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The potential of rice intensification in Paoy Char, Banteay Meanchey province, western Cambodia: Case study in in Trapeang Thma Khang Tboung and Poay Ta Ong Villages

By student:

David Farmer: NDI09068 .....

Leonardo Gueli: ADK08009 .....

Maria Zintl: EMA08021 .....

Rada Kong: EMA 0801 .....

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Abstract

Rice farming has always been essential to the economic and cultural fabric of Cambodian life. Within this context, the study focused on the possibilities and constraints of the intensification of rice production in the rural Banteay Meanchey province and the impacts of intensification methods on the livelihood of local farmers. The rice production systems were identified as rainy season rice, dry season rice, and System of Rice Intensification (SRI), and several issues were investigated: Inputs, credit and marketing issues; impacts of rice production on soil quality; labour and livelihood activities; introduction of SRI growing techniques; irrigation infrastructure and water management.

Inputs for rice production have been rising in use and costs, while revenues are fluctuating. Micro-loan agencies can help build capital although farmers are not aware of them. PH and electrical conductivity values were at optimum levels for rice production, but aluminum toxicity and phosphorous deficiency are problematic. Labour intensity in rice farming is generally high, while the amount of labour depends on cultivation practices. The adoption of dry season rice production does not interfere with other livelihood strategies. The introduction of SRI management practices to the study area by ADDA and ECOSORN has strongly influenced dry season rice production. Insufficient irrigation infrastructure and water management remains a barrier to production.

The potential for intensifying rice production can be found in the increased adoption of dry season irrigated rice cultivation, especially with the application of SRI management practices, whereas conventional methods can contribute little to increasing yields further. However, many constraints can still be found in most of the issues mentioned above. Those need to be overcome for intensification to be truly successful.

1. Introduction—Leonardo main author and Maria co-author

Rice production has been central in Cambodia's long history. From the massive ancient Khmer Empire to the fall of the Khmer Rouge, the rise and falls of kingdoms within the region were always closely tied to the technology, policies, and trends of rice production. Thus, the ability to ensure a constant supply of rice has been the cornerstone towards sustaining the livelihoods of Cambodian citizens.

Despite the importance of rice as a widely consumed staple for the livelihoods of Cambodians, domestic production is far from being outstanding. Cambodia is dwarfed in total annual rice production at 5,995,000 Tons compared to neighboring Thailand at 27,879,000 Tons (FAOSTAT 2007). Cambodia has also been importing more rice than it produces, as the last 20 years have shown a trend of rice imports surpassing exports in Cambodia. Though imports have been cut in half from the 163.300 Tons deficit in the '80s to 80.300 Tons in 2004, this imbalance remains a heavy burden in the Cambodian trade balance currently estimated to be 12.7 million US$ a year (FAOSTAT 2007). If Cambodia is to succeed in erasing this deficit, rice production in Cambodia must rise. This will come at the hands of the rural people of Cambodia, with most to some extent engaged in rice production and around 85% of the cultivated area cropped with lowland rice (O'Brien 1999, cited in SCW 2006).

Rural households rely largely on the rice they can produce, both for their own consumption and as a source of cash income. Finding methods to increase rice yields and assess the potential impacts would be relevant to both helping the livelihoods of rural people and turn Cambodia into a net rice exporter. One of these methods is intensification, or increasing and differentiating inputs to produce more rice on the same land. This is being advocated by development NGOs and the Government alike as a solution towards raising rice production.

One region within Cambodia that could benefit from increased rice production would be the Banteay Meanchey province, due to their low production with one crop of rain-fed rice per year and a yield below the national average at 1.5 t ha. Government organizations and local development projects are attempting to increase rice production within this region using several intensification approaches – namely through cultivating another crop per year during the dry season, expanding conventional rice growing methods, or the System of Rice Intensification (SRI). All of these intensification programs face numerous physical and social constraints.

Water has always been one of the most important factors and constraints towards rice production; it is supplied by a lake and reservoir and appears to be sufficient to allow for a dry season crop to be grown. However, the irrigation canals need restoration and a lack of community organization seems to complicate the proper operation and maintenance of the irrigation scheme. Moreover the hierarchical institutional system appears to be unsuitable in addressing local conflicts over water use.

Increasing yield through conventional methods usually requires an increase in agronomic inputs such as fertilizers, mechanization, and more labour (Koma 2002). Since the farm-gate price of rice has not risen with the cost of many inputs, the profitability of achieving higher yields is questionable (Singh *et al.* 2007). A chance to reduce the amount of inputs such as fertilizer or pesticides lies in an accurate application of the SRI techniques.

SRI management practices are different from traditional rice growing techniques since rice seedlings are transplanted when young, wider spacing between individual plants to allow for vigorous tillering, and rice fields are kept moist but not flooded. Moreover, SRI is based on

the idea that inputs as inorganic fertilizers and herbicides can be substituted by careful and more ecologically sustainable agronomic management practices, such as weeding and manure application (Surridge 2004).

Rice farming, even if the most important economic activities, is not the only livelihood strategy for rural households. Among others, livestock rearing and temporary migration and sale of labour are additional ways to produce food for the household or generate income. Those other activities may compete with rice cultivation in terms of e.g. labour supply and land availability (Shams 2007). Given these constraints, it is not assured that increased rice production is possible and beneficial to the livelihoods of farmers, which is why the impacts and effectiveness of different proposed management systems to increase rice field yields must be analyzed. The identification of the potential for intensified rice production and the impacts of expanding production should be addressed.

Considering all this, the research developed around the following main research question:

What is the potential for intensified rice production in Paoy Char and what are the impacts on the livelihood of farmers?

In addition, several sub research questions have been guiding the investigation:

1. What rice production systems are available in the study area?
2. What are the ecological impacts of these production systems on the soil capacity/quality of the area?
3. What are the common household economic activities aside from rice cultivation, and how will these interact with the adoption of rice intensification?
4. What influences are rice farmers facing from external entities with regard to their production systems? How might these influence the farmers' choices?

2. Methodologies

2.1 Process of research implementation—Maria main author and Leonardo co-author

In order to investigate the potential for intensified rice production in Trapeang Thma Khang Tboung (TTKT) and Paoy Ta Ong (PTO) and its impacts on the livelihoods of farmers, a research plan including a draft timeline and several quantitative and qualitative methods or "tools" was prepared before leaving for the field. The main and sub research questions served as guidelines in the design of the methods. The research design and methods were revised once our Cambodian group members joined us in Phnom Penh and were later adapted to the realities in the field.

To assure that the obtained results were valid and relevant, triangulation of methods, researchers and data were applied. This entailed the use of several methods, teams of researchers, and data gathered to shed light on the same issue.

Apart from the methods described in detail below, numerous tools were applied during our research. Background knowledge was derived from a variety of secondary data. Valid data was also found through observations, informal conversations with local people, discussions with the lecturers and other research teams, and debriefings with the interpreter. The locals also participated, as they voluntarily drew a map of the area for our benefit during one focus group meeting.

2.2 Employed methods and reflections

Sampling methods—Rada main author and David co-author

Through conducting semi-instructed interviews with the village chiefs, the two selected villages were naturally stratified farmers into two groups: Exclusively rainy season rice cultivation (single crop a year) in TTKT and dry season rice with rainy season rice cultivation (two crops a year) in PTO. SRI techniques during the dry season rice became another category. As the main research question focused on the potential of rice intensification and its impact on famers' livelihoods, separation by different rice production systems was the easiest criteria for population (household) stratification.

The ranking of households by wealth in PTO by the ECOSORN project was of great interest to the researchers. 20 households were selected by the project as representative farmers who would be trained in SRI and other techniques. There were four wealth rankings: Rich, medium, poor and poorest (See appendix). The study then sought to find further detail if the adoption of intensified rice production was related to wealth ranking/household resources by interviewing farmers that were part of the program, making the research more qualitative and based on case studies. Three representative farmers from each medium and poor (no representative farmers were poorest) and 3 non-representative farmers from each medium, poor and poorest were purposively selected from PTO, totalling 15 farmers. However, one poor representative farmer was chosen by chance, replacing poorest non-representative farmer who was not available (See table 1).

However, wealth ranking by household did not exist in TTKT. Thus the village chief was consulted based on ECOSORN project criteria to purposively select at least 10 farmers each from rich, medium and poor categories. Then five were randomly selected from each, totalling 15 farmers. This sampling method would unintentionally sabotage the feasibility of statistically analyzing the collected data since the numbers of selected farmers were not

proportionally calculated from the sub-population of rich, medium, poor and poorest. Therefore, the data presented statically in the report assumed that the sample farmers were randomly selected proportioning to its population. For easy comparison, medium, poor, and poorest in PTO were called rich, medium and poor as in TTKT. A farmer from each wealth ranking and 3 from each village was chosen for in-depth interviews, totalling 6 farmers.

Table 1: Number of selected farmers

Village	Households	Selected households			Total
		Rich	Medium	Poor	
Trapeang Thma Kang Tboung (TTKT)	284	5	5	5	15
Poay Ta Ong (PTO)	212	6 (3 rep. farmers)	7 (4 rep. farmers)	2	15

Questionnaire survey—Rada main author and Maria co-author

The data colleted from conducting semi-structured interviews with village chiefs of each village were surprisingly different from the results of the pre-data collection when writing the synopsis. Farming was highly mechanized, inorganic fertilizers were heavily used, and households had many plots that weren't necessarily near one another. The planned questionnaire was revised after many debates since the main and sub-research question(s) were overly ambitious and time was limited.

The revised questionnaire was tested twice with two farmers to familiarize the interpreter and interviewer with the questionnaire survey. This also tested the approximate time used, the relevancy of questions, and the manner of asking. Alternately, the questionnaire consisted only of quick to answer, quantitative questions focused on the whole farm in relation to land size, yield, fertilizer use, production constraints, adoption of SRI and self-food sufficiency (see appendix for more detail).

Time constraints prevented individual plot analysis, resulting in the inability to assess yield and fertilizer use. As suggested by Reardon and Glewwe (2000), farming data should be collected based on plots because it yields more observations and variation that allowed for precise estimations of farm production functions. The whole farm could be calculated from summing individual plots. However, follow-ups using in-depth interview reduced these errors to some extent.

The group was split into three small groups consisting of Danish and Cambodian students. To complete questionnaire on time, the Cambodian student or interpreter were the interviewers while the Danish students wrote the results down. Nevertheless, the Danish students did switch roles as the interviewers to gain valuable learning experience. Some challenges include the difficulty in translating local phrases and measurements that don't have an equivalent in English. Sometimes the information given by farmers was not translated by the interpreter or Cambodian students for the Danish students. A few farmers were unable to recall the amount of fertilizer used, labour used, and yield.

Soil testing—David main author and Maria co-author

Different intensification regimes and methods for rice cultivation will often have very significant effects on local ecosystems, especially by the alteration of the chemical processes that occur within the soil (Kundu and Ladha, 1999, and Savithri, Perumal, Nagarajan, 1999). The timing of submergence, frequency of cropping, and timing/volume of chemical inputs

play a major role in soil nutrient availability and transformation, and thus the enhancement or degradation of a rice cultivation system (Savithri, Perumal, Nagarajan, 1999). Therefore, the study aimed to test the ecological changes caused by dry season (SRI) and rainy season rice cultivation.

To test these ecological impacts of rice intensification, the study focused on the effects of different management regimes on soil nutrients, pH, and salinity. The study aimed to inventory the total amount of Phosphorus, Nitrogen, and Carbon found in the soil. Also, Aluminium content, pH, and salinity will be tested to determine if the soil suffers from Al toxicity, extremely alkaline or acidic conditions, and high salt content that would stunt rice growth (Dobermann and Fairhurst, 2000 and Landon, 1996).

Soil sampling method

3 dry season farmers that practice SRI and 3 rainy season farmers were selected for sampling. Within each group, dry season farmers were selected based on wealth based on Medium, Poor, and Very poor criteria, while rainy season farmers were selected based on Rich, Medium, and Poor. 3 soil samples for each field were taken randomly by walking and digging from the first 10-20 centimeters of the topsoil, where most of the biological and chemical activities take place (Brady and Weil, 2004). A total of 18 samples were taken back to Denmark for laboratory analysis.

C:N Ratio

Due to the inability to effectively determine the amount or the chemical state of useable mineral nitrogen in the soil in submerged field conditions, the study endeavored to determine the total amount of Nitrogen and Carbon by percentrage, formulating a C:N ratio (Dobermann and Fairhurst, 2000 and Kundu and Ladha, 1999). Since a large C:N ratio would hopefully indicate the build up of Soil Organic Matter, while a smaller one would indicate rapid decomposition, the results of the test would indicate if submerged field conditions are helping to resuscitate the health of the soil (Kundu and Ladha, 1999).

The study would use the Dumass Combustion technique through a Mass Spectrometer, giving total %N, %C, and the C:N ratios of each sample.

Phosphorus

Phosphorus is one of the essential nutrients needed for proper rice cultivation (Landon 1996). Phosphorus testing was conducted using the Olsens extraction method using a Aquaquart, colormetric test kit, since the Olsen test is more versatile towards dry soil samples and is effective in measuring available P (Dobermann and Fairhurst, 2000). 5.0 grams of each sample were diluted with 0.5 M Sodium Hydrogen Carbonate, solution adjusted to a pH of 8.0, at a dilution of 1:10 grams to solution. However, some samples were not diluted to the inability to produce visible results. In the subsequent range of values recorded from the test, the first values were used and converted into ppm through multiplying the recorded value by the dilution rate and 5 (Landon, 1996). These were recorded and differentiated accordingly. The threshold values used for the Olsen-P were based from the Booker Tropical Soil Manual, and they are:

High: > 15 ppm of P (Fertilizer response unlikely).
Medium: 15-5 ppm of P (Fertilizer response probable).
Low: < 5 ppm of P (Fertilizer response most likely).

