aspect, SRI also encourages farmers to reduce the amount of chemical fertilizers and increase the amount of organic ones instead. Therefore, practicing SRI not only saves the environment but also helps farmers save their input costs and health expenses.

Table 45: Changes in Use of Organic Fertilizer

Farmer	Plot (ha)	Before	After	Farmer	Plot (ha)	Before	After
A1	(a) 0.70	-	As much as	F1	(bb) 0.15	-	3 tractors
A2	(b) 0.15	3 Ox carts	3 Ox carts		(cc) 0.60	-	5 tractors
	(c) 0.10	2 Ox carts	4 Ox carts	F2	(dd) 0.20	-	Increased
A3	(d) 0.60	15 Ox carts	15 Ox carts		(ee) 0.15	-	Increased
	(e) 0.48	10 Ox carts	10 Ox carts	F3	(ff) 015	0	3 Ox carts
B1	(f) 1.00	3 Ox carts	3 Ox carts		(gg) 0.15	0	3 Ox carts
	(g) 1.00	700kg	700kg	G1	(hh) 0.14	-	4 Ox carts
B2	(h) 1.00	1000kg	1000kg		(ii) 0.12	0	0
B3	(i) 2.00	0	0	G2	(jj) 0.16	As much as	As much as
	(j) 0.06	As much as	As much as		(kk) 0.12	As much as	As much as
	(k) 0.40	-	6 Ox Carts		(ll) 0.15	As much as	As much as
C1	(l) 0.88	-	8 Ox Carts	G3	(mm) 090	1500	2500
	(m) 1.98	-	8 Ox Carts		(nn) 0.10	As much as	As much as
C2	(n) 1.00	6 Ox carts	6 Ox Carts	G4	(oo) 0.12	3 Ox carts	3 Ox carts
C3	(o) 0.50	-	As much as		(pp) 0.16	4 Ox carts	4 Ox carts
	(p) 0.50	-	As much as	G5	(qq) 0.50	As much as	As much as
D1	(q) 0.25	As much as	As much as	H1	(rr) 0.20	As much as	As much as
	(r) 0.35	As much as	As much as		(ss) 0.20	As much as	As much as
D2	(s) 0.20	10 sacks	12 sacks	H2	(tt) 0.26	6 Ox carts	6 Ox Carts
	(t) 0.25	As much as	As much as	H3	(uu) 0.14	As much as	As much as
D3	(u) 0.35	-	As much as	H4	(vv) 0.09	As much as	As much as
E1	(v) 0.21	5 sacks	5 sacks				
	(w) 1.50	0	1500kg	H5	(ww) 0.20	As much as	As much as
E2	(x) 0.25	0	0	H6	(xx) 0.10	0	0
	(y) 0.30	0	2 Ox carts	H7	(yy) 0.23	20-30 Ox carts	20-30 Ox carts
E3	(z) 1.70	-	500kg	H8	(zz) 0.23	As much as	As much as
	(aa) 0.25	-	10 Ox carts				

Thirdly, another aspect that SRI can prove to the concept of sustainability is its contribution to human resource development. As explained and discussed already in Chapter 3 part 3.6.7, and even the results of this study also cannot prove directly on the SRI's contribution to human resource development; however, the stands here are still the same as in Chapter 3, based on the household interview and field observation. Through their experiences, farmers have realized the bad effects of chemical fertilizers on the soil and their health and incomes. Moreover, farmers in some areas said that keeping much water in the field is not good for air circulation in the root zone but they have no choice since availability of water is not stable; plus water can prevent weeds from growing; so they can save time and labors for weeding. Therefore, here can say that by practicing SRI, farmers have learnt, adapted and applied what are good for their farming.

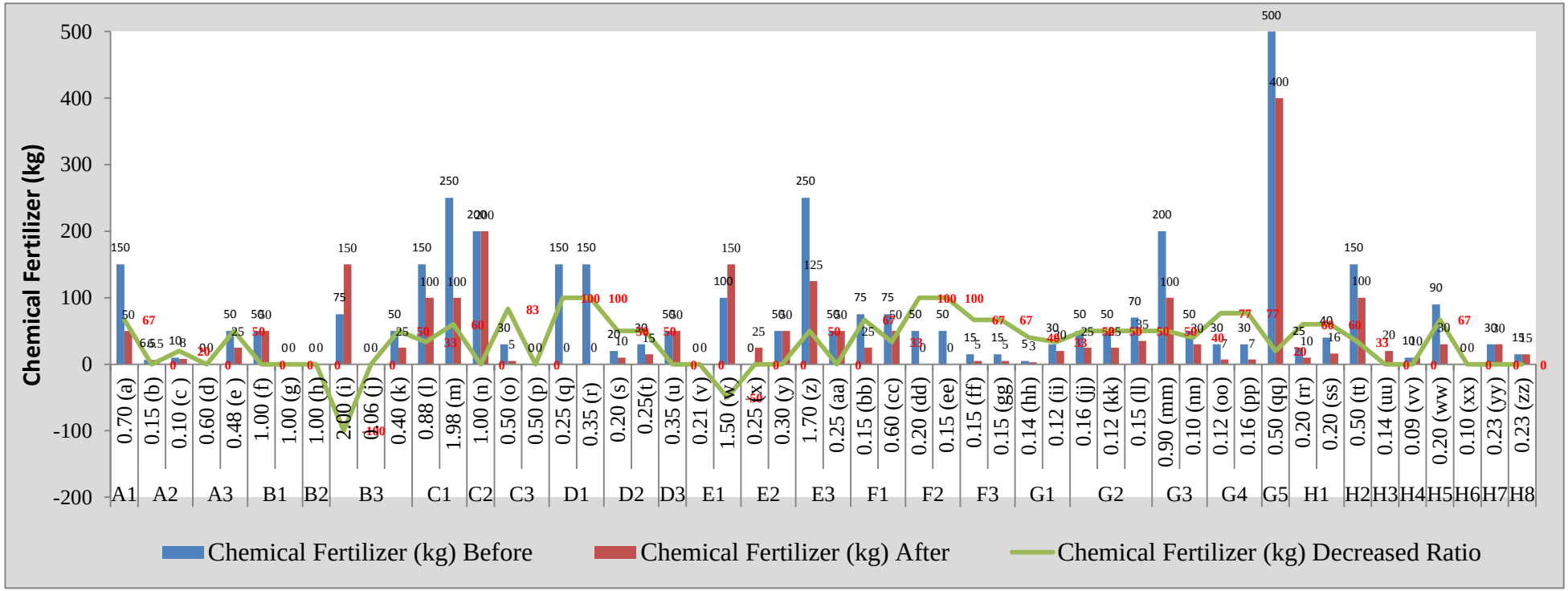


Figure 50: Changes in Use of Chemical Fertilizers

Lastly, it is about the social impact from SRI practice. However, this study found a little contribution of SRI on the social improvement. As discussed, farmers have been lacking the collective works for their own communities, although SRI farmers said they are willing to share their knowledge and experiences to other farmers. Social improvement may need time as it is hard to change the human's mindset.

Based on the discussion on the four elements of sustainability concept, SRI can be considered as the sustainable method; however, SRI dissemination and promotion are needed to ensure its sustainability.

Next is going to prove SRI as one of sustainable agricultural systems. From the findings of this study, SRI can tolerate with the shortage drought. As explained in 1st and 2nd case studies, even with a little amount of rain, by practicing SRI farmers still could get the higher production compared to conventional one. Besides the results of this study, the SRI's resilient ability was also proved by the results of other research conducted in the Philippines (read the details in Chapter 3 part 3.18). Moreover, all selected farmers have been practicing SRI for a long time and they will continue as they said during the household interviews. In addition, at the country level, the number of farmers practicing SRI keeps increasing from 47,039 hectares in 2007 up to 59,785 hectares in 2009 (Chhay, 2010). Moreover, according to Cornell's website retrieved on February 4, 2016 (http://sri.cals.cornell.edu/countries/cambodia/index.htm), during the 4th National Farmers Conference held on April 4, 2013, minister of MAFF reported that SRI is a one of factors of the increases in rice productivity from 2.74t/ha in 2008 to 3.13t/ha in 2012. He continued that cultivated areas under SRI are about 101,719 ha with SRI households ranging from 150,000 to 200,000. At global level, now 45 countries are supporting SRI (Uphoff, 2008). This clearly shows the SRI's persistence.

Finally, based on the merit of SRI as explained here, SRI can be considered as one of sustainable agricultural systems. So far, SRI has been proved to increase paddy productions, farmers' incomes and save water. Therefore, SRI dissemination and promotion are needed to ensure the food security and enhance farmers' livelihood; especially to help farmer adapt with climate change.

CHAPTER 7: CONCLUSION

This chapter is going to wrap up the core findings of this research and also emphasize some implications based on the found results. Therefore, this part is going to be divided into three sections: (1) summaries of the findings; (2) answers to research questions; and (3) implications.

7.1 Summaries of Findings

Irrigation and labor cost are playing important roles in farming practices. Two types of irrigation applications found in study areas are plot-to-pot irrigation and pumping irrigation. Even in irrigated areas, water accessibility is still limited due to the limited function of system and lack of maintenance and proper operation. In irrigated upstream (g), farmers have high chances to access to irrigation but farmers need to pump water from canal in case of less rain. In irrigated downstream (h), most of farmers get their plots irrigated by pumping because of less water from upstream and bad conditions of canals. In all rain-fed areas of this study, farmers still highly depend on rain and most of them can grow rice only once per year. Besides, irrigation problems, farmers have also facing the labor shortage during the land preparation, nursery preparation, transplanting and harvesting times since young people are working for non-farming jobs in and outside the villages or overseas. This causes the labor cost becomes the highest one followed by chemical fertilizer and irrigation. However, this research found that the “Sharing-hand” concept which has still been practiced in some rural areas of Cambodia can help farmers deal with the labor shortage and save the hired labor cost. Moreover, labor costs for conventional practice and SRI practice are not much different since the labor distribution and requirement for both practices are not much different; plus the total of labor cost depends on the availability of family members and the “Sharing-hand” that farmers have received or returned.

On another hand, availability of family members and distance from pot to home have no correlation with the increase of SRI degree adoption. Therefore, the key to improving the degree of SRI adoption are famer zeal and careful attention. Based on the case studies discussed in the previous Chapter, SRI has been proved that it can help farmers increase their productions and be able to contribute paddies to markets from 17% up to 83% of their total harvests; besides the sufficiency of self-consumption. More importantly, this study has also concluded that SRI can increase not only the village productions but also possibly can increase the country productions with the increasing number of SRI farmers and SRI applied areas.