Aluminium

Aluminium toxicity is often a problem in acidic soils, which are ideal for rice soils grown in cultivated soils in Cambodia (White, White, Oberthur, Pheay, 1999 and Landon, 1996). This often causes stunted root growth, and helps to inhibit Phosphorus availability (Dobermann and Fairhurst, 2000). A colometric Aluminium test was conducted using 1:5 dilution with a 1 M KCL solution, using a 1:5 ratio of grams to solution. All values were recorded as mg/L-1, then converted into Al g/ 100g soil by dividing each recorded value by 2 once converted into grams of Al g/ 200g soil. This is due to the dilution rate being equivalent of 200 g soil / 1 L.

The threshold value for Al toxicity is 2-3 me Al / 100g soil (Landon, 1996). This is also equivalent to 5.4 x 10^(-4) g Al / 100 g soil to 8.1 x 10^(-4) g Al / 100 g soil.

pH

Although rice soils are naturally acidic, low pH values and thus high acidity will often result in lower nutrient uptake and help cause Aluminium toxicity at pH< 5.0 (Dobermann and Fairhurst, 2000). PH values are lowered even further during submergence (Dobermann and Fairhurst, 2000). A pH meter with a silicon chip sensor was used to determine the current pH of all 18 samples. Acceptable pH values include the optimum range of 5.0-6.5, with a tolerance range from 4.0-8.0 pH (Landon, 1996).

Electro Conductivity

High EC values indicate a high presence of soluble salts, which inhibit plant growth (Landon, 1996). Under submergence, EC rises even further, reducing the uptake of both potassium and calcium (Dobermann and Fairhurst, 2000). EC measurements were conducted in mS/cm^3 using an Electro Conductivity Meter, and corrected using a multiplier of 3.6, mS/cm^(-1) (Landon, 1996). Threshold levels were determined using the Booker Tropical Soil Manual at saturation extract:

EC < 2 mS cm^(-1): Optimum salinity (Salt Free)
EC 4-8 mS cm^(-1): Yields of many crops restricted (Slightly Saline)
EC 8-15 mS cm^(-1): Only tolerant crops have satisfactory yield (Moderately Saline)
EC > 15 mS cm^(-1): Only very tolerant crops have satisfactory yield (Highly Saline)

Semi-structured interview (SSI)—Leonardo main author and David co-author

During the research work, 12 semi-structured interviews have been carried out. It is possible to divide them in two groups, since the first six interviews had a different function, and have been made at a different time, compared to the other six.

In order to have a general picture of the reality in the area, six key informants have been contacted during the first two days after our arrival. The outlines for the first interviews were prepared beforehand and were thought to include all the different aspects concerning the rice production, from the historical background, to the technical constrains.

The six key informants were selected for their different roles in the villages, in order to show different perspectives on the situation: four were representatives of the farmers, one was the local operator of the ECOSORN/ADDA project, and the last one was a functionary of the Provincial agriculture department.

The first interviewee was our facilitator, a simple farmer that gave us a general idea of the villages reality and the relevant aspects of rice production in the area, moreover he got us in touch with the other relevant informants for the survey. The last three interviews were made with the village chief of PTO and his vice, and the village chief of TTKT, they provided us with a deeper knowledge about the "numbers" of the village: number of household, size of production, adopted techniques, economical activities and possible constrains. The documents, they provided us with, have been of great importance in order to select the households for the questionnaire.

The other two interviewees where request more practical information related to the rice intensification initiatives carried out both by the ECOSORN and by the province. For instance were asked the names of the farmers chosen for the SRI project, the reason behind their selection, the support they were receiving and an opinion on the results the project was obtaining.

In-depth interviews—Leonardo main author and David co-author

After the questionnaires surveys were completed and the data collected painted an informative but broad picture of the situation. To gain a deeper understanding of the situation, in-depth interviews were conducted to collect more details. From the 32 farmers interviewed with the questionnaires, six farmers were selected with three from each village. The selection was based on their production systems: Three exclusively farmed rainy season rice, and three from both the dry and rainy seasons. This would have possibly represented different social status within the two groups.

The outline for the interviews previously prepared were unsuitable due to the differences between farmers in applying the SRI techniques and the others were answered less than what we expected. A new guideline was prepared focusing more on the different ways to produce rice in the last 5 years, the techniques applied, and the difficulties experienced. The study kept the inclusion of the interpreter in the process into consideration while reformulating the new guidelines. This allowed him to understand the motivations that the interviews were based on. The finished guideline was a combination of open questions and fill-in tables towards issues that needed explanation to have a detailed image of all the practical aspects of the rice cultivation activity.

Limitations include the unforeseeable difficulties for the interviewees to understand abstract questioning such as ranking the importance of different economical activities. Possible improvements could include the provision of visual aids to assist comprehension. The group also experienced difficulties while working with the interpreter, whom occasionally dominated the conversation without informing the Danish students.

Regardless, the interviews were extremely informative since it allowed farmers the possibility to give details of their impressions of using the new techniques learnt from the project while expressing the frustration relative to the constrains that they face when applying them. It also allowed them to list other problems as water management or lack of credit at a low interest.

Focus Group Discussion (FGD)—Leonardo main author and David co-author

Two FGDs were organized with one for each village. This was to discover the opinions of farmers about the topics that would have been explored by the successive questionnaires and issues that could have been common in order to avoid focusing too early on individualistic matters. This was to obtain opinions on matters suggested by the farmers themselves, rather

that only on questions imposed by us. Both the groups were composed by 10 people, appertaining to different status and gender and were facilitated by two students.

During these interviews, translation proved to be a problem. Keeping control over a discussion in another language was a difficult task and the contribution of the interpreter and the Cambodian students were fundamental. Two different approaches were tried in the two FGDs. The first was organized in a common space with the Cambodian facilitators synthesizing points discussed on posters, while the rest of the group was observing and taking notes with the translator. In the second FGD, only one of the two facilitators was Cambodian, with the translator asking and translating questions and answers while the farmers actively participated by writing maps.

The group expected the problem of the discussion being monopolized by few influential participants. This obstacle, accentuated by the hierarchical Cambodian culture in terms of roles was present and had only been partially dealt with. The information obtained was still valuable, two calendars of both rice crop varieties and livelihood activities calendar recorded.

Trapeang Thma - Khang Tboung & Poay Ta Ong

Rice - project; Questionnaire survey and soil samples

(Image: ALOS 2005)

Figure 1: Map of studied area and GPS points of questionnaire survey and soil samples

3. Results and discussion

3.1 General facts about the rice production systems—Maria main author and Rada co-author

Rice farmers in Paoy Ta Ong and Tropeang Thmar Khang Tboung cultivate rice on fields located South, East and North of the water reservoir lake. Fields North and South of the lake are currently cultivated only with rainy season rice, while the smaller area in the East is also used for dry season rice cultivation.

During the rainy season farmers grow one crop, choosing early and medium varieties in the area North of the lake and early, medium or late varieties in the area in the South. This is mainly due to the topography of the area, since late varieties are chosen for lower lying land. East of the lake, farmers from Paoy Ta Ong grow dry season irrigated rice, choosing early varieties. Commonly used varieties and their cropping calendar are shown below in Table 2.

Table 2: Local name of common used varieties and its calendar

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 IR 66	-	-

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rice production Σ												
Rainy season rice												
Early varieties												
Medium varieties												
Late varieties												
Dry season rice												
Early varieties												

In Tropeang Thmar Khang Tboung, according to the village chief, farmers cultivate a total of 429 ha of rainy season rice, with around 30 % early and medium varieties, and 70 % late varieties. Currently, farmers from this village only grow rainy season rice. In Paoy Ta Ong, as stated by its vice village chief, farmers own 130 ha of land South of the lake which is cultivated with rainy season rice (RSR), and 32 ha East of the lake used for dry season irrigated rice, the latter roughly corresponding to 32 households growing dry season rice. The number of crops grown during one dry season is two or three, depending on the farmer.

The area cultivated with RSR owned by farmers ranges from up to 80 – 100 ha belonging to the richest of farmers to plots as small as 0.5 ha owned by the poorest of farmers. Plots for dry season cultivation are generally small, ranging between 0.25 ha and 1.25 ha. Yields in RSR are lower than in dry season rice. The average yield after chemical fertilizers have been introduced is 1.5 t/ha, sometimes up to 2 t/ha (MAFF, 2007). Yields have not risen over the last years, even if the amount of fertilizer applied tends to have increased.

In dry season irrigated rice yields are considerably higher than in RSR. This might be due to choice of varieties, management practices and amount of radiation intercepted, among other

things. Typical yields from dry season irrigated rice crops are 4 t/ha (MAFF, 2007), applying nutrients from a combination of manure and inorganic fertilizer, which is giving better results than pure application of huge amounts of chemical fertilizers

Generally, cultivation in the rainy season is less labour intensive than in the dry season. This is, among other things, due to the fact that irrigating the fields regularly is not necessary, as they are simply flooded, and due to certain management practices as for example direct seeding.

Farmers growing RSR usually broadcast seed, around 100 kg per ha, and thus do not use time or hired labour for transplanting. In dry season irrigated rice, agronomic management practices vary from farmer to farmer. As estimated by the vice village chief of Paoy Ta Ong, around 50 % of farmers broadcast seed, while the other 50 % prepare nurseries and transplant seedlings on their irrigated rice fields.

The use of chemical fertilizers and herbicides is more important in RSR cultivation than in dry season rice cultivation. Inorganic fertilizers are generally applied in reasonably large amounts, no one nowadays seems to apply less than typical standard amounts; around 100 kg per ha are applied in RSR, says the vice village chief of Paoy Ta Ong. This is in sharp contrast to practices in the late 1980s, when fertilizer application in Paoy Ta Ong began and amounts as small as 10 kg per ha were applied to the rice fields. Mostly, for the rice fields a 16-20-0 fertilizer, DAP (18-46-0) and Urea (46-0-0) are used.

In dry season rice cultivation, according to the vice village chief of Paoy Ta Ong, farmers mostly combine the use of inorganic and organic fertilizers, with good results for their yields. Typical amounts applied are 50 kg/ha of inorganic fertilizer plus 5 t per ha of animal manure. Before the use of manure was introduced, farmers used up to 250 kg/ha of inorganic fertilizer on their irrigated field, achieving lower yields than with the current practice. Manure is not applied to the fields South of the water reservoir: transport of manure to the fields is made difficult by the distance to the homestead; the application of manure is complicated by the large size of plots and the flooding of the area in the rainy season.

Herbicides are widely applied, especially to fight Kajib (*Pentapetes phoenicea*) and Smout Beak Kbal (*Echinochloa colona*), the main weeds. Insecticides are rarely applied. A pest which is a constraint to rice production is rodents, which are fought by burning the fields when they are fallowed.

Harvesting is done manually, so it is very labour intensive. Animals are used for transporting materials, but not for ploughing; the level of mechanization here is rather high: According to the village chief, the farmers in Tropeang Thmar have 48 hand tractors, 6 threshing machines and 3 tractors of their disposal.

So far, during the dry season the area South of the lake is fallowed and used for grazing or, in a few cases, for the cultivation of water melons. Many farmers claim to be interested in growing dry season rice South of the lake once the canal irrigation system has been restored.

SRI techniques do not seem to be used in the rainy season. In irrigated rice, SRI techniques are applied to a certain extent, but typically farmers will not apply all of the SRI practices. The most commonly used are the selection of pure breed seed, transplanting and the use of organic fertilizer, whereas only slightly more than half of the farmers adhering to SRI techniques transplant their seedlings in rows or take wider and equal spacing into consideration. Comparison could be obtained in Table 3.

Table 3: Range of adoption of SRI principles/techniques

Total number of SRI farmers adopting a certain technique	Specific techniques
13 (100 %)	Pure breed seed, Transplanting, Organic fertilizer like manure or compost
12 (92 %)	Younger seedlings
10 (77 %)	Vigorous seedlings, Shallow transplanting, One seedling per hill, Frequent weeding
9 (69 %)	Keep water level shallow
8 (62 %)	Level soil
7 (54 %)	Transplant in rows, Wider and equal spacing

3.2 Trends in inputs, credit, and marketing—David main author and Rada co-author

Inputs and Prices

The villages of TTKT and PTO have both adopted mechanization and the use of chemical inputs simultaneously since the 1980's in order to cultivate their RSR fields. Rice yields have risen in the past decades, but at the cost of purchasing fertilizers, herbicides, and fuel. Unfortunately, as the farmers are increasingly adopting the use of these methods to cultivate their rice fields, the price of these agronomic inputs have risen sharply. All 30 farmers within both villages listed the high price of inputs as being one of the major constraints towards their rice production systems. Only a handful of the richer farmers were able to generate a profit despite rising costs, while the incomes of the poorer farmers were affected greatly.

Though all farmers except six listed the high fluctuation of prices being a major problem to rice production, the poorer farmers interviewed in both the in-depth interviews and questionnaires often did not have a way or the cash flow to store their rice until the price was high and had to sell to the market at lower prices.