However, most of farmers have low accessibility to markets due to the limited access to information and also because of the lack of collective works. Study also has found that farmers so far have agreed with the price offered by the middle men because farmers do not want to spend on the transportation and lifting labor cost. The important discussion that the study made is the collective sale in a large amount helps farmers to get higher prices compared to an individual sale.

Based on the expenditure on agricultural input and income analyses, farmers could earn profits and have improved their livelihood by practicing SRI. Importantly, SRI has also been proved to be one of sustainable agricultural systems, since it can positively contribute to all the elements of sustainability concepts and two components of sustainable agricultural system.

7.2 Answers to Research Questions

To find it easily to understand the results of this research, this part is going to answer each research question, by following the research questions mentioned in Chapter 1 part 1.3 and the analytical framework given in Chapter 4 part 4.4.

Research Question 1: how are labor and irrigation used in the rice growing season?

The research found out that in the study areas the average family members in each household is 4.48; however, the full availability of members who can help during rice growing is only 2.20. During the fieldworks, it was noticed that only elder people or parents work every day in the field; while other family members can help during weekend or when they are free from schools or workplaces. Regarding the labor distribution during the farming period, farmers hire people or are very busy during land preparation, nursery preparation, transplanting and harvesting times. During the tiller and panicle stages, farmers go to check the plots every two or three days to check the water or wee. In case of labor shortage, because young people are working outside the villages, farmers need to hire other people or ask help from neighbors. That kind of help here is called "Sharing-hand" which has been practiced and passed from one generation to another.

Regarding the irrigation application in the study areas, two types of irrigation have been found. They are plot-to-plot irrigation and by-pumping irrigation. So far, irrigation fee has been priced and collected under the operation of Farmer Water User Community which exists in irrigated upstream (g). However, the fee collection has not been working well. Most of farmers do not pay the irrigation fee due to the limited access to water as explained earlier. Normally, plot-to-plot irrigation is priced more expensive than by-pumping irrigation; according to the household interviews. In rain-fed areas, there is no FWUC to collect the irrigation fee. Farmers still depend on rain for their farming. Based on the findings, actually, farmers do not spend on irrigation fee but on the fuel cost for pumping machine. In case of water shortage due to the drought or less rain, farmers both in irrigated areas and rain-fed areas need to find other sources for irrigation such as stream, river, or ponds nearby. However, with longer drought, farmers will miss or delay their farming; especially in rain-fed areas.

Research Question 2: how much can SRI farmers contribute their products to the markets?

By practicing SRI, most of farmers have increased their products up to 200%; while the lowest increased ratio ranges from 0% to 11%. It means that some farmers have not increased their products at all. So far, it was firstly assumed that other factors might influence the practices that cause the low results of SRI. Finally, it was concluded that farmer zeal and careful attention play important factors on improving SRI production since the labor availability of family members and distance from plot to home have no correlation with the increase of the SRI degree adoption. While, most of farmers can increase their products, besides; sufficiency of self-consumption, farmers are able to contribute their surplus to the markets from 17% up to 83% of their total productions. Although the results also found some farmers could not contribute their productions and even not enough for their self-consumption, those farmers are practicing conventional method which yields lower than the SRI one.

Regarding the market situation, during the household interview, farmers said they normally agree on the price offered by the middle men even it is cheaper than one at the markets because

farmers do not need to spend on the transportation and labor fee. Another interesting finding on this market issue is the benefit of collective sale here defined as the collected amount of paddies which are sold at one time. With the collective sale, farmers can get the higher price than the individual sale. For example, Jasmine variety (ERV) sells for 1,600Riel per Kg if farmers can collect a big amount and sell. Otherwise, the price is only 1,350Riel per Kg for single sale. This dissertation also has discussed the two possible ways that collective sale could happen in the village or among the villagers: (1) the short distance between each household's house or plot where farmers easily gather their products; and (2) good relationship with the neighboring household.

Research Question 3: how does SRI affect the livelihood of adopters?

Based on the expenditure on agricultural inputs and incomes analyses, farmers could earn more profits by practicing SRI compared to the conventional practice. The main expenditure during the rice growing is on the hired labor followed by chemical fertilizer and irrigation. Some farmers had spent a lot on the hired labors because they did not receive the "Sharing-hand" from their neighbors and help from their family members. According to the household interview, farmers normally hire labors during the land preparation, transplanting and harvesting time. Hired cost can be negotiated; however, the price is keeping increasing due to the labor shortage in the villages. Most of farmers have still used the chemical fertilizer; but they are trying to reduce or stabilize the amount or increase the amount of organic fertilizer instead as much as they can collect the material. For the irrigation, farmers spend on the fuel cost for the pumping machine.

Currently, by selling the surplus, farmers can earn more incomes compared to the past 10 years. Owing to the special interviews with the six main selected farmers, they told the changes of their properties, debts and incomes. Incomes from farming had been a main source during the past 10 years. Later, by practicing SRI, farmers can earn more from the surplus they can produce, then pay the debts and send children to schools. Therefore, farming is not the only main sources of incomes anymore. Non-farming paid and remittances are also the farmers' incomes.

Besides, answering all the research questions, this research has also discussed over the inter-related issues in order to improve the farmers' livelihood and community.

Firstly, enhancement of social capital can help farmers build the strong collective power in order to get more access to information especially on markets and development issues, gain more bargaining power to sell their paddies in better price, share their knowledge, experiences and information, and improve their communities or villages' infrastructures or facilities such as construction of small canals or ponds to save water during the drought.

Secondly, in order to prove that SRI can help farmers save their input cost and improve their livelihood, six main farmers among the selected farmers had been asked to record their farming activities day by day continuously for two years of farming from 2014 to 2015. The results showed that there is no much different in labor requirement between SRI and conventional practices; although SRI requires a little more labors in water management, these labors can be reduced with the better irrigation system and proper water distribution. Moreover, two case studies were also explained and discussed to build more solid evidences to prove that SRI really

can improve farmers' incomes and livelihoods; importantly SRI can lead to the increase in paddy productions in villages or communities and finally can lead to the national country productions. Based on the analyses done in Chapter 6 part 6.8, in 2009 SRI could increase the rice production about 24.28%.

Thirdly, this research has also applied the Agricultural Household Concept to identify the characteristics of selected farmers in the study areas. Again based on the incomes and expenditure analyses, it was concluded that most of selected farmers are defined as the Net Sellers. While, only some are defined as neither Net Sellers nor Net Buyers. Only two farmers who practice conventional practices are defined as the Net Buyers because they failed to produce enough for their self-consumption.

Last but not least, this research has also discussed the merit of SRI and its sustainability. As explained and discussed in the Chapter 6, SRI has been proved as one of the sustainable agricultural systems because SRI can fulfill the four elements of sustainability concept and two components of sustainable agricultural systems.

7.3 Implications

The results of this research have explained and visualized the real situations which are now happening in the rural villages of Cambodia; especially in the study areas. Irrigation improvement and rehabilitation in study areas; particularly in irrigated downstream village, have been neglected and farmers still have been suffering with poor function of irrigation system and water distribution; while, farmers in rain-fed villages have been fighting against the drought. Therefore, these results strongly indicate that improvement and rehabilitation of small scale irrigation in irrigated areas and establishment of water storage facilities in rain-fed areas are needed or required more development.

Moreover, the results and findings on the contribution of SRI farmers in the rice markets are original and unique to prove that more extension and promotion works on SRI are really important in order to increase the national country productions. Importantly, since the government failed to import 1 million-milled rice by 2015, it is highly hoped that SRI can help the farmers or rice producers to increase their productions in the future; then the government will be able to import more. Additionally, to inspire other farmers to practice SRI, and to help researchers or extension workers to have solid evidences to prove the merit of SRI in improving famers' livelihood, this research did intensively follow up works with six farmers to record their farming activities continuously for two years. There is no this kind of research done before. The results fruitfully showed that practicing SRI requires same amount of working days in the fields as doing conventional one; moreover, SRI can help farmers improve their livelihood. Therefore, it recommends that these findings can be used to encourage the farmers to practice SRI and other NGOs or development agencies to promote SRI. Moreover, these findings can be used or referred for further research to make stronger clarification or to find new findings for the sake of agricultural development.

The diminishing of social capital in the rural areas will cause the big issues for the rural development in Cambodia; while the government has been working so hard on the infrastructure and construction development, but has been taken the social capital improvement for granted.

This research has found that the concept of “Sharing-hand” and the “Collective works” have been diminished in some rural areas. Recently, most of research has ignored this concept and no research works to improve it. Therefore, further research or studies on these issues are needed to in order to build up the future solutions. Importantly, this research found that “Sharing-hand” is very important to help Cambodian farmers save their agricultural input cost especially on the hired labor cost, and improve their relationship among their neighbors. In addition, enhancement of social capital as discussed in this research shows the great effects to improve the rural farmers’ livelihood; as the World Bank stated that Social Capital is an important factor in the progress of social-economic development (CDRI, June 2012). Working on promoting new farming techniques such as SRI is not enough to make the big changes for rural people. Again, the enhancement of social capital activity should be included or strengthened in the action plans of all the development projects or activities.

Regarding the market accessibility in the rural areas, this research also found that middle men have still played important role in deciding the bought amount and prices. To build the better market systems for farmers; delivery of market information through the proper channels is needed. Otherwise, middle men or traders will gain market power at the loss of small farmers; especially those who cannot get the updated market information.

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APPENDIX I: **QUESTIONNAIRE FOR HOUSEHOLD SRI FARMERS AND NON-SRI FARMERS**

Date: .....

Interviewer: .....

Objectives:

1- Explain whether SRI farmers can contribute their products to the markets.
2- Analyze the labor cost.

A- Household-Level Information:

a1- Name: …… a2- Sex: …… a3- Age: …..……(a4- Head of family or….....)

a5- Village: …… a6- District: ……..... a7- Province: ……..

a8- Family members, education and occupation (Under the same roof):

No.	Name	Relationship	Sex	Age	Education	Occupation
1.						
2.						
3.						
4.						
5.						

a9- Economic Status:

Income			Expense		
Income-generating activities		How much per month?	Items		How much per month?
1.			1.		
2.			2.		
3.			3.		
4.			4.		
5.			5.		
Income □ < or □ > Expense? Other sources: …….. (Loan or others)					

B- Agricultural Information:

b1- Livestock:

b1-1 Cow:.....b1-1-1 Ownership: Yes or No (Rent: .....)

b1-2 Chicken: .....b1-2-1 Ownership: Yes or No (Rent: .....)

b1-3 Duck:.....b1-3-1 Ownership: Yes or No (Rent: .....)

b1-4 Others:.....b1-4-1 Ownership: Yes or No (Rent: .....)

b1-5 If you sell some of them:

b1-5-1 How much can you get in a month or in a year? .....

b1-5-2 How many can you sell in a month or in a year?.....