Amongst this backdrop, it would appear that switching to manure as an alternative to purchasing fertilizers is limited. 12 out of 32 farmers bemoaned the lack of manure available as cattle have become increasingly scarce since more farmers moved towards mechanization and spent less time rearing livestock.

Credit

Despite the entrance of ECOSORN and micro-credit agencies such as AMK, Prasac, and others, securing cheap loans is still a major concern. This is especially apparent between the dry season and rainy season farmers, as 6 out of 12 dsr farmers cite the lack of credit as a major problem, while only one rsr farmer cites it as a problem. Even those that do not list the lack of credit as a problem will complain about high interest rates.

Amongst these concerns, two different loan schemes exist: Public and private loans. Several NGOs exist to provide public loans with low interest rates under different schemes. AMK provides individual microloans at 1,000,000 riels per Household, while Prassac gives loans at 800,000 riels only given to farmers that have formed a collective. Both of these loan schemes offer an interest rate of 3%, and have only been established in the past two years. In contrast,

private loans from wealthier farmers at higher interest rates at 5% as well as loans from nearby neighbors and families have commonly been cited as farmers' main source of loans.

Although the village chief claims that farmers on average are applying for public rather than private loans, most of the farmers interviewed that received loans were typically from private sources. Some farmers eschew even the cheaper public loans at 3% due to being too expensive to pay back, and numerous farmers weren't even aware of these NGOs. It would appear from the in depth interviews and questionnaires that farmers are deathly afraid of falling into a debt cycle, where they are poorer than before due to paying interest or even risk losing their land as cited by 3 DSR farmers.

Market

There were two types of traders, internal and external who dealt with paddy rice commercialization. Namely internal traders are local rice mill owners and external traders are middlemen or traders themselves coming from Cambodian-Vietnamese border or Cambodian-Thai border. During feedback meeting, commune chief said it was hard to conclude which one because farmers were so flexible and economic. They would sell paddy rice to whoever will to pay higher price.

The majority of famers sold paddy rice right after harvest at lower price to pay the debt and to invest in other livelihood activities. Only large capital farmers could store haft or over haft of production for later sell at higher price. It was pointless or might be so risky for less resourceful farmers to store the paddy rice in expect to sell at higher while the debt interest was increasing and rice price was not ensured to increase. Price of paddy rice was depending on the cultivar. For example last season 2007/08, the price of rice cultivar were selectively collected and shown in Table 4.

Table 4: Common rice varieties and its price

Rice varieties	Price right after harvest (bath/ton) (December-January)	Price later after harvest (bath/ton) (March-April)
Phkar Romdul Somali Dormalis	7500-8000	9500
Neang Khon Neang Ming Phkar Tnong Phkar Doung Car 8	6000-6500	7000-7500

Note:

Price of individual cultivar within the group can vary little

Exchange rate from bath to US dollar was 0.02882 in Dec-Jan and 0.02818 in Mar-Apr (Source: www.oanda.com)

3.3 Soil analysis—David main author and Maria co-author

C:N Ratio

Although the study did not perform a statistical analysis between the dry season rice (DSR) and RSR crops or between different income levels in terms of C:N ratios, the averages taken for each of the farmer's samples appear to not have any significant difference from each other. All of the field averages have a low C:N ratio, ranging from 9.6-11.0. This is surprising, given that the DSR fields are submerged more often than their rainy season

counterparts, and should have slower decomposition rates and thus more soil organic matter due to anaerobic conditions (Kundu and Ladha, 1999). Also, the fact that the RSR farmers do not add any kind of bulk material to the soil to help build up soil organic matter while all DSR farmers add manure adds to the mystery (Kundu and Ladha, 1999).

The similarities between the C:N ratios could be due to the fact that all farmers sampled add chemical fertilizers to their production systems. Though there is typically a great loss of NO3 during the fallowing period for rainy season farmers, there is still a deal of Nitrogen stored in the soil coupled with the straw that the students have observed being left that could conserve it (Kundu and Ladha, 1999). However, Nitrogen should still be lost from the system due to erosion or pollution, and the above 0.30% nitrogen in the soil of all samples is much larger than the usual 0.15% found in most tropical soils in South East Asia (Brady and Weil, 2004 and Kundu and Ladha, 1999).

The lack of discrepancy might be explained by the dry season farmers having lower C:N ratios than usual. This could be due to both the time of sampling, which wasn't too long after they had applied fertilizer, the use of manure that contains many organic nitrogen compounds that are not easily degraded, and the fact that nitrate mineralizes quickly under submerged conditions (Kundu and Ladha, 1999 and Brady and Weil, 2004).

The C:N test does not differentiate between immobilized or mineralized nitrogen found in the soil (Dobermann and Fairhurst, 2000). Though the results may be similar, the two systems may differ in available nitrogen and nitrogen that is tied up organically, meaning that the total nitrogen found may not necessarily reflect what plants can use (Dobermann and Fairhurst, 2000 and Kundu and Ladha, 1999). Most nitrogen tests rely on nitrogen found in different parts of the rice plant itself, and the test does not express the full story (Balasubramanian, Morales, Cruz, and Abdulrachman, 1999).

Phosphorus

The results from the Phosphorus sampling show some stark differences between the rainy season farmers and the dry season farmers, as well as differences between wealth classifications.

All of the rainy season farmers had low levels of Phosphorus at <5 ppm, while the richest farmer had the highest at 1.7 ppm and the medium and poor farmers were similar at 0.308 ppm and 0.45 ppm respectively (Landon, 1996). This is quite strange, given that the richest farmer only applied 100 kg fertilizer, while the medium farmer applied both manure and 150 kg of fertilizer compared to the poorest farmer, which applied none. This could be due to the medium farmer's fields being deficient to begin with, and needs to keep applying fertilizers or nothing would grow while the other farmers may still have an available phosphorus reservoir.

P-deficiency is not surprising, given that many soils in southeast Asia are deficient, and given the amount of fertilizers that supply massive amounts of nitrogen amongst without any rotational cropping that could re-supply the soil with P, such low rates are not surprising (Dobermann and Fairhurst, 2000 and White et al 1999). Phosphorus also decreases through erosion and prolonged periods of flooding, both of which occur during the fallow and cultivation systems respectively (Dobermann and Fairhurst, 2000).

The medium and poor farmers sampled have sufficient amounts of phosphorus, as they have 7 ppm and 5.5 ppm respectively. Both of these are between the 5-15 ppm classification for medium phosphorus level of classification, while the poorest farmer has a phosphorus level of

2.93, below the <5 ppm deficiency threshold (Landon 1996). The latter's phosphorus deficiency could be explained by the minimal amount of manure compared to her counterparts, as the manure should be able to help build organic material that would act as a phosphorus reservoir (Dobermann and Fairhurst, 2000 and Brady and Weil, 2004). Also, the poorest farmer applies the least fertilizer in both the rainy and dry seasons.

The differences between the two groups could be explained by the fact that flooding will initially result in higher phosphorus availability and mineralization (Dobermann and Fairhurst, 2000). However, a causal relationship cannot be established between fertilizer/manure applications and P availability, as the farmers with the least amount of phosphorus are those that apply the most.

Aluminium

All of the farmers except for Oum Mann face problems with excessive aluminium, as all are either within or above the 0.00054 g Al / 100 g soil to 0.00081 g Al / 100 g soil range. This is surprising, since none of the samples have a pH less than 5-5.5, which usually causes aluminium toxicity (Dobermann and Fairhurst, 2000 and Landon, 1996). Typically, aluminium binds and helps release additional H into the soil solution, lowering the pH even further (Brady and Weil, 2004).

For the rainy season farmers, it is interesting to note that the poorest farmer has the least amount of aluminium, while the poorest farmer in the dry season strata appears to have the largest. In general, it appears that the rainy season farmers have the largest amounts of aluminium in their soils in comparison to the dry season farmers. There appears to be no causal relationship between cultivation and Al toxicity, and it appears strange that yields are stable.

However, the lack of Phosphorus in the RSR fields may be explained by the fact that abundant aluminium binds with phosphorus anions, and creates insoluble compounds that are unavailable to plants (Landon, 1996).

pH

The pH of all the fields sampled had pH levels that were optimal for rice production as they were between 5.0-6.5 pH, although the dry season irrigation fields had the highest on average (Landon, 1996). This is incredibly fortunate for the farmers, as highly acidic conditions will flush potassium out of the system, and lock soluble phosphorus and reduces nitrification (Brady and Weil, 2004 and Landon, 1996).

The dry season farmers had decreasing pH values that matched with decreasing wealth, which also matched the amount of available phosphorus. It also appears that aluminium levels increase as pH decreases, possibly causing the decrease in available phosphorus as well as the aluminium forms complexes (Dobermann and Fairhurst, 2000 and Landon, 1996). However, the same relationship does not exist for the rainy season farmers, as the farmer with the highest pH does not have the highest phosphorus availability and has the highest aluminium levels.

None of the farmers were known to have applied lime and none of the key informants have listed any problems with acidity. However, pH tends to lower during flooding when soils are generally acidic, so while the DSR fields are at their lowest pHs, the RSR farmers may

actually face more acidic conditions when they start flooding their fields (Dobermann and Fairhurst, 2000).

EC

None of the farmers sampled showed any problems with salinity, as all measurements were under the <2 mS/cm^(-1) benchmark (Landon, 1996). The dry season farmers and the rainy season farmers did not have any significant differences in values, as the dry season farmers had an average EC of 0.144 mS/cm^(-1) while the rainy season farmers had an EC of 0.148 mS/cm^(-1). The dry season farmers appeared to have decreasing EC rates according to wealth, while the rainy season farmers' EC contents did not have any relationship in wealth ranking.

Since salinity often increases with over-application of fertilizers as well as flooding, it is odd to see that there weren't any differences between the two cultivation systems, and the fact that the amount of fertilizer or manure applied did not have a relationship with EC content (Brady and Weil, 2004). Given that the soils of this region are not prone to salinity problems, this is hardly surprising (White, et al, 1999).

However, we do not know how much of the salinity is related to sodium versus other sodic cations. An exchangeable sodium percentage test would have been helpful since sodium will often displace potassium and calcium ions on the cation exchange complex, making it a limiting nutrient (Dobermann and Fairhurst, 2000).

3.4 Labour and livelihood activities—Rada main author and Leonardo co-author

Family labour availability

The results from questionnaire survey of family labour availability were shown in Figure 1. The number of family members was almost the same (5.43) in the two villages. However, the amount of labour spent by each family was found to be 1.4 higher in PTO than in TTKT village. This was probably due to the slightly higher number of children (0.51) that were able to help with farm work. It could also be due to the high population of very old people in TTKT. It is not unusual in Cambodia for the poor to have more children than richer families.

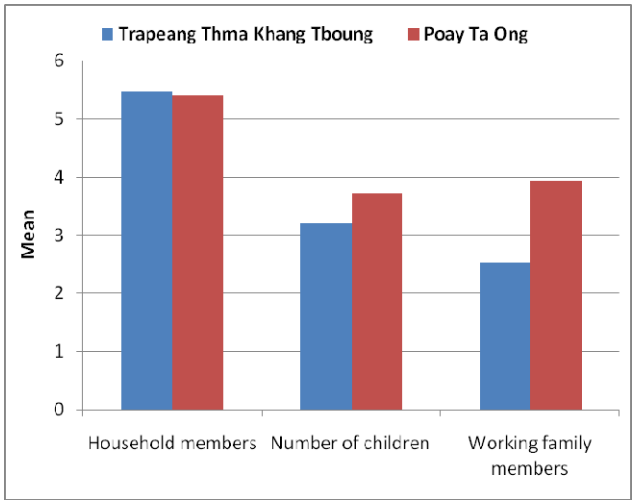


Figure 2: Differences of family labour availability

In relation to social status, there weren't any noticeable differences in the number of family members, number of children, and family working hours between the rich and the medium households (see appendix). Nevertheless, compared to these two groups the poor seemed to have less, and they might be either recently married or widowed families.

Labour requirement of different rice production systems

Labour is one of main production factors in subsistence farming that was not yet replaced by agricultural machineries. Rice cultivation is considered to have a high labour demand although it varies according to the eco-systems of rice production. Table 5 below assessed the labour requirements for DSR following SRI and RSR following conventional techniques. It was assumed that the type of cultivars, either photoperiod-sensitive or not, would have no influence on the labour requirement of a rice production system or management practice.

SRI based DSR required 53.5 labour-days, while conventional based RSR required only 36% of the DSR labour-days. The highest labour demanding tasks were transplanting (20 times higher), weeding (about 10 times higher), nursery and land preparation (about 6 times higher) and organic fertilizer application (5 times higher) from highest to least. However, harvesting demanded 33% less labour in DSR as it typically grows modern photoperiod-insensitive cultivars in which the plant is shorter and remains standing after maturing. This is in contrast to the traditional or improve photoperiod-sensitive cultivars that are commonly cultivated in RSR.

Table 5: Evaluation of required labour for dry season and rainy season rice

Rice production systems	Dry season rice following SRI techniques	Rainy season rice following conventional techniques
Growing techniques	(man-day*/ha)	(man-day/ha)
Nursery, seedling uproot and selection	3	n/a
Land preparation		
- 1st ploughing	1.5	0.3
- 2nd ploughing	1.5	0.3
- Harrowing	1	n/a
Sowing		
- Broadcasting	n/a	1
- Transplanting	20	n/a
Weeding		
- By hand	10	n/a
- By herbicides	n/a	1
- Harrowing**	n/a	0.5
Fertilizer application		
- In organic fertilizers	1	1
- Organic fertilizers	5	n/a
Harvesting	10	15
Threshing	0.5	0.5
Total	**53.5**	**19.6**

Note:

* Man-day was considered for 8 working hours

** Harrowing was done by special designed equipment mainly to reduce seedlings density, but also supplementary tillage and weeding

n/a: non applicable

Labour spent on transportation was excluded

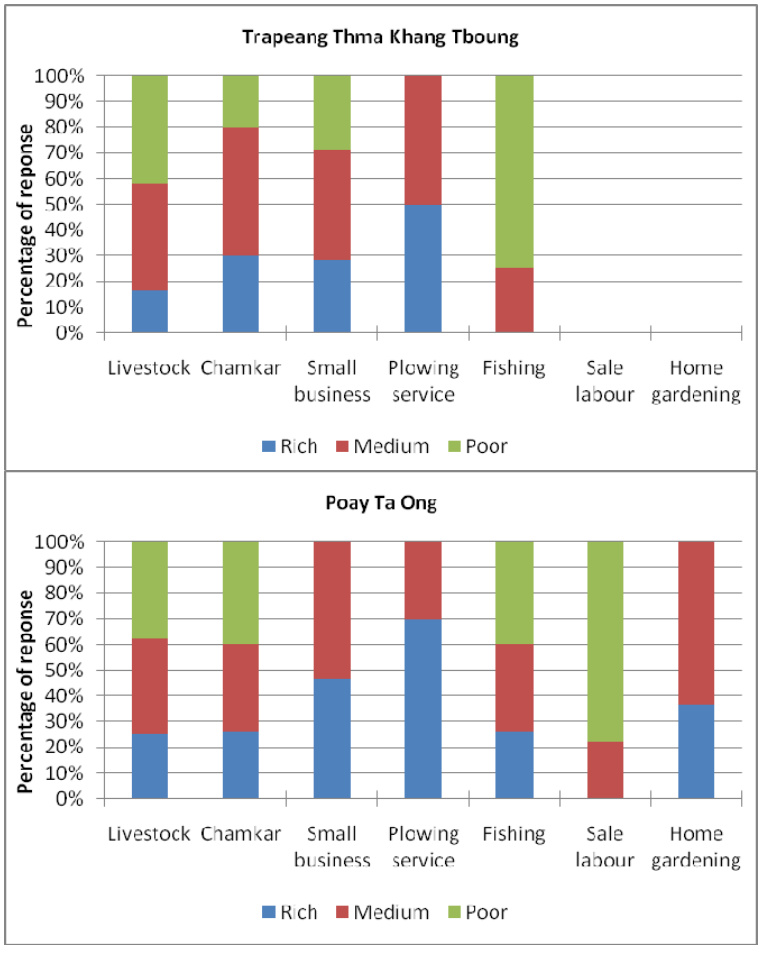
According to secondary research, DSR demanded more manual labour than RSR mainly due to managing irrigation systems and pests, and it will be even more intensive labour if applying SRI techniques. However, if compared with conventional based rain-fed lowland rice where sowing is performed by transplanting instead of broadcasting is more common, following SRI actually reduce considerably labour.

"Cultivating rice through SRI techniques has truly cut down significant labour input since it requires the seed less amount, transplanting in broader space, and less weed population", said by agricultural extension officer.

Likewise, the rice farmers in the southeast of Cambodia who have changed from conventional to SRI techniques appreciate the amount of labour saved. As Uphoff (2007) reported, one of farmers' stated that transplanting time has been cut from 50 to just 25 labour-days. With this amount of labour, family labour alone was sufficient and hired labour was not necessary anymore. However, in this case SRI farmers hired more labour than conventional farmers because of broadcasting and pesticides used. There was no relationship between family labour and rice yield ($p = 0.856$).

Livelihood activities aside from rice production

Farmers' livelihood strategies in both villages were extremely diverse (Figure 3. The farmers did not only grow rice but also perform other activities categorized as livestock, chamkar, small business, ploughing service, fishing, sale labour and home gardening.



Note:

- *Chamkar* referred to multi or mono cropping either on the rice field after harvest or hilly area. The cropping includes food/cash crops (water melon, cassava, mungbean, long bean, seasame, mulberry, and corn), vegetables (egg plant, cucumber, tomato, lettuce, and water spinach), and some fruit trees (mango, jackfruit, and banana).
- *Small business* referred to income sources like grocery sale, credit service, battery recharge service, tractor maintenance mostly for the rich and for the medium there were tailor, rice distillation, house building service, and teacher. The poor normally had Khmer noodle and traditional cake production.
- *Home gardening* referred to vegetables growing nearly home-stay mostly water spinach, herbals and lettuces.

Figure 3: Livelihood activities aside from rice production

One farmer managed to run small businesses on the basis of capital and human resources as described in the box below. Rich farmers owning tractors or handle tractors in TTKT were commonly hired for ploughing. Fishing and labour sale were popular for the poor as it did not have input costs, and home gardening for water spinach was done by the rich and medium in PTO for pig feed, sale and self consumption as well.

The livelihood activities were further analyzed in terms of importance and higher input requirements of labour and cash. The results are shown in Table 6. Rice production was considered by the rich and the medium as the main source of income while demanding the most labour and cash, whereas the poor prioritized off-farm jobs; Namely fishing. The second one was livestock for the medium and the poor while it was the off-farm job service for the rich, which was mostly ploughing.

Table 6: Rank of livelihood activities

Social status	Livelihood activities	Criteria for ranking		
		Income	Labour	Cash inputs
Rich	Rice	****	****	***
	Livestock	*	*	*
	Chamkar and home gardening	**	***	**
	Off-farm jobs including fishing	***	***	****
Medium	Rice	****	****	****
	Livestock	***	****	****
	Chamkar and home gardening	**	**	**
	Off-farm jobs including fishing	*	*	*
Poor	Rice	***	***	***
	Livestock	***	***	***
	Chamkar and home gardening	*	*	*
	Off-farm jobs including fishing	****	****	****

Note:

Numbers of star (*) represented level of importance/amount that **** was the most important or biggest amount.

According to in-depth interview, farmers seemed to put more value in rice production as it was a stable food source and must be done precisely on time. The sudden labour demand during transplant and harvest gave rice farming the reputation for being labour intensive. In fact, labour spent was not high if considering round year time as already shown in Table 5.

“I had 0.5 hectare. I spent only two days, one day for broadcasting and another day for harvesting since I hired tractor to plough and labour to harvest. Actually, I spent most of my time fishing in the big lake”, said by one of poor farmers.

Trapeang Thma Lake has been the main source of water, protein (fishes) and income. Poor households especially depend on fishing. The income from fishing was invested in buying inorganic fertilizers, hired labour, and hired ploughing. Moreover, other expense son health, foods, and children education was due to the income from fishing. Thanks to the protected area and the community fishery, the fish stock has been preserved and there have not been complaints about falling fish stocks or quality.

Various livelihood strategies have allowed farmers to ensure that they were food secure in terms of quality and quantity. All respondents reported that their rice production was sufficient for household consumption; however, 5 out of 30 said that they had to buy or borrow rice from the other due to unexpected circumstances. This extra source of income must have been from other income sources. The combined activities by using common and

private property enabled an optimum utilization of labour within households consisting of men, women and children and the use of natural resources acted as a buffer toward different crises (Sham and Ahmed 1996).

Insignificant interference of intensified rice production

There was an assumption that intensified rice production would take time from other activities within the household such as livestock, home gardening, and/or fishing leading to mono cropping of or specification in rice. This would diminish the diversification of food stuff as well as the overall nutritious value in spite of stable food sufficiency. Through in-depth interview and focus group discussion, the assumption was rejected.

Generally, farmers believed that intensifying rice production did not have an impact on other activities in term of either labour or cash inputs. At least three methods were used to increase rice yield productivity helped them to cultivate on larger area and to save more time for other activities. Those were shifting from animal traction to mechanization, greater amounts of inorganic fertilizers used rather than organic ones to restore the soil fertility, and the application of pesticides to manage the weed and insects.

Growing a second crop in dry season using conventional techniques doubled the amount of labour, and it was even greater with the adoption of SRI techniques. A second crop did take time from other activities, but farmers (Especially the poor) were willing to do so since those activities were mostly seasonal migration to work as field hands along the western Cambodian-Thai border. Furthermore, it kept farmers within the village, allowing them to work on chamkar, fishing, or rearing animal. For those who did not migrate, they were able to adjust and kept performing the activities that they did previously.

"Before growing second crop in dry season, there were about 20 households who sent their family members to work outside the village. Nowadays there remain only a few... and besides working on rice field they could engage in other activities that it would have never been possible", - Chief of PTO village.

Nevertheless, most of respondents reported that labour was the principal constraint in addition to possible damage from rats, cattle, and buffalo in cultivating the second crop in the southern fields once the canal construction finished. The poor were especially looking forward to the completion of the canal whereas the richer farmers would only grow on a small part of their total land or not at all.

3.5 Adoption of the System of rice intensification (SRI), knowledge dispersal and influences from ADDA/ECOSORN- Maria main author and David co-author

Activities of ADDA/ECOSORN in the study area

The most important innovation in rice production in the study area in recent years has been the introduction of DSR production in 2005 and of SRI techniques for agronomic management, put into practice in 2008.

The training in the use of SRI techniques was carried out by ADDA (Agricultural Development Denmark Asia), a Danish NGO, which was contracted by ECOSORN (Economic and Social Relaunch of Northwest Provinces Project in Cambodia), a joint project of the Kingdom of Cambodia and the European Union. ADDA's goals are, amongst others, to facilitate poor farmers to improve their situation themselves, by introducing socially and

ecologically sustainable agricultural projects and promote capacity building to farmers' organisations and agricultural training institutions (www.adda.dk).

Banteay Meanchey was chosen by ADDA for their activities, as it is an especially poor province. The project under the facilitation of ADDA is being carried out since 2008 and until 2010. Selection of farmers in the study villages was conducted by ADDA and ECOSORN and began in 2006, when 20 farmers from each village were selected. Certain selection criteria had to be fulfilled, as disposing of 0.5 to 1.5 ha of land in close proximity to the village, basic means for ploughing and interest in participation. Then 8 farmers were directly trained by ADDA and those were later supposed to train the remaining 12 farmers.

ADDA provides teaching of SRI practices in courses and practical training in applying them. However, inputs such as seeds, tools and even cows have also been provided by ADDA/ECOSORN.

Before being trained, most farmers used "traditional" rice growing techniques and found their own "farmers' best practice" way of growing rice by trial and error.

As a result of the training, some farmers now grow DSR; most farmers seem to consider it an advantage to have rice cultivation as an income source which makes it necessary and possible for them to stay in the village in the dry season.

Picture 1: Demonstrative trial field of SRI based DSR

ADDA/ECOSORN are running some farmers' experiments in the area East of the lake in order to compare the performance of different management practices, such as different spacing, number of seedlings per hill, row planting versus random planting and so on. Moreover, the farmers trained in SRI practices apply these practices to some extent on some of their plots.

Part of the philosophy of the ADDA training is that other farmers can see how their trained neighbours apply the SRI management practices on their fields and the yield these plots give. The farmers who have not been trained are even encouraged to visit the SRI rice fields and judge for themselves about the performance of SRI rice production. The objective is to encourage imitation of SRI management practices by other farmers.

Assessment introduction of SRI to the area and implications for the future

It is far from certain that ADDA's approach is bound to be successful. Indeed, there is also some criticism of participatory extension approaches within the scientific community. One aspect is that it is difficult to interpret communities' reactions to induced agricultural innovations and projects, as it is pointed out by Neubert (2000). Active local involvement in a participatory project might be seen as a way to receive something in return, such as seeds or other inputs, rather than an approval of the project as such. Generally, the introduction of a more labour-intensive management practice, even if it is using resources in a more intensive and sustainable way, is not likely to be accepted easily. Less labour-demanding management practices will most likely be preferred. It is relevant to know under which conditions farmers are willing to adopt more labour-intensive management practices.

This might be the case if resources are becoming more limited and if a market for the products from sustainable intensification exists (Neubert 2000). Generally, the agricultural development strategy of designing farmers' experiments or introducing new agronomic management practices in order to have them copied by other farmers is not always successful. Even if obviously performing well, new management practices, such as for example terracing or row planting, are not always being adopted by farmers due to a lack of interest in changing their old practices.

As far as "self marketing" is concerned, ADDA/ECOSORN have been very successful in the study area; virtually all rice farmers have heard of them and know along general lines what the organisations are working on in the commune. Farmers also seem to be very aware of the possibility to get advice from ADDA/ECOSORN, whereas other extension services seem to be less on-hand for farmers. Other institutions have, however, also provided agronomic training throughout the last years. Still other sources of knowledge are also used by farmers, such as advice from other farmers or, in particular in the case of problems of pests and diseases, information supplied by the sellers of herbicides and pesticides.

SRI has been put into practice very recently; still, most farmers are expressing their satisfaction with its performance. There seems to be a genuine interest in the application of SRI practices itself rather than only in any "additional benefits" that might come from ADDA/ECOSORN, such as the provision with quality seeds.