B2- Cultivated Plots:

b2-1 Garden:..... ha b2-1-1 Ownership: Yes or No (Rental fee:……...)

b2-1-2 Distance from house:…….. min/on foot

b2-2 Plot 1: .....ha b2-2-1 Ownership: Yes or No (Rental fee:……...)

b2-2-2 Distance from house:……...min/on foot

b2-3 Plot 2: .....ha b2-3-1 Ownership: Yes or No (Rental fee:……...)

b2-3-2 Distance from house:……...min/on foot

b2-4 Plot 3: .....ha b2-4-1 Ownership: Yes or No (Rental fee:……..)

b2-4-2 Distance from house:……...min/on foot

B3- Agricultural Tools:

b3-1 Tractor:.....b3-1-1 Ownership: Yes or No (Rent:……..)

b3-2 Animal drawn cart:.....b3-2-1 Ownership: Yes or No (Rent:……..)

b3-3 Sickle:.....b3-3-1 Ownership: Yes or No (Rent:……..)

b3-4 Plough: .....b3-4-1 Ownership: Yes or No (Rent:……..)

b3-5 Harrow: .....b3-5-1 Ownership: Yes or No (Rent:……..)

b3-6 Others:.....b3-6-1 Ownership: Yes or No (Rent:……..)

B4- Rice farming practices:

b4-1 Do you practice SRI or traditional methods? ☐ SRI or ☐ Traditional or ☐ Both

b4-2 How many times do you grow rice? ☐ One or ☐ Two or ☐ others

b4-3 Traditional Practices:

No.	Areas	Varieties (Name, local, late or early)	Irrigation (Canal, river, pumping or gravity)	Yields			
				Before	2013	2014	2015
1.							
2.							
3.							

b4-4 Agricultural Inputs:

No.	Inputs	Types	How many?			How much?			Decrease or Increase
			2013	2014	2015	2013	2014	2015	
1.	Chemical fertilizers								
2.	Natural fertilizers								
3.	Seeds								
4.	Labors								
5.	Others								

b4-5 Any difficulties? Comments?

…… .....

.....

C- SRI Practices:

c1 When did you start practicing SRI? .....

c2 Where did you learn or know about SRI? .....

c3 Why did you decide to practice it? .....

c4 What do you know about SRI? .....

c5 Yields:

No.	Areas	Varieties (Name, local, late or early)	Irrigation (Canal, river, pumping or gravity)	Yields			
				Before	2013	2014	2015
1.							
2.							
3.							

c6 Agricultural inputs for SRI practices:

No.	Inputs	Types	How many?			How much?			Decrease or Increase
			2013	2014	2015	2013	2014	2015	
1.	Chemical fertilizers								
2.	Natural fertilizers								
3.	Seeds								
4.	Labors								
5.	Others								

c7 How do you keep your harvest?

.....

.....

.....

.....

c8 Do you have any difficulty in keeping your harvest? Yes or No? If yes, what are they?

.....

.....

.....

.....

c9 SRI Principles Versus Traditional:

No.	Principles	SRI	Traditional
1	Level the paddy field and provide drainage		
	- For plowing, how many time?		
	- Drain water out or not?		
2	Keep water less in the paddy field		
	- How many cm and when?		
3	Raise nursery beds or use dry nursery beds		
4	Select purified and dense seedlings for transplanting		
	- Mix seeds with other seeds or not?		
	- How to select dense seeds?		
5	Transplant seedlings youngers than 15 days		
6	Transplant big seedlings immediately		
7	Transplant one plant per hill		
8	Transplant seedlings shallowly with roots horizontal		
9	Transplant seedlings with square pattern or in line		
10	Transplant seedlings 25-40 cm apart		
11	Apply natural fertilizer as much as possible		
12	Weed at least 2-4 times a season		

c10 Have you still been informed about the SRI training or promotion? ☐ No or ☐ Yes

c11 If No. Why? : .....

c12 If Yes, from where or who? :.....

c13 Are you still attending SRI training or field trip? ☐ Yes or ☐ No

c14 If Yes, Why? .....

c15 Benefits from practicing SRI: .....

.....

.....

c16 Difficulties in practicing SRI: .....

.....

.....

c17 Suggestion, comments and commitment:

.....

.....

.....

D- Consumption and Market:

d1 Is your harvest enough to feed your family members?

- d1-1 Yes: (Just Enough or More than enough)
- d1-2 No: (How many months is your harvest not enough?) .....

d2 In case: You have more than enough, do you sell it? Yes or No

- d2-1 Yes:
  - d2-1-1 How many kg you can sell? .....
  - d2-1-2 How do you sell it? .....
  - d2-1-3 What is the price? .....
- d2-2 No:
  - d2-2-1 Why don't you sell? .....

d3 In case: You do not have enough:

- d3-1 How many kg of rice do you buy? .....
- d3-2 Where do you buy it? .....
- d3-3 What is the price? .....

d4 Is it difficult to sell or buy the extra rice? Why?

.....

.....

.....

d5 What do you think about the price when you sell or buy?

.....

.....

.....

E- Labor requirement:

e1 How many family members can help you in farming? .....

e2 Are some of them still studying? .....

e3 How can they manage their study and farming time? .....

.....

.....

e4 Do you share your hands with your neighbors? Yes or No

- e4-1 If Yes: In what condition? .....

  .....

  .....

- e4-2 If No: Why? .....

  .....

  .....

e5 Do you have any difficulty in working at the field?

.....

.....

e6 Detail about the labor consumption:

No.	Cultivation Cycle	When?	Power sources?	How many (person and time)?	How much?
1	Land preparation				
2	Nursery preparation				
3	Transplanting				
4	Tillering Stage				
5	Panicle Initiation				
6	Ripening Stage				
7	Harvesting				

e7 Suggestions, comments and others:

.....

.....

(End of Questionnaire!)

APPENDIX II: FARMER'S FARMING DAILY ACTIVITY RECORD SHEET

សកម្មភាពការងារកសិកម្មប្រចាំថ្ងៃទី_____ខែ_____ឆ្នាំ

Daily Farming Activity: Day Month Year

ឈ្មោះ Name

ភូមិ Village **ឃុំ** Commune **ស្រុក** District **ខេត្ត** Province

ម៉ោង Time	៥ព្រឹក 5am	៦ព្រឹក 6am	៧ព្រឹក 7am	៨ព្រឹក 8am	៩ព្រឹក 9am	១០ព្រឹក 10am	១១ព្រឹក 11am	១២ថ្ងៃត្រង់ 12pm	១រសៀល 1pm	២រសៀល 2pm	៣រសៀល 3pm	៤រសៀល 4pm	៥ល្ងាច 5pm	៦ល្ងាច 6pm

សកម្មភាព Activity

ចំនួនមនុស្ស No. of People

សកម្មភាពការងារកសិកម្មប្រចាំថ្ងៃទី_____ខែ_____ឆ្នាំ

Daily Farming Activity: Day Month Year

ឈ្មោះ Name

ភូមិ Village **ឃុំ** Commune **ស្រុក** District **ខេត្ត** Province

ម៉ោង Time	៥ព្រឹក 5am	៦ព្រឹក 6am	៧ព្រឹក 7am	៨ព្រឹក 8am	៩ព្រឹក 9am	១០ព្រឹក 10am	១១ព្រឹក 11am	១២ថ្ងៃត្រង់ 12pm	១រសៀល 1pm	២រសៀល 2pm	៣រសៀល 3pm	៤រសៀល 4pm	៥ល្ងាច 5pm	៦ល្ងាច 6pm

សកម្មភាព Activity

ចំនួនមនុស្ស No. of People

APPENDIX III:

LIST OF EXTRA INFORMATION ON SELECTED FARMERS

Farmer	Number of Family Member by Plot	Age of Family Head	Education Level of Family Head	Area (ha)	Degree of SRI Adoption	Sex of Family Head (1: Male; 0:Female)
A1	5	68	10	0.7	16	1
A2	5	61	5	0.15	67	1
A2	5	61	5	0.1	67	1
A3	5	45	9	0.6	83	1
A3	5	45	9	0.48	83	1
B1	4	48	5	1	16	0
B1	4	48	5	1	83	0
B2	4	65	3	1	83	0
B3	4	33	2	2	58	1
B3	4	33	2	0.06	58	1
B3	4	33	2	0.4	58	1
C1	6	50	12	0.88	67	1
C1	6	50	12	1.98	67	1
C2	7	33	3	1	58	1
C3	3	39	0	0.5	83	0
C3	3	39	0	0.5	83	0
D1	4	65	6	0.25	92	1
D1	4	65	6	0.35	92	1
D2	4	52	2	0.2	67	0
D2	4	52	2	0.25	67	0
D3	4	52	7	0.35	67	1
E1	2	48	8	0.21	75	1
E1	2	48	8	1.5	16	1
E2	5	59	4	0.25	75	1
E2	5	59	4	0.3	16	1
E3	5	42	4	1.7	75	0
E3	5	42	4	0.25	25	0
F1	5	33	9	0.15	75	1
F1	5	33	9	0.6	75	1
F2	4	57	6	0.2	100	1
F2	4	57	6	0.15	100	1
F3	4	40	5	0.15	75	1
F3	4	40	5	0.15	75	1
G1	2	50	6	0.14	58	0
G1	2	50	6	0.12	58	0
G2	10	44	7	0.16	75	1
G2	10	44	7	0.12	75	1
G2	10	44	7	0.15	75	1
G3	7	49	12	0.9	58	1

G3	7	49	12	0.1	58	1
G4	3	53	0	0.12	75	1
G4	3	53	0	0.16	25	1
G5	3	78	3	0.5	67	0
H1	3	36	7	0.2	16	0
H1	3	36	7	0.2	83	0
H2	7	85	6	0.26	83	1
H3	3	27	4	0.14	67	1
H4	4	61	4	0.09	67	1
H5	4	68	0	0.2	25	1
H6	5	44	10	0.1	25	1
H7	4	37	9	0.23	75	1
H8	4	50	6	0.23	75	1

APPENDIX IV:

RECORDS OF MAIN FARMERS FOR 2014-2015

1- Main Farmer G1 in Irrigated Upstream (g) in Kampong Speu Province

Plot1: 0.14ha, Chomreak Pdao Variety (LRV), Used Seed: 3kg

Plot 2: 0.12ha, IR 66 Variety (ERV), Used Seed: 5kg

Month	Day	Time		Activities	No. of Person	Notice
Apr-14	1	9 to 10am	1	Nursery preparation (Plot 2)	1	tractor=40000R
	2	4 to 6pm	2	Irrigate the nursery (Plot 2)	1	
	3	7 to 9am	2	sowing (Plot 2)	1	
	6	7 to 9am	2	Irrigate the nursery (Plot 2)	1	
	13	3 to 5pm	2	Irrigate the nursery (Plot 2)	1	
	16	8 to 10am	2	Land Preparation (Plot 2)	1	Tractor=80000R
	18	4 to 6pm	2	Irrigate the land (Plot 2)	1	
	19	7 to 11am	4	Uproot and Transplant (Plot 2)	3	
		2 to 6pm	4	Uproot and Transplant (Plot 2)	3	
	23	8 to 10am	2	Check the water (Plot 2)	1	

Month	Day	Time		Activities	No. of Person	Notice
May-14	2	9 to 11am	2	Weed (Plot 2)	1	
	5	2 to 4pm	2	Check water (Plot 2)	1	
	8	7 to 8am	1	Check water (Plot 2)	1	
	15	9 to 10am	1	Check water (Plot 2)	1	
	23	2 to 4pm	2	Weed (Plot 2)	1	
	27	8 to 10am	2	Apply Fertilizer (Plot 2)	1	

Month	Day	Time		Activities	No. of Person	Notice
June 2014	3	6 to 8am	2	Prepare nursery bed (Plot 1)	2	
		9 to 11am	2	Sow (Plot 1) on 0.04 ha of land	1	
	11	7 to 8am	1	Pump water to the field (Plot1)	1	
					2L*5,000R	
	20	10 to 11am	2	Pump water to the field (Plot1)	1	
					2L*5,000R	
	27	7 to 11am	2	Pump water to the field (Plot1)	1	
					2L*5,000R	
	29	7 to 10am	3	Land preparation (Plot 1)	1	Tractor=80000R
	30	7 to 11am	4	Transplant (Plot 1)	8	
		3 to 5pm	2	Drain water out (Plot 2)	1	

Month	Day	Time		Activities	No. of Person	Notice
Jul-14	5	7 to 10am	3	Harvest (Plot 2)	4	
		1 to 4pm	3	Harvest (Plot 2) and Transport home	2	
	6	7 to 10am	3	Harvest (Plot 2)	4	
		1 to 4pm	3	Harvest (Plot 2) and Transport home	2	
	28	7 to 9am	2	Apply Fertilizer (cow dung) for (Plot 1)	1	
		2 to 5pm	3	Check water and pick snails out (Plot 1)	1	
	30	2 to 5pm	3	Drain water out and pick snails out (Plot 1)	1	
	31	7 to 11am	4	Check water and pick snails out (Plot 1)	1	

Month	Day	Time		Activities	No. of Person	Notice
August 2014	6	3 to 5pm	2	Check water (plot 1)	1	
	12	7 to 10am	3	Transport fertilizer to field (Plot 1)	1	
		1 to 4pm	3	Check water (Plot 1)	1	
	14	7 to 10am	3	Irrigate water to the field (Plot 1)	1	

Month	Day	Time		Activities	No. of Person	Notice
Sep-14	8	10 to 11am	1	Check water (Plot 1)	1	
	9	8 to 12am	4	Apply fertilizer (Plot 1)	1	
		3 to 5pm	2	Weed (Plot 1)	1	
	12	9 to 11am	2	Weed (Plot 1)	1	
	23	2 to 5pm	3	Cut grass along the field bank (Plot 1)	1	
	24	7 to 10am	3	Cut the grass (Plot 1)	1	
	30	2 to 4pm	2	Weed (Plot 1)	1	

Month	Day	Time		Activities	No. of Person	Notice
Oct-14	3	3 to 4pm	1	Check water (Plot 1)	1	
	19	8 to 9am	1	Check water (Plot 1)	2	
	26	7 to 9am	2	Check water (Plot 1)	1	

Month	Day	Time		Activities	No. of Person	Notice
Nov-14	25	2 to 4pm	2	Check paddy field (Plot 1)	2	
	27	8 to 10am	2	Check water (Plot 1)	1	

Month	Day	Time		Activities	No. of Person	Notice
Dec-15	25	7 to 10am	3	Harvest (Plot 1)	2	
		1 to 5pm	4	Harvest (Plot 1)	2	
	27	7 to 10am	3	Tie the harvest at the field (Plot 1)	2	
		2 to 5pm	3	Transport harvest home (Plot 1)	2	By Tractor but Lift the harvest to tractor by farmers

2- Main Farmer H1 in Irrigated Downstream (h) in Kampong Speu Province

Plot: 0.20ha, IR Variety (ERV), Used Seed: 15kg (Direct Sowing)

Month	Day	Time		Activities	No. of Person	Notice
Apr-14	7	1 day	8	Prepare Land	1	Tractor
	8	8 to 11am	3	Irrigate the water	1	pumping
	10	9 to 11am	2	Sow (Direct sowing)	1	
	17	8 to 10am	2	Check the water	1	
	26	4 to 6pm	2	Weed	1	
	27	4 to 6pm	2	Weed	1	

Month	Day	Time		Activities	No. of Person	Notice
May-14	5	9 to 10am	1	Check the water	1	
	8	9 to 11 am	2	Check the water	1	
	13	4 to 5pm	1	Weed	1	
	17	7 to 8am	1	Check the water	1	
	23	9 to 11am	2	Apply Fertilizer	1	
	24	7 to 9am	2	Check the water	1	
	27	8 to 10am	2	Weed	1	

Month	Day	Time		Activities	No. of Person	Notice
Jun-14	3	7 to 8am	1	Check water	1	
	7	7 to 8am	1	Check water	1	
	10	7 to 8am	1	Check water	1	
	13	4 to 6pm	2	Weed	1	
	15	7 to 8am	1	Check water	1	
	18	7 to 9am	2	Check water	1	
	24	7 to 9am	2	Check water	1	
	28	7 to 9am	2	Check water	1	

Month	Day	Time		Activities	No. of Person	Notice
July 2014	3	2 to 4pm	2	Drain water out	1	
	5	7 to 11am	4	Harvest Dry season rice	1	
		1 to 5pm	4	-	1	
	6	7 to 11am	4	-	2	
		1 to 5pm	4	-	2	
	7	7 to 11am	4	-	2	
		2 to 5pm	3	Carry harvest home	2	
	9	8 to 10am	2	Threshed by rented machine	21 containers*10,000R	

3- Main Farmer C1 in Rain-fed (c) in Kampong Speu Province

Plot 1: 1.98ha, Jasmine Variety (ERV), Used Seed: 30kg

Plot 2: 0.88ha, Chmar Prum Variety (LRV), Used Seed: 24kg

Month	Day	Time		Activities	No. of Person	Notice
May 2014	25	5 to 9am	4	Transport fertilizer to the field	1	Plot 1
		2 to 4pm	2	Transport fertilizer to the field	1	Plot 2
	27	5 to 11am	6	-	2	Plot 1
		2 to 4pm	2	-	2	Plot 2

Month	Day	Time		Activities	No. of Person	Notice
June 2014	6	5 to 11am	6	Plough the nursery bed (Plot 1)	2 persons with 1 tractor=35,000R	
		2 to 4pm	2	Sow (Plot 1)	2	For ERV
	8	5 to 4pm	12	Irrigate water to nursery bed (Plot 2)	1	For LRV
					3L of Fuel * 5,000R	
	9	5 to 11am	6	Plough the nursery bed (Plot 2)	2 persons with 1 tractor=35,000R	
		2 to 4pm	2	Sow (Plot 2)	2	For LRV

Month	Day	Time		Activities	No. of Person	Notice
July 2014	4	5am till after 6pm	16	Irrigate field for transplanting	1	Plot 1
					3L*5,000R	

Month	Day	Time		Activities	No. of Person	Notice
Sep-14	21	5 to 12pm	7	Uprooting (Plot 1)	2	
		2 to 6pm	4	Uprooting (Plot 1)	2	
	22	5 to 12pm	7	Transplanting (Plot 1)	2	
		2 to 6am	4	Transplanting (Plot 1)	1	
	23	5 to 12pm	7	Land Preparation (Plot 2)	2	Tractor=80000R
	30	5 to 12pm	7	Land Preparation (Plot 1)	2	Tractor=115000R
		2 to 6pm	4	Land Preparation (Plot 1)	2	
		9 to 11am	2	Uprooting (Plot 1)	2	
		2 to 6pm	4	Uprooting (Plot 1)	2	

Month	Day	Time		Activities	No. of Person	Notice
Oct-14	1	5 to 11am	6	Transplanting (Plot 1)	1	
		12 to 6pm	6	Transplanting (Plot 1)	1	
	2	5 to 11am	6	Transplanting (Plot 1)	1	
		12 to 5pm	5	Transplanting (Plot 1)	2	
	3	5 to 12pm	7	Uprooting (Plot 1)	6	
		2 to 6pm	4	Uprooting (Plot 1)	2	
	4	7 to 11am	4	Transplanting (plot 1)	6	
		12 to 4pm	4	Transplanting (Plot 1)	2	
	5	6 to 11am	5	Uprooting (Plot 2)	2	
		2 to 6pm	4	Uprooting (Plot 2)	2	
	6	6 to 11am	5	Uprooting (Plot 2)	2	
		2 to 6pm	4	Uprooting (Plot 2)	2	
	7	6 to 11am	5	Transplanting (Plot 2)	2	
		2 to 6pm	4	Transplanting (Plot 2)	2	
	8	6 to 11am	5	Transplanting (Plot 2)	2	
		2 to 6pm	4	Transplanting (Plot 2)	2	
	9	6 to 11am	5	Transplanting (Plot 2)	2	
		2 to 6pm	4	Transplanting (Plot 2)	2	
	10	5 to 9am	4	Uprooting (Plot 2)	2	
		2 to 4pm	2	Uprooting (Plot 2)	1	
	11	5 to 7am	2	Transplanting (Plot 2)	2	
	12	5 to 7am	2	Transplanting (Plot 2)	2	
	13	5 to 7am	2	Transplanting (Plot 2)	2	