From our observations as well as communication with farmers, we can conclude that the "copying" of SRI practices by farmers not especially trained in using SRI is at least partly happening. There is an interest for watching what is happening on the SRI fields of the trained farmers and on the experimental plots, asking SRI farmers about practices, buying seeds from them and so on. It is however not so obvious, whether farmers copying certain management

practices are aware of the reasons of applying a specific technique, such as row planting, and the advantages it might give them. Another aspect is that time constraints prevent farmers from applying more time consuming activities such as regular weeding.

According to the local ADDA representative, Tek Monorom, farmers use SRI techniques in the area East of the lake in both dry and rainy season production. Farmers from TTKT have also been trained in applying SRI techniques, but currently no one seems to be doing so in the RSR production South of the lake; according to ADDA it is not clear why this is the case. Many farmers owning plots in the South, however, claim that they will start growing DSR using SRI techniques once the canal system has been restored.

Generally, ADDA/ECOSORN has established themselves as important stakeholders in the study area and appear to have promoted SRI successfully in the East area of the lake. South of the lake, no SRI practices in RSR are applied so far. Whether SRI will be as successful in dry season production South of the lake, where many fields are less easily accessible because they are further from farmers' homesteads, as in the East, will be seen once the irrigation canal system has been restored. A functioning infrastructure is, in this case, a prerequisite for applying the know-how on SRI practices.

3.6 Water irrigation management—Leonardo main author and David co-author

Water management is a critical issue in Cambodia since it is a country that faces a periodic alternation of drought and flood from having a bi-modal rainfall regime and does not currently have the ability to effectively control its hydrological potential.

Historical background of water use

Since rice has always been the staple crop of the nation, all efforts to control irrigation were geared towards maximization of its production. This close relationship between water management, rice production, and Cambodian prosperity is clearly visible throughout Cambodia's history.

The Khmer Rouge regime also believed that an increase of rice production was to be achieved through an extensive control of water supplies. The regime forced most of the population to work in the rice fields, with the goal of growing multiple crops per using a massive irrigation system (Mak, 2001). However the results were disastrous. Most of the irrigation infrastructure built by the regime is now un-useable or useless (Chandler et al 1988, Pijpers 1989 cited in Nesbitt 1997). The irrigation systems within the two villages are examples of this sordid past.

Institutional configuration

Water supplies are currently managed by the Ministry of Water Resources and Meteorology (MOWRM). These organizations control both maintenance of already existing irrigation structures and the planning of new ones. The ministry finances possible projects, and is thus given priority over others connected to the water use such as the Ministry of Agriculture, Forestry and Fisheries (MAFF), or the Ministry of Environment. From the center to the periphery the administration of water issues has a "pyramidal shape", on top there is minister, than the provinces, districts, communes, and finally villages. Any matter is carried out in a hierarchical way that appears to slow down the intervention process.

Present condition of irrigation system in the commune of Paoy Char

PTO and TTKT are in area consisting of an agglomerate of six villages and rice fields situated along the southeastern sides of a modest lake that serves as the only source of water. The main water management infrastructure present is a dam that edges the southern border of the lake. This dam is equipped with a principal floodgate situated in proximity of the south-east corner of the lake and another secondary gate closer to the south-west one. This structure has been recently built in 2004 by a joint Cambodian-Japanese project and is part of a broader plan of restoration of the entire irrigation system of the area, in order to permit the growth of rice during the dry season in the area down the lake. The plan schedules to fix the canal network connected to the dam. Due to the bad condition of these canals, the majority of the rice fields in the area can be utilized to grow rice only during the wet season. The work is still in progress and by the time of the compilation of this report it is impossible to define when the work will be accomplished.

Until the restoration is completed, there is a disparity in the condition of the fields situated in the eastern side from the ones in the south. While the lack of any irrigation permits the south to have only one yield per year, minor canals in the eastern fields allows for dry season cultivation.

The absence of a reliable system of canals that would allow for irrigation during the dry season in the southern fields is considered by the farmers themselves to be one of the main constraints against the intensification of the productivity. In PTO village 7 out of 16 farmers selected for the questionnaires stated that the lack of irrigation is preventing them from growing rice twice a year. In TTKT village the figure is closer to 10 out of 15 farmers, with three of them repeated twice that the lack of control over the water is the main problem, since droughts and floods diminish heavily their productivity.

While the questionnaires were carried out, another issue related to the water management was raised: The conflict with the northern farmers and the problem with utilizing a resource with multiple stakeholders.

Conflicts in water management

Two other villages outside of the study area located in the northern side of the lake, Pongro and Sambour conflict with their southern counterparts in numerous ways. The rice farmers from these villages have the opposite interest in utilizing of the dam, creating what the locals refer to as the “gate conflict”. This issue appears to represent a major constraint to rice cultivation in the area.

The issue was explored through the in-depth interviews with selected farmers, explaining the conflict’s dynamics in detail. Since the dam was built, the lake volume increases drastically from 100 million m^3 up to 170 million m^3 during the wet season. This results in the flooding of the fields situated in the northern area of the lake, caused by the floodgate in the south that, when is kept shut, prevents a natural flow of the water downstream. The farmers from Pongro and Sambour open the gate in order to drain their fields and save their yields, causing flooding to the southern fields and effectively destroying their yields. The situation doesn’t have a compromise, since both groups risk losing the entire seasonal yield.

Six farmers have been interviewed and all of them accuse the Pongro and Sambour villagers of compromising the production in the southern fields. When asked how to solve the situation the answers given ranged widely. Ourm Mar, village chief of Paoy ta Ong, declares that his

only possibility is to report the fact to the commune chief in Paoy Char, since is the only institutional figure having power over the issue. Nine floods have been reported to the commune chief in the last 4 years, but it seems that no concrete initiative has been taken in order to address the problem.

The other farmers are divided between those that want action, such as blocking the water in excess using wooden poles, and others that only complain the inefficiency of the political initiatives. Either the communal chief doesn't have an effective power to control the illegal flooding, or he allows it to happen.

This conflict is one of the largest constraints towards rice intensification. Even when the canals are completed, the issue of involuntary flooding would ruin yields regardless of what system is used. Also, there doesn't appear to be any kind of community organization that can settle this issue. This problem may remain chronic, and if this issue is not resolved, then farmers may not be willing to invest in intensification schemes during the rainy season if the risk of a ruined crop is too great. However, this does not effect dry season irrigation since the flooding only occurs during the wet season.

4. Conclusions—all group members

The issues that surround rice intensification in the villages of TTKT and PTO are as complex as they are legion. Although most of the ecological, financial, technological, and knowledge infrastructure exists for further dry season and SRI cultivation, numerous barriers can still prevent farmers from utilizing these resources and hamper their potential for intensifying their rice production schemes.

In the fields south to the lake, intensification using conventional methods cannot be expanded any further since any additional application of fertilizer, herbicides, or other chemical inputs is unlikely to increase yields. Mechanization through the use of tractors and hand tractors is frequently used; still, there is potential for further mechanization in transplanting or harvesting.

Further intensification of rice production can be accomplished by expanding dry season rice cultivation and the use of SRI practices into the fields south of the lake. This can be accomplished once the canal systems in the southern fields are completed, while training and financial resources are readily available thanks to ECOSORN and multiple micro-loan agencies.

Expanding intensification through dry season irrigation and SRI face many challenges however. Farmers are heavily reliant on chemical inputs that have been increasing in price throughout the decade, while rice prices fluctuate wildly. Despite manure being the recommended nutrient source for SRI, the increase in mechanized farming has resulted in the drop in cattle rearing, making manure scarce.

SRI was found to be more labour intensive due to transplanting, the amount of weeding, and other time consuming activities in comparison to rainy season cultivation. Also, only families that are large could perform SRI effectively, while smaller families would rather rely on mechanization.

There are various water management issues involving the irrigation systems both east of the lake and south of the lake. The canal system east of the lake does not have an effective community management strategy, despite attempts in the past by the community and

government organizations, although ECOSORN is willing to try again using a different scheme. Because of this, inappropriate timing of flooding is a frequent problem for farmers downstream since farmers north of the lake will release water prematurely to drain their own fields. Coupled with the fact that only one side of the canal will be completed in the southern section of the lake, water management will continue to be an issue towards rice cultivation, much less intensification.

Micro-credit has only become recently available in the area, and despite the offer of lower interest rates in comparison to private loans, many of the farmers found the interest rates to be too high while most had no knowledge of what agencies were available. Also, despite the availability of knowledge provided by ECOSORN by the effects of chemical inputs, most farmers receive information on chemical application through industry salesmen, and have no knowledge of the environmental effects of using these inputs.

Despite all this, there are still some strengths. Farmers have multiple streams of income through different livelihood strategies, and none of these other than migrant labour are disrupted by the adoption of SRI.

Soil conditions, though facing problems with Al toxicity and phosphorus deficiency, are ideal in pH and EC for growing rice and neither method of production appears to create any significant changes in the soil chemistry of the fields. Given that there is no difference between the C:N ratios found for of the production methods either, it appears that intensification through DSR or SRI will not have a negative effect on the soils.

Knowledge dissemination through the use of ADDA/ECOSORN was found to be very effective in training and spreading information on SRI techniques, as farmers would observe the representative farmers and follow by example. Consequently, SRI practices are likely to be further established in the area.

These factors greatly affect the potential for intensification of rice production in the study area. While there is not a future for further intensification with conventional methods, the study found that the potential for increased rice production lies in the expansion of DSR cultivation and the implementation of SRI practices. Despite the wide range of resources available for intensification, many issues in terms of community water management, knowledge dispersal, market prices, and the increase in labour still need to be addressed in order to truly take full advantage of the potential for intensification. Once these challenges are addressed, the villages of TTKT and PTO can fully realize their vast potential and bask in the multitude of benefits for intensifying their rice production systems.

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Appendices:

Appendix 1: Synopsis

Synopsis
On

The potential of rice intensification in Poey Char,
Pnom Srok, Banteay Meanchey Province, Western Cambodia

Proposed for field study in SLUSE course 2009

Supervisors:

By student:

David Farmer: NDI09068

Maria Zintl: EMA08021

Leonardo Gueli: ADK08009

Rada Kong: EMA 0801

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Introduction

Rice production has been central in Cambodia's long history. From the massive ancient Khmer Empire to the fall of the Khmer Rouge, the rise and falls of kingdoms within the region were always closely tied the technology, policies, and trends of rice production. Thus, the ability to ensure a constant supply of rice has been the cornerstone towards sustaining the livelihoods of Cambodian citizens.

Despite the importance of rice as a widely consumed staple for the livelihoods of Cambodians, domestic production is far from being outstanding. Cambodia is dwarfed in total annual rice production at 5,995,000 Tons compared to neighboring Thailand at 27,879,000 Tons (FAOSTAT 2007). Cambodia has also been importing more rice than it produces, as the last 20 years have shown a trend of rice imports surpassing exports in Cambodia. Though imports have been cut in half from the 163.300 Tons deficit in the '80s to 80.300 Tons in 2004, this imbalance remains a heavy burden in the Cambodian trade balance currently estimated to be 12.7 million US$ a year (FAOSTAT 2007).

If Cambodia is to succeed in erasing this deficit, rice production in Cambodia must rise. This will come at the hands of the rural people of Cambodia, with most to some extent engaged in rice production and around 85 % of the cultivated area cropped with lowland rice (O'Brien 1999, cited in SCW 2006). Rural households rely largely on the rice they can produce, both for their own consumption and as a source of cash income. To find methods to increase rice yields and assess their potential impacts would be relevant to both helping the livelihoods of rural people and turn Cambodia into a net rice exporter on the world stage. One of these methods is intensification, or using more inputs to produce more rice in the same land, which is being advocated by development NGOs and the Government alike as a solution towards raising rice production.

One region within Cambodia that could benefit from increased rice production would be the Banteay Meanchey province, due to their low production with one crop of rain-fed rice per year and a yield below the national average at 1.5 t ha^{-1}. Government organizations and local development projects are attempting to increase rice production within this region using several intensification approaches – namely through cultivating another crop per year during the dry season, expanding conventional rice growing methods, or the System of Rice Intensification (SRI).

All of these intensification programs face numerous physical and social constraints. Water has always been one of the most important factors and constraints towards rice production, and is supplied for the region from a lake and reservoir that appears to be available in sufficient amount to allow for a dry season crop to be grown. However, the irrigation canals currently need restoration and a lack of community organization seems to complicate the proper operation and maintenance of the irrigation scheme. Increasing yield through conventional methods usually requires an increase in agronomic inputs such as fertilizers, mechanization, and more labour (Koma 2002). Since the farm-gate price of rice has not risen at the same pace as the cost of many inputs, the profitability of achieving higher yields is questionable (Singh, Ekanem, Tegegne, and Muhammad 2007).

Rice farming, even if the most important economic activity, is not the only livelihood strategy for rural households. Among others, livestock rearing and temporary migration and sale of labour are other ways to produce food for the household or generate income. Those other activities may compete with rice cultivation in terms of e.g. labour supply and land availability (Shams 2007).

Given these constraints, it is not assured that increased rice production is possible and beneficial to the livelihoods of farmers, which is why the impacts of each proposed system must be analyzed as well as the effectiveness of different management systems in increasing rice yields. The identification of the potential for intensified rice production and the impacts of expanding production need to be addressed. Therefore the study proposes the following questions to determine what rice systems currently exist, the capacity of the villages to intensify their rice production systems, and the effects of adopting rice intensification systems and methods on the livelihoods of the farmers.