Month	Day	Time		Activities	No. of Person	Notice
Nov-14	7	5 to 11am	6	Harvesting (Plot 1)	1	
		12 to 6pm	6	Harvesting (Plot 1)	1	
	8	5 to 11am	6	Harvesting (Plot 1)	1	
		12 to 6pm	6	Harvesting (Plot 1)	1	
	9	5 to 11am	6	Harvesting (Plot 1)	1	
		12 to 6pm	6	Harvesting (Plot 1)	1	
	10	5 to 11am	6	Transport harvest home (plot 1)	1	
		12 to 6pm	6	Transport harvest home (plot 1)	1	
	11	5 to 11am	6	Harvesting (Plot 1)	1	
		12 to 6pm	6	Harvesting (Plot 1)	1	
	12	5 to 11am	6	Harvesting (Plot 1)	1	
		12 to 6pm	6	Harvesting (Plot 1)	1	
	13	5 to 11am	6	Harvesting (Plot 1)	1	
		12 to 6pm	6	Harvesting (Plot 1)	1	
	14	5 to 11am	6	Transport harvest home (plot 1)	1	
		12 to 6pm	6	Transport harvest home (plot 1)	1	
	15	5 to 11am	6	Harvesting (Plot 1)	1	
		12 to 6pm	6	Harvesting (Plot 1)	1	
	16	5 to 11am	6	Harvesting (Plot 1)	1	
		12 to 6pm	6	Harvesting (Plot 1)	1	
	17	5 to 11am	6	Harvesting (Plot 1)	1	
		12 to 6pm	6	Harvesting (Plot 1)	1	
	18	5 to 11am	6	Transport harvest home (plot 1)	1	
		12 to 6pm	6	Transport harvest home (plot 1)	1	

Month	Day	Time		Activities	No. of Person	Notice
Dec-14	2	5 to 11am	6	Harvesting (Plot 2)	1	
		12 to 6pm	6	Harvesting (Plot 2)	1	
	3	5 to 11am	6	Harvesting (Plot 2)	1	
		12 to 6pm	6	Harvesting (Plot 2)	1	
	4	5 to 11am	6	Harvesting (Plot 2)	1	
		12 to 6pm	6	Harvesting (Plot 2)	1	
	5	5 to 11am	6	Harvesting (Plot 2)	1	
		12 to 6pm	6	Harvesting (Plot 2)	1	
	6	5 to 11am	6	Transport Harvest home (Plot 2)	1	
		12 to 6pm	6	Transport Harvest home (Plot 2)	1	
	7	5 to 11am	6	Harvesting (Plot 2)	1	
		12 to 6pm	6	Harvesting (Plot 2)	1	
	8	5 to 11am	6	Harvesting (Plot 2)	1	
		12 to 6pm	6	Harvesting (Plot 2)	1	
	9	5 to 11am	6	Harvesting (Plot 2)	1	
		12 to 6pm	6	Harvesting (Plot 2)	1	
	10	5 to 11am	6	Harvesting (Plot 2)	1	
		12 to 6pm	6	Harvesting (Plot 2)	1	
	11	5 to 11am	6	Transport Harvest home (Plot 2)	1	
		12 to 6pm	6	Transport Harvest home (Plot 2)	1	

4- Main Farmer D1 in Rain-fed (d) in Takeo Province

Plot: 0.25ha, Saen Pidao Variety (ERV), Used Seed: 20kg

Month	Day	Time		Activities	No. of Person	Notice
May and June 2014	27	6 to 10am	4	Prepare nursery bed (15mx15m) Sowing about 1hr	2	Plot 1
					Pump 1L*5,000R	
	1	7 to 8am	1	Apply fertilizer	1	
					4 to 5 ox carts	
	5	6 to 8am	2	Plough and level the field	1	
					1 person with 2 cows	
	6	6 to 9am	3	Plough and level the field	1	
	7	6 to 10am	4	Plough and level the field	1	
	8	6 to 10am	4	Plough and level the field	1	
	9	6 t0 10am	4	Plough and level the field	1	
	10	6 to 10am	4	Plough and level the field	1	
	15	6 to 9am	3	Harrow the land	1	
	16	6 to 9am	3	Harrow the land	1	
	18	3 to 4pm	1	Uproot the seedlings	2	
	19	6 to 10am	4	Plough the land	1	with 2 cows
		7 to 11am	4	Transplant	6	
		2 to 6pm	4	Uproot the seedlings	3	
	20	6 to 11am	5	Plough the land	1	2 cows
		7 to 12pm	5	Transplant	6	
		2 to 6pm	4	Uproot the seedlings	3	
	21	6 to 10am	4	Plough the land	1	2 cows
		7 to 12pm	5	Transplant	7	
		3 to 6pm	3	Uproot the seedlings	4	
	22	6 to 10am	4	Plough the land	1	2 cows
		7 to 11am	4	Transplant	6	
		3 to 6pm	3	Uproot the seedlings	4	
	23	6 to 10am	4	Plough the land	1	2 cows
		7 to 11am	4	Transplant	5	
		3 to 6pm	3	Uproot the seedlings	2	

Month	Day	Time		Activities	No. of Person	Notice
June 2014	24	6 to 10am	4	Plough the land	1	2 cows
		7 to 12pm	5	Transplant	8	
	25	8 to 10am	2	Replace seedlings	2	
	26	8 to 11am	3	Weed	2	
	30	7 to 4pm	9	Pump water to the field	1	
					3L*5,000R	
Month	**Day**	**Time**		**Activities**	**No. of Person**	**Notice**
July 2014	5	3 to 6pm	3	Apply Fertilizer	1	
	7	8 to 10am	2	Apply Fertilizer	1	
	No harvest due to drought, Farmer sold the unripened rice plants as grass with incomes of 1million Riel					

5- Main Farmer D2 in Rain-fed (d) in Takeo Province

Plot: 0.20ha, Krohorm Variety (LRV), Used Seed: 20kg

Month	Day	Time		Activities	No. of Person	Notice
June 2014	10	5 to 8am	3	Prepare nursery bed	1	
				1 time=40,000R with 2 cows		
	20	5 to 8aam	3	Prepare nursery bed	1	40,000R
		9 to 10am	2	Sow	2	
	21	7 to 10am	3	Pump water to field and weed	1	
					3hrs=3L*5,000R	

Month	Day	Time		Activities	No. of Person	Notice
July 2014	23	3 to 5pm	2	Irrigate the field for land preparation	1	1L=5000R
	24	8 to 12pm	4	Prepare land for transplant	1	Tractor=48000R
	26	8 to 11am	3	Transplant	7	
		1 to 4pm	3	Transplant	8	
	30	8 to 10am	2	Check the water	1	

Month	Day	Time		Activities	No. of Person	Notice
August 2014	8	4 to 5pm	1	Check the water	1	
	13	3 to 5pm	2	Weed	1	
	20	8 to 10am	2	Check the water	1	
	25	3 to 5pm	2	Apply fertilizer	1	

Month	Day	Time		Activities	No. of Person	Notice
September 2014	7	3 to 4pm	1	Weed	1	
	15	8 to 10am	2	Check the water	1	
	20	2 to 4pm	2	Weed	1	
	27	7 to 8am	1	Check the water	1	

Month	Day	Time		Actvities	No. of Person	Notice
November 2014	6	6 to 7am	1	Check the water	1	
	18	8 to 9am	1	Apply fertilizer	1	
	23	4 to 6pm	2	Weed	1	
	25	3 to 5pm	2	Irrigate the field	1	2L*5000R
	29	7 to 8am	1	Check the water	1	

Month	Day	Time		Activities	No. of Person	Notice
October 2014	5	5 to 6am	1	Check the water	1	
		7 to 8am	1	Weed	1	
	11	5 to 7am	2	Irrigate the field	1	2L*5000R
		8 to 9am	1	Apply fertilizer	1	
	17	4 to 6pm	2	Check the water	1	
	23	7 to 8am	1	Check the water	1	
	28	4 to 6pm	2	Weed	1	

Month	Day	Time		Activities	No. of Person	Notice
December 2014	3	7 to 9am	2	Check the water	1	
	8	4 to 5pm	1	Check the water	1	
	13	3 to 5pm	2	Drain water out	1	
	16	8 to 11am	3	Harvest	3	
		2 to 5pm	3	Harvest	3	
	17	8 to 11am	2	Transport the harvest home	3	
		2 to 5pm	3	Harvest	3	
	18	8 to 11am	3	Harvest	3	
		2 to 5pm	2	Transport the harvest home	3	

6- Main Farmer D3 in Rain-fed (d) in Takeo Province

Plot: 0.35ha, Korhorm Variety (LRV), Used Seed: 24kg

Month	Day	Time		Activities	No. of Person	Notice
May and June 2014	3-May	7 to 10am	3	Prepare Nursery bed	1	2 cows
					40,000R	
	13-May	7 to 10am	3	Prepare Nursery bed	1	2 cows
					40,000R	
	18-Jun	7 to 10am	3	Prepare Nursery bed and Sow for 1hr	2	4 borrowed cows
		11 to 3pm	4	Pump water to the field	3L*5,000R	

Month	Day	Time		Activities	No. of Person	Notice
Auguest 2014	15	7 to 10	3	Uproot seedlings	4	
	16	7 to 11	4	Transplant	10	4 cows
	18	7 to 10	3	Uproot seedlings	6	
	18	7 to 11	4	Transplant	10	
		No more record				

APPENDIX V:

RECORDS OF MAIN FARMERS FOR 2015-2016

1- Main Farmer G1, in Irrigated Upstream (g) in Kampong Speu Province

Plot: 0.12ha, IR66 Variety (ERV), Used Seed: 5kg

Month	Day	Time		Activities	No. of Person	Notice
Mar-15	18	8 to 11m	3 hrs	Irrigate the field	1	(1.5hr=6500R)x2=13,000R
	20	10 to 12pm	2 hrs	Prepare nursery	1	by Tractor=25,000R
		1 to 2pm	1 hr	Sow	2	
	26	3 to 5pm	2 hrs	Irrigate the field by gravity	1	
	27	8 to 10am	2 hrs	Irrigate the nursery	2	1L=3,500R
	31	8 to 9am	1 hr	Check the water at the field	1	
		12 to 1pm	1 hr	Transport fertilizer to the field	1	Cow manure

Month	Day	Time		Activities	No. of Person	Notice
Apr-15	1	6 to 7am	1 hr	Transport fertilizer to the field	1	Cow manure
	2	6 to 7am	1 hr	Transport fertilizer to the field	1	Cow manure
	4	9 to 11am	2 hrs	Prepare land for transplanting	2	by tractor for 20,000R
	5	10 to 12pm	2 hrs	Prepare land for transplanting	2	by tractor for 20,000R
	6	7 to 11am	3 hrs	Irrigate the field	1	
		2 to 5pm	3 hrs	Uproot the seedlings	1	
	7	7 to 10am	3 hrs	Transplant	1	
		1 to 5pm	4 hrs	Transplant	2	
	8	7 to 10am	3 hrs	Transplant	1	
		1 to 3pm	2 hrs	Transplant	1	
	11	7 to 10am	3 hrs	Check the water at the field and pick up the snail	1	
	16	2 to 4pm	2 hrs	Check the water at the field	1	
	18	7 to 10am	3 hrs	Irrigate and Replace the spoiled seedlings by snail	1	
	24	7 to 9am	2 hrs	Check the water at the field	1	

Month	Day	Time		Activities	No. of Person	Notice
May-15	3	7 to 10am	3 hrs	Apply fertilizer (1hr) and weed (2hrs)	1	
	5	1 to 3pm	2 hrs	Check the rice plants and withdraw the spoiled plants	1	
	6	2 to 4pm	2 hrs	Weed	1	
	12	7 to 9am	2 hrs	Check the water (1hr) and apply fertilizer (1hr)	2	
	15	2 to 4pm	2 hrs	Weed	1	
	17	2 to 4pm	2 hrs	Weed and remove the spoiled rice plants	1	
	18	3 to 5pm	2 hrs	Weed and remove the spoiled rice plants	1	
	29	8 to 10am	2 hrs	Irrigate the field by gravity	1	
		2 to 4pm	2 hrs	Irrigate the field by gravity	1	

Month	Day	Time		Activities	No. of Person	Notice
Jun-15	2	9 to 10am	1 hr	Check the water at the field	1	
	4	8 to 9am	1 hr	Check the water at the field	1	
		3 to 4pm	1 hr	Check the water at the field	1	
	7	7 to 9am	2 hrs	Check the water at the field	1	
	10	8 to 10am	2 hrs	Irrigate the field by gravity	1	
	14	8 to 9am	1 hr	Check the water at the field	1	
		2 to 3pm	1 hr	Check the water at the field	1	
	18	7 to 10am	3 hrs	Irrigate the field by gravity	1	
	21	9 to 10am	1 hr	Check the field during panicle stage	1	
	24	9 to 10am	1 hr	Check the paddy field	1	
	28	8 to 9am	1 hr	Check the ripen paddy	1	

Month	Day	Time		Activities	No. of Person	Notice
Jul-15	1	9 to 10am	1 hr	Check the ripen paddy	1	
	4	9 to 10am	1 hr	Check the ripen paddy	1	
	6	1 to 3pm	2 hrs	Harvest by machine	1	(1a=4000R)
		3 to 6pm	3 hrs	Transport the harvest back home	3	
				Yield= 10 Kantel*60kg=600kg		*Kantel is one of traditional weights

Plot: 0.12ha + 0.14ha, Neang Minh (LRV), Used Seed: 10kg

Month	Day	Time		Activities	No. of Person	Notice
Jun-15	24	5pm to 6pm	1	Soak the seed	1	
	25	7 to 9am	2	Irrigate the field for nursery preparation	2	Rent the pumping machine=20,000R
	26	6 to 8am	2	Nursery preparation	2	Rent the tractor=20,000R
		8 to 9am	1	Sow the seeds	1	

Month	Day	Time		Activities	No. of Person	Notice
Jul-15	4	7 to 9am	2	Irrigate the nursery	2	Rent the pumping machine=20,000R
	11	7 to 9am	2	Irrigate the nursery	2	Rent the pumping machine=20,000R
		8 to 9am	1	Apply Fertilizer	1	
	18	2 to 4pm	2	Irrigate the nursery	2	Rent the pumping machine=20,000R
	22	7 to 10am	3	Uproot the seedlings	3	Hire 3 persons=36,000R
	23	7 to 11am	4	Plough land for transplanting	3	Hire 2 and tractor=40,000R
	24	7 to 11am	4	Transplanting	8	Hire 8 persons=96,000R
	29	7 to 9am	2	Check water (2hrs) and apply fertilizer (2hrs)	2	
	30	7 to 9am	2	Check water (2hrs) and apply fertilizer (2hrs)	2	

Month	Day	Time		Activities	No. of Person	Notice
Aug-15	5	8 to 10am	2	Check water (1hr) and Weed (1hr)	1	
	8	7 to 9am	2	Check water (1hr) and Weed (1hr)	1	
	10	7 to 9am	2	Irrigate the plot (plot to plot)	1	
	11	2 to 4pm	2	Irrigate the plot (plot to plot)	1	
	19	7 to 9am	2	Check water (1hr) and Weed (1hr)	1	
	22	8 to 10am	2	Check water (1hr) and Weed (1hr)	1	
	30	7 to 9am	2	Irrigate the plot (plot to plot)	1	
	31	7 to 9am	2	Irrigate the plot (plot to plot)	1	

Month	Day	Time		Activities	No. of Person	Notice
Sep-15	2	7 to 9am	2	Weed	1	
	4	8 to 10am	2	Weed	1	
	11	7 to 9am	2	Check water (1hr) and weed (1hr)	1	
	12	7 to 9am	2	Weed (1hr) and Apply fertilizer (1hr)	1	
	15	8 to 10am	2	Weed (1hr) and Apply fertilizer (1hr)	1	
	20	7 to 9am	2	Check water (1hr) and weed (1hr)	1	
	25	7 to 9am	2	Irrigate the plot (plot to plot)	1	

Month	Day	Time		Activities	No. of Person	Notice
Oct-15	2	8 to 10am	2	Check water (1hr) and Weed (1hr)	1	
	4	7 to 9am	2	Check water (1hr) and Weed (1hr)	1	
	10	7 to 9am	2	Irrigate the field (Plot to plot)	1	
	14	7 to 9am	2	Check the plot (water)	1	
	18	8 to 10am	2	Check the plot (water)	1	
	23	2 to 4pm	2	Check the water	2	
	29	8 to 10am	2	Check the water	2	

Month	Day	Time		Activities	No. of Person	Notice
Nov-15	6	8 to 10am	2	Check the rice plant (productive stage)	1	
	12	7 to 9am	2	Check the water	1	
	17	2 to 4pm	2	Check the water	1	
	26	7 to 9am	2	Check the rice plant (panicle stage)	1	

Month	Day	Time		Activities	No. of Person	Notice
Dec-15	8	7 to 9am	2	Check the rice plant (Ripening stage)	1	
	11	3 to 5pm	2	Check the rice plant (lay down the rice plant)	1	
	12	7 to 11am	4	Harvest (by hand)	1	
		1 to 5pm	4	Harvest (by hand)	1	
	13	7 to 11am	4	Harvest (by hand)	3	Family and neighbors
		1 to 5pm	4	Harvest (by hand)	2	Family members
	14	7 to 11am	4	Harvest (by hand)	2	Family members
		1 to 5pm	4	Harvest (by hand)	2	Family members
	15	7 to 10am	3	Transport harvest home	2	Family members
		2 to 5pm	3	Transport harvest home	2	Family members
	16	7 to 10am	3	Transport harvest home	2	Family members
				Yield 15Kantel*60kg=900lkg		

2- Main Famer H1 in Irrigated Downstream (h) in Kampong Speu Province

Plot: 0.20ha + 0.20ha, Raing Chey Variety (LRV), Used Seed: 15kg

Month	Day	Time		Activities	No. of Person	Notice
Jun-15	15	7 to 10 am	3	Prepare the nursery bed by tractor	2	Total cost= 130,000Riel (2hrs for sowing)
		2 to 5pm	3	Prepare the nursery bed by tractor	2	

Month	Day	Time		Activities	No. of Person	Notice
Jul-15	19	6 to 10 am	4	Prepare the land for transplanting by tractor	1	Total cost= 40,000Riel
		6 to 10 am	4	Uproot the seedings	2	
		2 to 5pm	3	Transplant	2	
	20	6 to 10 am	4	Uproot and Transplant	2	
		1 to 5pm	5	Uproot and Transplant	2	
	21	6 to 11am	5	Uproot and Transplant	1	
		1 to 5pm	4	Uproot and Transplant	1	
	30	6 to 10 am	4	Prepare the land for transplanting by tractor	2	Total cost= 80,000Riel
		1 to 5pm	4	Prepare the land for transplanting by tractor	2	
	31	6 to 10am	4	Uproot the seedlings	3	
		1 to 5pm	4	Transplant	4	

Month	Day	Time		Activities	No. of Person	Notice
Aug-15	1	8 to 12pm	4	Uproot and transplant	2	
		2 to 5pm	3	Uproot and transplant	3	
	2	7 to 11am	4	Uproot and transplant	1	
		1 to 5pm	4	Uproot and transplant	1	
	3	6 to 11am	5	Uproot and transplant	1	
		1 to 5pm	4	Uproot and transplant	1	
	4	6 to 11am	5	Uproot and transplant	1	
		1 to 5pm	4	Uproot and transplant	1	
After Transplanting till harvesting time, farmers did not spend much time in the plots because there was much water, no weed and no water management because it was difficult to drain water out. That was why, even during the harvesting time, water still remained in the plots.						