Research questions

Main research question:
What is the potential for intensified rice production in Poey Char[1] and what are the impacts on the livelihoods of farmers?

Sub research questions:

1. What rice production systems are available in the study area?
2. What are the ecological impacts of these production systems on the soil capacity/quality of the area?
3. What are the common household economic activities aside from rice cultivation, and how will these interact with the adoption of rice intensification?
4. What influences are rice farmers facing from external entities with regard to their production systems? How might these influence the farmers' choices?
5. Do farmers meet their personal food consumption needs from their livelihood activities? How do their current and perceived food consumption needs influence their intensification decisions?

Historical context and background of study area

Cambodia's historical empires were deeply tied with their ability to develop infrastructure towards mass-producing rice. One of the reasons for the massive political and economic development of the Khmer Empire was due to the construction of an impressive network of canals that freed the production from the irregular monsoon seasons. The increase and stabilization of food production was lost when the canals fell into disrepair due to war and negligence, thus bringing the end of the Khmer Empire (Mak, 2001).

Though reliable production data during the dark ages is non-existent, rice again assumed a central role during the colonial period. The French planned to develop export rice and used two systems of cultivation. On one hand, large-scale rice plantations were built, controlled by the French settlers, with the fields irrigated by new canals and linked to Phnom Penh by railways. On the other hand, the traditional methods where left unchanged for local people that were forced to pay high colonial taxes with their crops.

After achieving independence in 1953, the government assumed control of the formerly French plantations and improved the irrigation systems. During the 1960's, rice production and export reached an all-time peak, also thanks to the education program promoted by the government. The Khmer Rouge regime (1975-'79) forced most of the population to work in the rice fields, with the goal of growing multiple crops per year through a massive irrigation system (Mak, 2001). The results were disastrous: With over a million dead of exhaustion, starvation, disease and execution, with production never surpassing or even reaching the peak of 1964. This failure can be to a large extent to the attributed to the total lack of knowledge in canal planning and building, resulting in most of the irrigation infrastructure built by the regime being unusable or useless (Chandler et al 1988, Pijpers 1989 cited in Nesbitt 1997).

After the fall of the Khmer Rouge, agriculture was organized on a collective basis and technical training was promoted in the universities. Today, according to FAO, 69% of Cambodian Share of total Dietary Energy Supply is composed by rice.

The Banteay Meanchay province in particular was hard hit by the Khmer Rouge reign, as it was the site of repeated attacks from Khmer Rouge Guerillas decades after they had been invaded by Vietnam. Within this historical context, the study will take place in two villages within the underdeveloped province, Trapeang Thma Tboung and Paoy Ta Ong. Within this area, yields are lower than national average and are representative of the province as a whole. The effects of the past, especially the legacy of the Khmer Rouge, reverberate in the region even today.

[1] Poey Char is the name of commune within Cambodian administrative

Research Paradigm

In answering the main research question, several terminologies must be defined in order to focus the research to increase validity and accuracy. The research is further narrowed down by identifying five key research sub questions that will yield the necessary information to answer the main research question.

Definitions

The livelihoods of people in rural Cambodia have been dependent on subsistence rice-based farming systems for millennia. According to the literature review, there is a tendency to produce rice not only for household consumption but also for the domestic and export markets. For commercialization, intensified rice production systems have been adopted to increase land productivity. Land productivity refers to soil quality, defined as the present capacity of a soil to produce a crop yield under a defined set of management practices. This is measured in terms of rice yield in relation to the production inputs (Gupta 1999).

Intensification is operationally defined in relation to rice production in a broad sense, meaning the achievement of increased production of rice on a given area of land with the term "intensification" not specifically related to certain techniques, but a variety of production methods and systems. Examples of intensification methods can encompass enhancing cropping management, increasing land utilization, and raising production inputs such as organic fertilizer, in-organic fertilizer, mechanization, labor and high yielding varieties for increased land productivity (Koma 2002). Another method of intensification is the System of Rice Intensification (SRI) that has been introduced and widely disseminated in developing countries, recognizing that rice production is essential in the agricultural sector. SRI consists of intensive labor requirements for rice cropping management with the intent of increasing land productivity as well as soil quality (Tech 2004).

The potential for intensified rice production can be defined as the incentives for and consequences of limits to increasing production. This includes the analysis of what is technically possible, what is profitable, what is the influence of political factors and what is the ecological impact. Looking at the impacts on the livelihoods of farmers, the study would assess the effects of diverting resources towards an increase in rice production might have on the way farmers "make a living" and the positive and negative influence it might have on each of the farmers' livelihood assets (Shams 2007).

What rice production systems are available in the study area?

To analyze the potential of intensifying the rice production systems within the Banteay Meanchey province, the study must first assess what is currently available and practiced. This can help provide a window into certain production systems given local physical, social, and economic constraints. This will also create a snapshot on the technical and resource capacity for intensification, as well as possibly identifying the current varieties of rice being grown and their nutritional value.

What are the ecological impacts of these production systems on the soil capacity/quality of the area?

In order to get an insight into the ecological impacts of the different rice production systems, the study will assess the nutrient characteristics of the soils and the quality of the water. These will include indicators such as soil nutrient status, nutrient loading of the water and water pollution from pesticides and fertilizers in order to determine the current status of their natural resource inventories, and if these intensification systems are being degraded by comparison of the different systems.

What are the common household economic activities aside from rice cultivation, and how will these interact with the adoption of rice intensification?

Household economic activities can be defined as any sort of work that brings benefit to the welfare of the family. This for example can include livestock rearing, non-farm jobs that bring additional revenue, gathering fish for personal consumption, or the planting of other crops. The study endeavors to identify how intensifying rice production will assist or compete with the amount of time, land, and labour given to these activities.

What influences are rice farmers facing from external entities with regard to their production systems? How might these influence the farmers' choices?

Farmers often make decisions based not only on the capacity of their resources, but also on the external factors that influence the breadth of their choices. Within the study area, various organizations such as the European Union project ECOSORN and the local government may be competing to promote different methods of intensification. Available infrastructure such as the irrigation canals and the capacity to use it in a socially effective matter can also be a major influence in farmers' decision to intensify.

The current dynamics of the current rice market also play a role in influencing the practices being adopted by farmers. The demand for and prices for rice, the fluctuating prices and supply of different agronomic inputs, and other market factors are as important as the capacity of farmers' lands to produce rice. Demand is not only determined by the quantity of rice, but the quality as well as preferences for certain cultivars.

The study will analyze the farmers' relationships to these external entities and their impacts on the choices available to them and thus the potential for rice intensification.

Do farmers meet their personal food consumption needs from their livelihood activities? How do their current and perceived food consumption needs influence their intensification decisions?

Food security will be operationally defined as the condition of satisfying basic nutritional needs with a readily secure and affordable supply of food at all times (See FAO 2003 for comparison). This can be assessed on an individual scale to determine the nutritional needs and wants through the analysis of the accessibility and affordability of food that is needed for a balanced diet. The study can also identify the effects of increasing rice intensification on the amount of income spent on other food items and subsequently the time spent on growing other crops (Shams 2007).

Concerns and Constraints

There are several constraints and concerns that the study faces in conducting this research project, both in practicality and research content. Time would be one of the most daunting constraints, as the study will only be conducted for two weeks and may not be long enough to perform all of the proposed research tasks as well as being unable to answer all of the sub questions effectively. Among other issues, the water quality issue may have to be abandoned, as well as identifying the nutritional quality of different rice varieties that the farmers have a possibility of cultivating.

Cultural difficulties can also be quite daunting. The study cannot ask certain questions directly and therefore cannot ascertain direct answers that would be needed for the project. Most of the answers received will have to be interpreted based on the researcher's assumptions or the assumptions of the translator, both of which may be inaccurate to varying degrees.

Other concerns could include the disinterest of farmers in rice intensification for different reasons other than those that we listed, and could very well derail the project. Some farmers may not even be interested in being farmers but have no other choice. Also, farmers may face conflict with local authorities that take care of the local protected areas that encompass the lake that supplies the water that would be used for DSR cultivation.

Methodologies

The study aims to investigate the potential for intensified rice production and its impacts on people's livelihoods and food security for the region. The five sub-research questions will specify the research scope and guide research methodology. With numerous study constraints, especially time, a number of both qualitative and quantitative methods will be used according to the advantages of each approach and the data needs of above research questions. Participatory village mapping will be performed to understand the resource availability, land use, and provide a snapshot of the landscape.

Additional support will derive from the results of semi-structured interviews that seek information of historical land use, household economic activities, various types of rice production systems and the natural and social resources in the village. Moreover, semi-structured interviews will identify possible constraints for intensification such as the restoration of the canal system that utilizes

the water from the lake within the protected area, market demand, price fluctuation, and the influence of external entities including rice-mill owners, agronomic inputs suppliers, and development projects as well as rice intensification policies either belonging to the government or development agencies.

After creating the village map that divides the boundaries of each rice production system area/land use/landscape (SRI, small and big scale conventional rice, dry season irrigated rice...etc) and understanding the history, growing techniques and timing of the rainy season, a small scale questionnaire will be conducted by sampling farmers in each area to identify household economic activities aside from rice production, to analyze the interaction/the competition of these activities on the adopting rice intensification. The questionnaire will also assess the economic performance of each rice production system and the impacts of rice intensification on food security. In-depth interviews will be conducted with farmers that best represent the different strata among the sample to identify their perceptions and opinions of each production system and the potential to intensify their rice production systems. The impacts of rice intensification on soil quality and possibly on water quality will be studied by taking samples from the fields of the farmers selected for the questionnaires and in-depth interviews.

Integrating these methods by utilizing their own distinct advantages in data quality will hopefully increase the reliability and validity of research because "the multi-method approach allows findings to be corroborated or questioned by comparing the data produced by different methods" (Denscombe 1998:85) and the opportunity to demonstrate the findings in explanative, explorative, descriptive and correlative way. Furthermore, it allows each research group member to address their individual expertises in applying each method and critically analyzing the complexity of rural society. This will allow each research group member to learn from each other and their specific skills, following the pedagogy of the SLUSE program.

Data collection and methods used

The table below explains the methods used, data needed, and the type of respondents that would answer the sub research questions, with the results subsequently answering the main research question.

Table 1:

Sub research questions	Methodology	Data needed	Respondents
1. What rice production systems are available in the studied area?	- Semi-structured interviews - Secondary sources - Independent/particular observations - Village mapping (GPS)	- Climate conditions and natural resources, infrastructure - Demography, market for agricultural products, land use, infrastructure - Evolution of rice cultivation - Household economic activities	- Provincial agriculture department - ECOSORN project staff - Village chief - Older villager(s) - Other development agencies if available
2. What are the ecological impacts of these production systems on the soil capacity/quality of the area?	- In-depth interview - Observations - Soil sampling and testing - Water sampling and testing	- Amount and types of inputs - Historical land use - Soil samples (soil structure, texture, fertility) - Water samples (nutritional load)	- Questionnaire farmers - In-depth interview farmers
3. What are the common household economic activities	- Semi-structured interviews - Secondary sources	- List all the household economic activities all around the year	- Selected sample farmers - Village chief

aside from rice cultivation, and how will these interact with the adoption of rice intensification?	- Small scale questionnaires - Observations	especially besides rice cultivation - The proportion of each activity to household income - The correlation and interaction among activities - Rice yields - The constraints of rice production	- Old villager(s)
4. What influences are rice farmers facing from external entities with regard to their production systems? How might these influence the farmers' choices?	- Small scale questionnaires - In-depth interviews - Semi-structured interviews	- Current local government and NGO programs - Effects and mandates of local government and NGOs - Perception and opinions of the farmers on rice intensification and towards external actors - Rice market demand - Nutritional value of rice grain	- Questionnaire farmers - In-depth interview farmers - Provincial agriculture department - ECOSORN project staff - Other development agencies
5. Do farmers meet their personal food consumption needs from their livelihood activities? How do their current and perceived food consumption needs influence their intensification decisions?	- Small scale questionnaires - In-depth interviews	- The sufficiency of rice production for household consumption - The affordability and supply of food products unavailable on site.	- Questionnaire farmers - In-depth interview farmers

Sampling methods

Purposive sampling method will be applied to select key informants for semi-structured interviews including representatives of the provincial or district agriculture departments, the ECOSORN project and the village chief. Hopefully by snowball sampling, we can identify other key informants once in the field. The combination of random and stratified sampling will be used in selecting respondents for small scale questionnaire survey. The sample for small scale survey can be range from 30 to 250 (Denscombe 2007). To fit within the time frame and limited resources, the smallest number of samples acceptable will be 30, and randomly selected after stratification. Three farmers from each stratum will be purposively selected for semi-structured/in-depth interview. Soil samples will be taken from one or two field(s) of the same three farmers.

Data analysis

The responses from semi-structured interviews and in-depth interviews will be recorded and categorized for analytical purposes. This will be followed by qualitative interpretation of the data. All unusual and unpredicted data trends will be highlighted for further investigation. The data from GPS will be downloaded and used to produce village map using ArcGIS to visually represent the cultivated areas under different rice production systems. The responses from small scale questionnaire will be coded and entered in Microsoft Excel, and will be exported to and analysed using the Statistical Package for the Social Science (SPSS V.14).

Time line

The time line below will be modified with the counterpart student in Cambodia according to the changes of research design and research instruments.

Table 2: Timeline

N^{o}	Date	Activities	Duration (day)
1	4-6/3/09	Working with counterpart students in Cambodia at RUA to agree on and finalize the research design, research instruments, and prepare to go the field	3
2	7/3/09	Making appointments with ECOSORN staff and provincial/district agriculture departments, or possibly interview them right away	1
3	8-9/3/09	- SSI with local representative, village chief, and interested farmers - Exposure to the village, participatory observation, village resources, land use, landscape - Mapping the village and land use by GPS - Identify respondents for questionnaire survey	2
4	10/3/09	Visiting other groups	1
5	11-13/3/09	Conducting questionnaire survey SSI with ECOSORN and agriculture department staff, or probably other NGOs staff there	4
6	14-(16)/3/09	SSI/in-depth interview with best representative farmers Taking soil samples	2
		Total	**13**

Note:

- Every evening all group members will have a meeting to share the information and their analysis on the situation
- All responses from SSI/In-depth interview will be noted down and briefly analyzed

Ethical consideration

The research will be carried out, to the best of our knowledge, a high ethical standard without causing any harm. The intention is to have the informed consent of the participants of our study with regards to conducting our research and they will be guaranteed confidentiality. The aim is to treat potentially sensible topics with care and respect. Hopefully, the findings of the study will be informative to rice farmers in our study area.

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Appendices

Draft of semi-structured interview guideline

Village chief:

1. How and when was the village was settled?
2. How many households are there? Male and female? Do you notice any rapid increase of the population in the last 10 years?
3. What economic activities are people doing in your village? Can you rank them in order of importance?
4. How many different types of rice production systems exist in your village? (SRI, dry season irrigation, rainy season, large scale mechanization)?

- Please rank them based on cultivated area and
- The number of HHs doing more than one rice production system, and the reasons they can do it (capital, water resource, labor, machinery, land size…etc)

5. Do you notice any shifts to certain types of rice production systems compared to the past? Any particular trends throughout the village? If yes, what, when, how and why?
6. Do you notice any changes in rice growing techniques (Increased use of agro-chemical application, machinery—handle machinery for soil preparation, threshing machine, more broadcasting, less transplanting)? If yes, what techniques are now being used? When have you first noticed them being implemented? Do you know why the villagers are using them?
7. What is the average productivity (yield) of each rice production system? Is it higher than the past? If yes, why? (increase chemical fertilizer, pesticides, management, new varieties…etc)
8. What are the constraints of rice production, for instance technical constraints, lack of credit and financial capital, or the lack of irrigation infrastructure?
9. How do farmers sell their products? Through middlemen, traders, or sell directly to rice millers?
10. Where can farmers access to the credit? Micro-credit, relatives, private owner?
11. What do farmers use their rice fields for after harvest for in dry season? Fallow/grazing?
12. What is the average farming land size (min and max)?
13. What kind of land ownership document do the most farmers hold? For example, do they have documents showing their own land (For example, land title, land certificate, and transfer documents)? Are they tenant farmers? Are they mostly in debt?
14. Do the farmers growing rice depend entirely the rainfall or supplementary irrigation water?
15. When were the irrigation canals constructed? By whom and how has it been used up to now?
16. Is there any initiative to restore the irrigation canals?
    If yes, by whom (community, NGO, government…etc)? If not, why (conflict with protected area to keep the around the year in the lack? Lack of cohesiveness of the villagers in sharing the resource?)
17. Are there other natural resources that farmers rely on for their livelihood (pond, lake, flooding forest…etc for fish, firewood, and non timber products)? Are these public land or are they private?

18. What activities of provincial/district agriculture department exist to improve rice productivity as well as people's livelihood?
19. Are there any NGOs working in the village? Who are they?
20. What are they working on? How have they helped with increasing rice production?
21. What do you think that the farmers can increase the productivity of their fields in the future?

ECOSORN coordinator/staff:

1. When was the project started in Banteay Meanchey?
2. Why was the area/the province selected for the project?
3. What has the project currently been doing, what have they done in the past, and what will be done in helping farmers to intensify their rice production?
4. How many villagers are now in the project? What criteria do you use to select them?
5. What benefits (Economic and social) do the farmers see from the project?
6. What is the system of rice intensification (SRI)? Can you briefly describe it?
7. What is the intent of the project in introducing these techniques farmers?
8. Is it difficult to get farmers to participate in the project? Why? What are the barriers that farmers face in adopting these practices?
9. To what degree do the farmers follow the SRI principles? Please explain in detail how farmers are applying the SRI principles.
10. What are the difficulties in applying these cultivation techniques? What do the farmers say are the most difficult to put into practice?
11. Were there any changes in terms of rice yields, farmer incomes, and ecological impacts that occurred in following the adoption of SRI principles? If so, what were they? Were these the changes are you looking for?
12. What is the farmers' perception of the effectiveness of the SRI techniques? What do you believe shaped their viewpoints?
13. When SRI was introduced, were there special climatic, environmental, socioeconomic considerations of its introduction to the region? What were they?
14. Is the success of introducing SRI being evaluated in an ongoing basis? How is it being evaluated? Who is doing the data collection and analysis?
15. Compared to other regions in Cambodia, does the SRI cultivation perform well in Banteay Meanchey?

Provincial/district agriculture department:

1. What kinds of rice production systems, including SRI, large scale conventional, dry season irrigation, and lowland rainfall, are currently being used in the Banteay province? Can you tell us how many households are under each system, and the average estimated area size of each?
2. When famers are determining which system and techniques to adopt, what criteria, limitations, and opportunities (ecological and economical) do they consider? Is this universal for the province?
3. Were there any changes in the composition of rice production systems since the last 10 years? If yes, what are the general trends, when did the changes occur, how and why?
4. Were there any changes in the growing techniques of each rice production system? If yes, what did they switch to and when did they adopt them? How did they adopt them and why?
5. What are the average rice productivities (In kg, min and max) for rain-fed, dry season (irrigated), and SRI rice systems?
6. Have rice yields increased compared to the past 10 years? What do you think has caused this? Why do you think this has occurred?
7. What activities/projects have been performed in the past to increase rice yields? Have any of these projects been successful in improving the farmers' livelihoods? Why or why not?
8. Do any NGOs collaborate in the activities/projects so far? What have they changed since they started working there? Do you find their interests competing with the government?
9. What do the farmers usually use the rice field for after harvest (Livestock rearing, use of different crops, ect?)
10. What are the constraints in increasing/intensifying rice production—technical, financial…?
11. How effective can the implementation of dry season rice production (irrigated rice cultivation) and SRI be in intensifying rice production?
12. What is the perception of farmers about SRI? Those that have not adopted it? Those who have?
13. What kind of land ownership documents do the farmers in the region typically hold? Do they have any documentation?
14. What are other main economic activities that farmers perform besides rice cultivation? Do you find that most farmers try to find jobs off the farm to supplement their income?

In-depth interview guideline

Farmer:

1. What type of system would you define yourself as using? Do you use a combination of different systems and techniques? Which ones do you do, and why do you do them?
2. What has changed in your land (Soil quality, productivity, ect) since you have adopted your current system (SRI, conventional large scale, dry season irrigation) and techniques?
3. What do you do aside from rice farming for the household? How much do these activities contribute towards buying enough of the food you need?
4. How have your daily activities changed since you've adopted your rice intensification system? Did you find yourself having to buy food that you once grew or collected? Are you happier since you have adopted this system?
5. Have you been contacted by NGOs who wanted to help intensify your rice production systems and improve your yields? What did they say they would do for you? Have you found them helpful?
6. Have you heard of any government programs that would help you intensify your production? Which programs have you heard of? What did these programs do? Have you found them helpful?
7. Who would you want to sell your rice to if you had a choice, and who do you believe would give you the highest price? Does anything prevent you reaching them?
8. Does your production system face water shortages? Why do you face water shortages?
9. Does anything prevent you from using the canal? If so, what then would need to be done to allow you to use it?
10. What type of rice do you sell? Why did you choose to grow and sell that rice (Prices, easier to grow, suggested by others)? Do you grow types of rice for your own consumption that is different from the ones you sell? Why?
11. Where did you find financial support to assist you in adopting your current intensification system? What was the interest? Was it easy to get, and was it dependable? What would you have done differently?

Draft questionnaire for small scale survey

The potential of rice intensification in Poey Char commune

Village: ……. Code: ……
Interviewer: …….. Questionnaire N^0: ……

Introduction of research group

We, a group of students from both the University of Copenhagen, Denmark, and the Royal University of Agriculture, Cambodia, study corporately the potential of rice intensification and its impacts on people's livelihood. We kindly ask you to participate in the questionnaire survey. Your answers will confidentially be kept anonymous.

Rice production system

□ a. Rainy season rice □ b. Early season rice □ c. Dry season irrigated rice

□ d. Floating rice □ e. SRI □ □ f. Other (please specify).....

I. Background information

1.1 Name (Optional):	1.2 Gender: Male □ Female □	1.3 Role in HH: .....
1.4 Education: a. Illiterate □ b. Primary □ c. Secondary □ d. High school e. University □		
1.5 Children: a. 0 □ b. 1-2 □ c. 3-5 □ d. >5 □		
1.6 Household members: a. 1-3 □ b. 4-6 □ c. >6 □		
1.7 How many members of the HH work on the rice field?		
1.8 How many HH members work on farm?		
1.9 How many HH members work off farm?		

II. Rice production

Plots

2.1 How do you use your plots throughout the year?
Plot 1:
Size:

a. Months	b. Grown crops/other use	c. Yield (t/ha)	d. Cultivation system and variety
....	....	....	....
....	....	....	....
....	....	....	....

Plot 2:
Size:

a. Months	b. Grown crops/other use	c. Yield	d. Cultivation system and variety
.....	....	....	....
.....	....	....	....
.....	....	....	....

Plot 3:
Size: .....

a. Months	b. Grown crops/other use	c. Yield	d. Cultivation system and variety
.....	....	....	....
.....	....	....	....
.....	....	....	....

 Note: More plots will be noted in notebook

2.2 What is your main rice production system?

Production System : ……

Irrigation

2.3 How much does your rice production depend on irrigation?

 a. I do not use irrigation

 b. I use irrigation during the dry season

 c. I use irrigation in the rainy season

 d. I use irrigation all year round

2.4 If you use irrigation – do you irrigate it yourself or do you hire someone to do it or does some administrative institution like the local government do it?

 a Myself b I hire someone c Administration..... d Other .....

2.5 If sufficient water was available throughout the year, would you cultivate a second crop?

why or why not?...

Fertilizer

2.6 Do you use fertilizers and what fertilizers are you using? □ No □ Yes

□ a. Inorganic fertilizers *(insert name of locally used inorganic fertilizer)*

□ b. Organic fertilizers

□ c. Inorganic and organic fertilizer

□ d. No fertilizers

If yes why?

….....
.....

(Possible follow up questions for researchers: wanting a higher/guaranteed yield, no organic f available, organic f of low quality, field too large to use organic f, field too far away from homestead to use organic f)

2.7 If you use inorganic fertilizer:

- What kind of fertilizers do you use? .....
- How long have you been using it?

1. Last year □ 2. 2-5 years □ 3. 6-10 years □ 4. >10 years

- How many bags/kilos are you using per hectare/plot? .....

If you use inorganic fertilizer, how has this changed your yield as compared to the past?

.....

Pesticides

2.6 Do you use pesticides and what pesticides are you using? □ No □ Yes

□ a. Inorganic pesticides *(insert name of locally used inorganic fertilizer)*

□ b. Organic pesticides

□ c. Inorganic and organic pesticides

□ d. No pesticides

If yes why?

….....
.....

(Possible follow up questions for researchers: wanting a higher/guaranteed yield, no organic p available, organic f of low quality, field too large to use organic p, field too far away from homestead to use organic p)

2.7 If you use inorganic pesticides:

- What kind of pesticides do you use? .....
- How long have you been using it?

1. Last year □ 2. 2-5 years □ 3. 6-10 years □ 4. >10 years

- How many ml/kg are you using per hectare/plot? .....

If you use inorganic pesticides, how has this changed your yield as compared to the past?

.....

Tillage

2.9 How do you plough your soil?

□ a animal traction □ b handle ploughing machine □ c tractor □ d other

2.6.1 Do you own it or do you borrow or hire it?

□ a Own □ b borrowed □ c hired □ d Other.....

2.6.2 If mechanized ploughing, how long have you been using mechanical ploughing?

□ a. Last year □ b. 2-5 years □ c. 6-10 years □ □ d. >10 years

2.6.3 What are the main reasons you started using it and did it work the way you expected it?

Expected outcome		Actual outcome
□	Save time	□
□	Save labour	□
□	Ease of work	□
□	Cheaper	□
□	I work more land	□
□	Others	□

Production system

2.7 Have you changed your production system (SRI, 1 crop, double crop) during the past 10 years? □ YES □ NO

2.8.1 Why did you choose the current rice production system?

.....
.....

2.8.2 Was it promoted by government or NGOs? □ Yes □ No

If yes, please mention the name .....

2.8.3 Is it more profitable than other systems? □ Yes □ No

2.9 What are the main constraints in your rice production? Please score from 1 to 5 which 1 is the least constraint and 5 is the most constraint.

N^0	Major constraints	Score				
		1	2	3	4	5
1	Lack market					
2	High fluctuation of price					
3	High price of inputs, eg. chemical fertilizers					
4	Poor soil fertility					
5	Lack access to water (climatic shock)					
6	Lack of capital or access to credit					
7	Lack of growing techniques/extension worker					
8	Lack of compost and manure					
9	Diseases, pests....etc					
10	Other (please specify).....					