Month	Day	Time		Activities	No. of Person	Notice
Dec-15	3	6 to 10am	4	Harvest	1	
		1 to 5pm	4	Harvest and transport back home	1	
	4	6 to 11am	5	Harvest	1	
		1 to 5pm	4	Harvest and transport back home	1	
	5	6 to 11am	5	Harvest	1	
		1 to 5pm	4	Harvest and transport back home	2	
	6	6 to 11am	5	Harvest	2	
		1 to 5pm	4	Harvest and transport back home	2	
	7	6 to 11am	5	Harvest	1	
		1 to 5pm	4	Harvest and transport back home	1	
	8	6 to 11am	5	Harvest	1	
		1 to 5pm	4	Harvest and transport back home	1	
	9	6 to 11am	5	Harvest	1	
		1 to 5pm	4	Harvest and transport back home	1	
	10	6 to 11am	5	Harvest	2	
		1 to 5pm	4	Harvest and transport back home	2	
Yield= 5 Kavouch (*200kg) and 4 Kantel (*60kg)=1.24t						

3- Main Farmer C1 in Rain-fed (c) in Kampong Speu Province

Plot 1: 0.88ha, Chmar Prum Variety (LRV), Used Seed: 22kg

Month	Day	Time		Activities	No. of Person	Notice
Jun-15	22	5 to 9am	4	Plough land for nursery preparation	1	Own tractor with 2L of fuel (2L*3000R)
	25	5 to 11am	6	Plough land for nursery preparation	1	Own tractor with 3L (*3000R)
		2 to 4pm	2	Sow	1	

Month	Day	Time		Activities	No. of Person	Notice
Aug-15	21	5 to 11am	6	Plough land for Transplanting	2	Own tractor with 5L (*3000R)
		2 to 5pm	3	Plough land for Transplanting	2	
	22	5 to 11am	6	Plough land for Transplanting	2	Own tractor with 5L (*3000R)
		2 to 5pm	3	Plough land for Transplanting	2	
	24	5 to 11am	6	Plough land for Transplanting	2	Own tractor with 5L (*3000R)
		2 to 5pm	3	Plough land for Transplanting	2	

Due to the delayed rainfall, farmer spent time and money to re-prepare the land for transplanting						
Month	**Day**	**Time**		**Activities**	**No. of Person**	**Notice**
Sep-15	10	7 to 11am	4	Plough land for transplanting	2	Own tractor with 5L (*3000R)
		12 to 4pm	4	Plough land for transplanting	2	
	11	5 to 11am	6	Uproot and Transplant	12	Sharing-hand (11 persons)
		12 to 6pm	6	Uproot and Transplant	12	

Month	Day	Time		Activities	No. of	Notice
Dec-15	16	7 to 11am	4	Harvest	6	Hired 6persons*30,000R
		1 to 6pm	4	Harvest	6	
	17	7 to 11am	4	Harvest	6	Hired 6persons*30,000R
		1 to 6pm	4	Harvest	6	
	19	8 to 11am	3	Transport harvest home	1	2L*3000R
		2 to 5pm	3	Transport harvest home	1	
	20	8 to 11am	3	Transport harvest home	1	2L*3000R
		2 to 5pm	3	Transport harvest home	1	
Because of much rain after transplanting, farmer did not spend time for water management and weeding.						
Yield (1800kg) all for self-consumption						

Plot: 1.98ha, Jasmine Variety (ERV), Used Seed: 60kg Direct Sowing

Month	Day	Time		Activities	No. of Person	Notice
Jun-15	7	5 to 11am	6	Prepare land for nursery	1	Own Tractor with 20L*3000R
	9	5 to 11am	6	Prepare land for nursery	1	
		3 to 5pm	2	Sow (20kg)	1	
	12	5 to 11am	6	Turn-over the soil for transplanting	1	
	14	5 to 11am	6	Turn-over the soil for transplanting	1	
	21	5 to 11am	6	Turn-over the soil for transplanting	1	
	24	5 to 11am	6	Turn-over the soil for transplanting	1	
Because of delayed rainfall, farmer decided to replough the land and apply direct sowing because it was too late for ERV to be transplanted						

Month	Day	Time		Activities	No. of Person	Notice
Aug-15	21	5 to 11am	6	Re-plough the land for DS	2	Own Tractor with 10L*3000R
	22	5 to 11am	6	Re-plough the land for DS	2	
	24	5 to 11am	6	Re-plough and apply DS (1hr)	2	
	25	5 to 11am	6	Re-plough and apply DS (1hr)	2	
Because of much rain after transplanting, farmer did not spend time for water management and weeding.						

Month	Day	Time		Activities	No. of Person	Notice
Dec-15	12	7 to 11am	4	Harvest	9	Hired 9 persons*30,000R
		2 to 6pm	4	Harvest	9	
	13	7 to 11am	4	Harvest	9	Hired 9 persons*30,000R
		2 to 6pm	4	Harvest	9	
	14	7 to 11am	4	Harvest	9	Hired 9 persons*30,000R
		2 to 6pm	4	Harvest	9	
	15	8 to 11am	3	Transport harvests home	1	Own tractor with 4L*3000R
		3 to 5pm	2	Transport harvests home	1	
	16	8 to 11am	3	Transport harvests home	1	
		3 to 5pm	2	Transport harvests home	1	
	17	8 to 11am	3	Transport harvests home	1	
		3 to 5pm	2	Transport harvests home	1	
	20	7 to 11am	4	Harvest	3	Hired 3 persons*30,000R
		2 to 6pm	4	Harvest	3	
	21	7 to 11am	4	Harvest	3	Hired 3 persons*30,000R
		2 to 6pm	4	Harvest	3	
	22	8 to 11am	3	Transport harvests home	1	Own tractor with 3L*3000R
		3 to 5pm	2	Transport harvests home	1	
	23	8 to 11am	3	Transport harvests home	1	
		3 to 5pm	2	Transport harvests home	1	
Yield (4000Kandab, 1000Kandab=1t)=4t, half for self-consumption, half for sale (1kg=1000R)						

4- Main Farmer D1 in Rain-fed (d) in Takeo Province

Plot: 0.05ha and 0.35ha, Saen Sorchey (LRV), Used Seed: 8kg

Plot : 0.05ha Saen Sorchey (LRV)

Month	Day	Time		Activities	No. of Person	Notice
Jul-15	1	6 to 9am	3	Plough the land	2	
	15	7 to 9am	2	Carry and apply fertilizer	2	Cow manure for 5 ox carts
		9 to 9:30am	0.50	Sow	1	
	17	7 to 8am	1	Drain water out of nursery	2	own pumping machine with 1L*3500R
	25	7 to 8am	1	apply fertilizer	2	Cow manure for 2 ox carts
	27	6 to 10am	4	Plough and harrow land	2	Own tractor with 3L*3500R

Month	Day	Time		Activities	No. of Person	Notice
Aug-15	7	7 to 9am	2	Uproot seedlings	4	
		2 to 5pm	3	Uproot seedlings	4	
	8	7 to 11am	4	Uproot and transplant	5	
		2 to 5pm	3	Uproot and transplant	5	
	9	7 to 11am	4	Uproot and transplant	5	
		2 to 5pm	3	Uproot and transplant	5	
No water management and weeding after transplanting because of much water.						

Month	Day	Time		Activities	No. of Person	Notice
Dec-15	3	7 to 10am	3	Harvest	2	
		10 to 11am	1	Carry harvest home	1	
		2 to 4pm	2	Harvest	2	
		4 to 5pm	1	Carry harvest home	1	
	4	7 to 10am	2	Harvest	3	
		1o to 11am	1	Carry harvest home	1	
	5	7 to 11am	4	Harvest	1	
		11 to 12pm	1	Carry harvest home	1	

Plot : 0.35ha Saen Sorchey (LRV)						
Month	Day	Time		Activities	No. of Person	Notice
Jul-15	20	7 to 10am	3	Plough the land	3	Tractor with 3L*3500R
	21	6 to 9am	3	Chase away the duck and chicken and drain water out	2	
	25	6 to 9am	3	Chase away the duck and chicken and drain water out	2	
Month	Day	Time		Activities	No. of Person	Notice
Aug-15	14	6 to 10am	4	Uproot the seedlings	2	
		3 to 5pm	2	Uproot the seedlings	2	
	15	6 to 9am	3	Uproot the seedlings	2	
		4 to 6pm	2	Uproot the seedlings	2	
	16	6 to 9am	3	Uproot the seedlings	2	
		4 to 6pm	2	Uproot the seedlings	2	
	17	7 to 11am	4	Plough the land for transplant	2	By tractor with 3L*3500R
	18	7 to 11am	4	Transplant	5	Hired 3 persons*20,000R
		2 to 6pm	4	Transplant	5	
Month	Day	Time		Activities	No. of Person	Notice
Dec-15	6	7 to 11am	4	Harvest and carry	5	Hired 2 persons*20,000R
		2 to 6pm	4	Harvest and carry	4	
	7	7 to 11am	4	Harvest and carry	3	Hired 2 persons*20,000R
		2 to 6pm	4	Harvest and carry	2	
	8	7 to 11am	4	Harvest and carry	2	
		2 to 6pm	4	Harvest and carry	1	
	9	7 to 11am	4	Harvest and carry	3	
		2 to 6pm	4	Harvest and carry	2	
Yield= (0.05ha=200kg)+(0.35ha=1500kg)=1.7t for self-consumption						

Plot: 0.20ha, Saen Pidao Variety (ERV), Used Seed: 5kg

Month	Day	Time		Activities	No. of Person	Notice
Jul-15	20	6 to 10am	4	Prepare land for nursery and sow	1	Tractor with 2L*3500R
	25	6 to 10am	4	irrigate the nursery and chase away the duck and chicken	1	Owned pumping machine 4hrs=4L*3500R
	26	7 to 10am	3	Check plot and chase away the ducks and chicks	1	
		1 to 3pm	2	Check plot and chase away the ducks and chicks	1	
	29	6 to 7am	1	Irrigate the nursery to be uprooted	1	Owned pumping machine 1hr*3500R
		2 to 5pm	3	Plough the land for transplanting	1	Tractor with 2L*3500R
Month	**Day**	**Time**		**Activities**	**No. of Person**	**Notice**
Aug-15	5	6 to 11am	4	Uproot the seedlings	2	
		4 to 6pm	2	Uproot the seedlings	2	
	6	7 to 11am	4	Transplant	5	Hired 3 persons*20,000R
		2 to 6pm	4	Transplant	5	
	7	6 to 9am	3	Uproot the seedlings	2	
		3 to 6pm	3	Transplant	3	Hired 1 person*10,000R
	8	7 to 12pm	5	Transplant	2	
	18	6 to 9am	3	Weed	1	
		3 to 6pm	3	Weed	1	
	19	6 to 10am	4	Weed	1	
	20	6 to 9am	3	Apply chemical fertilizer	1	10kg (50kg=100,000R)
Month	**Day**	**Time**		**Activities**	**No. of Person**	**Notice**
Oct-15	27	7 to 10am	3	Harvest by own machine	1	Owned machine with 2L*3500R
	28	2 to 4pm	2	Collect and transport harvest	4	
	29	8 to 11am	3	Collect and transport harvest	3	
	30	9 to 11am	2	Collect and transport harvest	3	
Yield=500kg (250kg=200,000R for sale) and Remaining for self-consumption						

5- Main Farmer D2 in Rain-fed (d) in Takeo Province

Plot: 0.25ha, Jasmine Variety (ERV), Used Seed: 7kg

Month	Day	Time		Activities	No. of Person	Notice
May-15	25	7 to 10am	3hrs	Plough the land (Land Preparation)	1	1 person with 2 cows for 25,000R
	26	7 to 10am	3 hrs	Plough the land (Land Preparation)	1	1 person with 2 cows for 25,000R
	27	7 to 8am	1 hr	Apply Fertilizer	1	Urea=5kg*2,300R
	29	7 to 10am	3 hrs	Prepare land (Clean and level the field)	2	
Month	**Day**	**Time**		**Activities**	**No. of Person**	**Notice**
Jun-15	3	8 to 10am	2 hrs	Prepare the nursery (3 hrs) and sow (1hr)	2	
	5	6 to 7am	1 hr	Irrigate the field	1	Rent the pumping machine with fuel provided=1hr=10,000R
	7	6 to 7am	1 hr	Irrigate the field	1	Rent the pumping machine with fuel provided=1hr=10,000R
	10	7 to 8am	1 hr	Apply fertilizer	1	organic
		3 to 5pm	2 hrs	Weed the nursery	1	
	12	7 to 8am	1 hr	Carry the waste to be applied to the field	1	leaves
	14	6 to 7am	1 hr	Irrigate the nursery	1	Rent the pumping machine with fuel provided=1hr=10,000R
	19	7 to 10am	3 hrs	Uproot the seedlings	1	
		3 to 5pm	2 hrs	Uproot the seedlings	1	
	20	7 to 9am	2 hrs	Uproot the seedlings	3	Hired 2 persons*10,000R
	22	7 to 10am	3 hrs	Irrigate the field	1	1hr=10,000R
		2 to 5pm	3 hrs	Transplant	4	Hired 3 persons*10,000R
	23	8 to 11am	3 hrs	Transplant	4	Hired 3 persons*10,000R
	25	6 to 7am	1 hr	Irrigate the field	1	1hr=10,000R
		3 to 4pm	1 hr	Irrigate the field	1	1hr=10,000R
	26	7 to 8am	1 hr	Apply fertilizer	1	Chicken manure
	27	6 to 8am	2 hrs	Weed the field	1	
		4 to 6pm	2 hrs	Weed the field	1	
	28	7 to 8am	1 hr	Carry the waste to be applied to the field	1	Chicken manure
		3 to 4pm	1 hr	Carry the waste to be applied to the field	1	Leaves
	30	7 to 9am	2 hrs	Carry the waste to be applied to the field	1	

Month	Day	Time		Activities	No. of Person	Notice
Jul-15	1	8 to 11am	3 hrs	Weed	1	
	2	8 to 9am	1 hr	Apply fertilizer	1	Chicken manure
	3	9 to 10am	1 hr	Apply fertilizer	1	Carry the waste from home to field
	4	7 to 9am	2 hrs	Weed	1	
	6	8 to 9am	1 hr	Apply fertilizer	1	Carry the waste from home to field
	8	8 to 9am	1 hr	Irrigate the field	1	1hr=10,000R
		3 to 5pm	2 hrs	Weed	2	
	9	6 to 8am	2 hrs	Apply fertilizer	1	Carry the waste from home to field and Urea 5kg*2300R
	10	7 to 9am	2 hrs	Weed	1	
	11	6 to 7am	1 hr	Apply fertilizer	1	Carry the waste from home to field
	13	8 to 10am	2 hrs	Weed	1	
		3 to 4pm	1 hr	Irrigate the field	1	1hr=10,000R
	14	7 to 8am	1 hr	Apply fertilizer	1	Urea=5kg*2,300R
		3 to 4am	1 hr	Carry waste to the field	1	
	15	7 to 8am	1 hr	Apply fertilizer	1	Carry the waste from home to field
	16	9 to 10am	1 hr	Irrigate the field	1	1hr=10,000R
	17	2 to 4pm	2 hrs	Weed	1	
	18	9 to 10am	1 hr	Irrigate the field	1	1hr=10,000R
	20	2 to 5pm	3 hrs	Harvest	2	Hired one person=10,000R
	21	7 to 11am	4 hrs	Harvest	3	Hired 2 persons*10,000R
		1 to 5pm	4 hrs	Harvest	4	Hired 3 persons*10,000R
	22	7 to 11am	4 hrs	Tie up the Harvest	1	
	23	7 to 11am	4 hrs	Tie up the Harvest	1	
	24	7 to 11am	4 hrs	Tie up the Harvest	3	Hired 2 persons*10,000R
	25	9 to 11am	2 hrs	Transport harvest to home	1	
		3 to 5pm	2 hrs	Transport harvest to home	3	Hired 2 persons*10,000R
	28	7 to 11am	4 hrs	Thresh	2	Hired 1 person*10,000R
		1 to 5pm	4 hrs	Thresh	2	Hired 1 person*10,000R
	29	7 to 11am	4 hrs	Thresh	2	Hired 1 person*10,000R
		1 to 5pm	4 hrs	Thresh	3	Hired 2 persons*10,000R
	30	7 to 11am	4 hrs	Thresh	3	Hired 2 persons*10,000R
		2 to 6pm	4 hrs	Thresh	3	Hired 2 persons*10,000R

Month	Day	Time		Activities	No. of Person	Notice
Aug-15	1	7 to 12	5 hrs	Dry the paddy	1	
		2 to 6	4 hrs	Dry the paddy	1	
	2	7 to 12	5 hrs	Dry the paddy	1	
	Yield=40 Thaing*24kg=0.96t=3.84t/ha for Sale 1kg*1000R					1 Thaing=2 Tao 1 Tao=12kg

Plot: 0.25ha + 0.20ha, Korhorm Variety (LRV), Used Seed: 15kg

Month	Day	Time		Activities	No. of Person	Notice
Jul-15	2	6 to 10am	4	Plough land for nursery preparation	1	with two cows=20,000R
	9	6 to 10am	4	Plough land for nursery preparation	1	with two cows=20,000R
		2 to 3pm	1	Sow the seeds	1	15kg
	10	2 to 3pm	1	Irrigate the nursery	1	1h=10,000R
	11	8 to 9am	1	Apply chemincal fertilizer on nursery	1	2kg (Urea)*2500R
	13	7 to 9am	2	Weed at the nursery	1	
		10 to 11am	1	Apply chemincal fertilizer on nursery	1	2kg (Urea)*2500R
		3 to 5pm	2	Weed at the nursery	1	
	15	8 to 9am	1	Irrigate the nursery	1	1h=10,000R
		2 to 3pm	1	Carry waste to apply in the plot	1	
	18	6 to 7am	1	Apply chemincal fertilizer on nursery	1	2kg (Urea)*2500R
	19	8 to 9am	1	Drain water out of nursery	1	1h=10,000R
	21	9 to 10am	1	Apply chemincal fertilizer on nursery	1	2kg (Urea)*2500R
	23	6 to 8am	2	Weed at the nursery	1	
		2 to4pm	2	Weed at the nursery	1	
	25	7 to 9am	2	Apply pesticide	1	1bottle=5000R
		3 to 5pm	2	Weed at the nursery	1	
	30	7 to 8am	1	Apply chemincal fertilizer on nursery	1	2kg (Urea)*2500R
	31	6 to 8am	2	Weed at the nursery	1	

Month	Day	Time		Activities	No. of Person	Notice
Aug-15	10	7 to 10am	3	Uproot the seedlings	1	Seedling for 2 Ploun*10,000R
		2 to 3pm	1	Uproot the seedlings	1	Seedling for 1Ploun*10,000R
	11	7 to 10am	3	Uproot the seedlings	1	Seedling for 2 Ploun*10,000R
		2 to 5pm	3	Uproot the seedlings	1	Seedling for 2 Ploun*10,000R
	12	7 to 11am	4	Plough land for transplanting	2	with 4 cows=60,000R
		2 to 5pm	3	Plough land for transplanting	2	
	13	6 to 11am	5	Level the land for transplanting	1	with 2 cows=80,000R
	14	7 to 11am	4	Transplant	5	Hired 5 persons*20,000R
		2 to 6pm	4	Transplant	5	
	15	7 to 11am	4	Transplant	5	Hired 5 persons*20,000R
		2 to 6pm	4	Transplant	5	
	16	7 to 11am	4	Transplant	2	Hired 2 persons*20,000R
		2 to 6pm	4	Transplant	2	
	18	7 to 9am	2	Apply chemical fertilizer	1	DAP 50kg=150,000R
		3 to 4pm	1	Carry waste to apply in the plot	1	
	20	7 to 10am	3	Weed in the plot	1	
	21	7 to 8am	1	Carry waste to apply in the plot	1	
		4 to 5pm	1	Carry waste to apply in the plot	1	
	23	8 to 10am	2	Apply pesticide	1	1bottle=5000R
	25	7 to 8am	1	Carry waste to apply in the plot	1	
	30	4 to 5pm	1	Carry waste to apply in the plot	1	

Month	Day	Time		Activities	No. of Person	Notice
Sep-15	7	8 to 10am	2	Weed in the plot	1	
		3 to 5pm	2	Weed in the plot	1	
	10	8 to 9am	1	Carry waste to apply in the plot	1	
	13	2 to 3pm	1	Carry waste to apply in the plot	1	
	20	9 to 10am	1	Carry waste to apply in the plot	1	
Month	**Day**	**Time**		**Activities**	**No. of Person**	**Notice**
Oct-15	2	8 to 10am	2	Carry waste to apply in the plot	1	
	10	9 to 11am	2	Apply chemical fertilizer to the plot	1	DAP 50kg=150,000R
	13	2 to 3pm	1	Carry waste to apply in the plot	1	
	18	8 to 10am	1	Apply Pesticide	1	1 bottle=50000R
	23	7 to 8am	1	Carry waste to apply in the plot	1	
	27	4 to 5pm	1	Carry waste to apply in the plot	1	

Month	Day	Time		Activities	No. of Person	Notice
Nov-15	4	7 o 8am	1	Carry waste to apply in the plot	1	
	10	2 to 3pm	1	Carry waste to apply in the plot	1	
	15	9 to 10am	1	Carry waste to apply in the plot	1	
	20	4 to 5pm	1	Carry waste to apply in the plot	1	
Month	**Day**	**Time**		**Activities**	**No. of Person**	**Notice**
Dec-15	10	7 to 11am	4	Harvest	5	Hired 5 persons*20,000R
		2 to 6pm	4	Harvest	5	
	11	8 to 11am	3	Transport harvest home	1	
		2 to 5pm	3	Transport harvest home	1	
	12	7 to 11am	4	Harvest	5	Hired 5 persons*20,000R
		2 to 6pm	4	Harvest	5	
	13	8 to 11am	3	Transport harvest home	1	
		2 to 5pm	3	Transport harvest home	1	
	14	7 to 11am	4	Harvest	2	Hired 2 persons*20,000R
		2 to 6pm	4	Harvest	2	
	15	8 to 11am	3	Transport harvest home	1	
		2 to 5pm	3	Transport harvest home	1	
Yield (0.20ha)=800Kg (self-Consumption) **Yield (0.25ha)=1t (Self-consumption)**						

6- Main Farmer D3 in Rain-fed (d) in Takeo Province

No enough recorded data to be analyzed