III. If using the SRI cultivation practice:

3.1 When did you start growing SRI?

□ a. Last year □ b. Last 2 years □ c. Last 3 years □ d. > last 3 years

3.2 Why do you decide to follow SRI principles? Please name the 4 most important reasons!

□ a. Some subsidy on inputs

□ b. Tempting to increase the productivity

□ c. Able to sell at higher market price due to organic certification/identification

□ d. Want to join the association to get techniques training

□ e. Want to join the association to get cheaper and easier interest credit service

□ f. More negotiating power on selling price

□ g. I was selected by the ECOSORN project for doing the SRI.

□ h. Others, please specify.....

3.3 To which extent do you follow SRI principles? Please score from 1 to 5 which 1 is the most and 5 is the least

N^0	SRI principles	Score				
		1	2	3	4	5
1	Growing healthy, vigorous and younger seedlings					
2	One seedling per hill					
3	Wider and equal spacing					
4	Shallow transplanting, just 1-2 cm deep					
5	Frequent weeding					
6	Avoiding flooding, improve soil aeration					
7	Organic fertilizer like compose and manure					
8	Other.....					

3.4 Do you notice any changes after following SRI principles? Please score from 1 to 5 which 1 is the least constraint and 5 is the most constraint.

N^0	SRI principles	Score				
		1	2	3	4	5
1	Yield increase					
2	Sustain/Improve soil fertility					
3	Higher price					
4	More accessible to techniques dissemination					
5	More accessible to credit					
6	Other……..					

IV. Labour and expenditure

Please state the amount of labour in rice production…

Rice production Σ	1.....	2.....
Varieties		
Yield (t/ha)		

Price (riel/kg)						
Time	Labour	Amount	Cost	Own labor	Hired labor	Cost
Land preparation						
Nursery						
Transplanting						
Harvesting						
Threshing						
Sheaving						
Pesticides application						
Inorganic fertilizers application						
Organic fertilizers application						

Note: If there are more one rice production system, note down into the note book

4.2 Please rank the relative importance of the different activities by put 1 is the most important

Name the most important activities your household is engaged in (like rice production, animal rearing, off-farm labour, fishing, vegetable production...). Then rank them according to their contribution to well-being, labour/time-demand, cost of inputs, estimated income.

Activities	Criteria		
	Income (estimates)	Labour	Input

V. External entities, potentials of rice intensification and food security

5.1 Who do you sell the rice to? (can be more than one, please rank 1 is the most frequent)

a. Money lenders □ b. Rice-mill owner □ c. Traders □ d. Middle men □ e. Other.....

5.3 Is your rice production sufficient to feed your household throughout the year?

□ a. Yes, my rice production is enough for household consumption

□ b. Yes, my rice production is enough to buy food throughout the year

□ c. No, how long (months)? a. 1-2 □ b. 3-4 □ c. 5-6 □ d. >7 □

5.2 Do you see the necessity to intensify rice production?

□ a. NO. I am currently not interested in increasing my production

□ b. YES. To supply sufficient household consumption

□ c.YES. To sell rice and thus increase cash income

□ d. Other: .....

5.4 What animals do you have and what do you use them for? Rank in order of importance of animals, 1 is the most important.

Animal	Number	Rank	Purposes
Cattle	.....		□ a. Capital asset □ b. Traction □ c. Plough service □ d. Selling □ e. Transportation services f. □ Other: .....
Buffalo	.....		□ a. Capital asset □ b. Traction □ c. Plough service □ d. Selling □ e. Transportation services f. □ Other: .....
Pigs	.....		□ a. Income sources □ b. Consumption □ c. Income source and consumption □ □ e. Other: .....
Chicken	.....		□ a. Income sources □ b. Consumption □ c. Income source and consumption □ □ e. Other: .....
Ducks	.....		□ a. Income sources □ b. Consumption □ c. Income source and consumption □ □ e. Other: .....
.....	.....		.....

5.5 Do you consume food not produced on your farm? How much?

□ a. None □ b. 10-30% □ □ c. 40-60% □ d. 70-90% □ e. 100%

Thank you very much for participation. I really appreciate your time!

Soil sampling data collection sheet

N0	Farmer's name	Farm code	Soil type	Physical characters				Chemical characters					
				Texture	Structure	Colour	Depth	pH	OM	N	P	K	EC
1													
2													
3													
4													
5													
6													

Appendix 2: Village wealth ranking criteria (ECOSORN, 2007)

A-Village wealth ranking criteria

Criteria	Better	Medium	Poor	Poorest
Type				
Food	Enough rice to eat and sale	Enough rice to eat whole year	Rice shortage 4- 6 months	Rice shortage more than 6 months
Land(land sized)	More than 4 ha	2-4ha	0,5-1,5ha	0-0,5ha
Rice yield	More than 100 Thang	65-100 Thang	30-65 Thang	Less than 30 Thang
Asset Cow and buffalo	More than 5 heads	3-5 heads	1-2 head	No
Transportation	1 car/ 2 motorbikes	1 motorbike & 2 bicycles	1-2 bicycles	0-1 bicycle
Tractor & hand tractor Other engines	1 tractor or 1 rice milling	1 hand tractor or 1 battery charge	No	No
House	Wood or brick with tile roof	Wood with tin or fibro roof	Straw, thatch house with bamboo or wood floor.	Small thatch house (Khtum)
Labor	Have money to hire the people for work	Sometime have money to hire the people to work	Sale labor	Sale labor
Credit	Have money or rice to lend to the other	No need to borrow money or rice. Have enough money to spend for the whole year	Borrow money or rice from the others	Borrow money or rice from others, difficult access to credit.

Appendix 3: Checklist questions for focus group discussion

Trapeang Thma Khang Tboung village

1. Can you show us where generally the rice field of this village are? Supported by map
2. Do you notice any change for the last five year or even later on
    - rice production systems and growing techniques?
    - agricultural machineries such as tractor, handle tractor, threshing machine...?
    - production inputs: fertilizers, herbicides, insecticides, used amount...?
3. What rice varieties do you prefer to grow? Is there any determination for own consumption and market supply?
4. What is your average paddy rice yield, minimum and maximum?
5. Do you have any access to any irrigation? If yes, from when and how it is operated?
6. When the canal is ready, will you prefer to grow rice in dry season?
    - If not, what are the constraints?
    - If yes, do you know about system of rice intensification techniques?
7. What are the constraints of your rice production systems?
8. Is water pollution a problem in your area?
9. What do you think you can do to increase the productivity?

Poay Ta Ong village

1. What rice production systems are available?
2. Could you tell and help us to draw the calendar of each rice production systems?
3. What livelihood activities are you doing a side from rice production?
4. Could you tell and help us to draw the calendar of each activities?
10. Do you notice any change for the last five year or even later on
    - rice production systems and growing techniques?
    - agricultural machineries such as tractor, handle tractor, threshing machine...?
    - production inputs: fertilizers, herbicides, insecticides, used amount...?
5. What do you know about system of rice intensification?
6. Why do you decide to be representative farmers? How can it be?
7. What training have you received then?
8. Any change regarding yield, cost, income, soil fertility after adoption SRI techniques?
9. What are the most difficulties to adopt SRI techniques?
10. Can you access to irrigation system? How is it?
11. Is there any problem with irrigation system? If yes, what are the solutions?
12. What are the constraint of your rice production?

Thank very much for your time and active participation!

Appendix 4: Revised questionnaire survey

Draft questionnaire for small scale survey

The potential of rice intensification in Poey Char commune

Village: ……. Code: ……
Interviewer: …….. Questionnaire N^0: ……

Introduction of research group

We, a group of students from both the University of Copenhagen, Denmark, and the Royal University of Agriculture, Cambodia, study corporately the potential of rice intensification and its impacts on people's livelihood. We kindly ask you to participate in the questionnaire survey. Your answers will confidentially be kept anonymous.

III. Background information

1.1 Name (Optional):	1.2 Gender: Male □ Female □
1.3 Household members: a. 1-3 □ b. 4-6 □ c. >6 □	
1.4 Children: a. 0 □ b. 1-2 □ c. 3-5 □ d. >5 □	
1.5 How many members of the HH work on the rice field?	

IV. Rice production

Rice production system

□ a. I grow rice in rainy season

□ c. I grow irrigated rice in the dry season

□ d. I apply SRI techniques

□ e. Other.....

Plots

2.1 How big is the area of your rainy season rice field?.....Own Borrow.....

2.2 Where is this land located in relation to the lake?

□ a. North □ b. East □ c. South

2.3 How big is the area of your dry season rice field? ..... Own Borrow.....

2.4 Where is this land located in relation to the lake?

□ a. North □ b. East □ c. South

2.5 How big is your total agricultural land (including Chamkar)? .....

2.6 Rainy season rice field:

Yield	Chemical fertilizers	Manure/compost	Insecticides/	Herbicides
.....	Yes No All the fields: Y N Amount	Yes No All the fields: Y N Amount	Yes No All the fields: Y N Amount	Yes No All the fields: Y N Amount

Do you use the field to grow other crops or fallow or grazing or other thing after harvesting?
.....

2.7 Dry season rice field:

Yield	Chemical fertilizers	Manure/compost	Insecticides/	Herbicides
.....	Yes No All the fields: Y N Amount	Yes No All the fields: Y N Amount	Yes No All the fields: Y N Amount	Yes No All Fields: Y N Amount

Do you use the field to grow other crops or fallow or grazing or other thing after harvesting?
.....

Tillage

2.7 How do you plough your soil?

□ a animal traction □ b handle ploughing machine □ c tractor □ d other

2.6.1 Do you own it or do you borrow or hire it?

□ a Own □ b Borrowed □ c Hired □ d Other.....

2.8 I will mention some possible constraints about rice production? Please answer Y N or DN

N^0	Major constraints	Yes	No	Do not know
2	High fluctuation of price			
3	High price of inputs, eg. chemical fertilizers			
4	Poor soil fertility			
5	Lack access to water			
6	Lack of access to credit			
7	Lack of extension worker			
8	Lack of compost and manure			
9	Diseases, pests....etc			
10	Other (please specify).....			

III. If using the SRI cultivation practice:

3.1 When did you start growing SRI?

□ a. Last year □ b. Last 2 years □ c. Last 3 years □ d. > last 3 years

3.2 Were you trained by ADDA/ECOSORN about SRI techniques? □ Yes □ No

3.3 Why do you decide to follow SRI techniques?

.....

3.4 To which extent do you follow SRI principles? Please score from 1 to 5 which 1 is the most and 5 is the least

N^0	SRI principles	Yes	No	Do not know
1	Pure breed			
2	Leveling the soil			
3	Transplanting in rows			
4	Vigorous and younger seedlings			
5	One seedling per hill			
6	Wider and equal spacing			
7	Shallow transplanting, just 1-2 cm deep			
8	Keep the water level shallow			
9	Frequent weeding			
10	Organic fertilizer like compose and manure			
8	Other.....			

3.5 Do you notice any changes since started adopting SRI techniques comparing before?

N^0	SRI principles	Yes	No	Do not know
1	Increase the yield			
2	Improve soil fertility			
3	Higher price of rice			
4	More accessible to techniques dissemination			
5	More accessible to credit			
6	More labor intensive			
7	Other……..			

3.6 Please list the activities that you do besides the rice production

Activities

V. Food security

5.1 Who do you sell the rice to? (can be more than one, please rank 1 is the most frequent)

□ a. Only own consumption □ b. Rice-mill owner □ d. Middle men

□ e. Other.....

5.2 Is your rice production sufficient to feed your household throughout the year?

.....

5.3 Would you like to grow second or third rice crop a year?

.....

Thank very much for your time and active participation !

Appendix 5: Revised in-depth interview guideline

In-depth interview guideline

Farmer:

1. From last time, you gave us a list of non-rice activities that you do for your wellbeing. Can you rank them according to importance (1 being the most important)?
   (like rice production, animal rearing, off-farm labour, fishing, Chamkar...)

   Can you rank them according to income? Labour hours per day? Costs of inputs?

Non-Rice Activities 2003	Criteria		
	Income (estimates)	Labour	Costs of inputs

Non-Rice Activities 2008	Criteria		
	Income (estimates)	Labour	Costs of inputs

2. How has your rice production system changed since 2003-2008?

Rice production Σ	2003	Why?	
Varieties			
Yield (t/ha)			
Price (riel/kg)			
Varieties	2008	Why?	
Yield (t/ha)			
Price (riel/kg)			
Activities	Labour hours? Expenses? 2003		Labour hours? Expenses? 2008
Land preparation (Ask about info about methods)			
Nursery/Direct Seeding			
Transplanting/Broadcasting			
Harvesting (Ask about info about methods)			
Threshing			
Sheaving			
Herbicides application			

(Ask about the amount of material they use)		
Inorganic fertilizers (Ask about the amount of material they use)application		
Organic fertilizers application(Ask about the amount of material they use)		

3. (SRI) Have you found that changing your rice production system to SRI takes time away from other activities? Which activities did it take time away from?
4. Have you heard of any government programs that would help you intensify your rice production? Which programs have you heard of? What did these programs do? Have you found them helpful?
5. Are you selling immediately after the harvest? Do you have the possibility to store it until the price rises? If not, what would you need?
6. Does your production system face Irrigation problems from the farmers up river? If yes, what do you feel is the solution?
7. (If farmers have land in the south) Will anything prevent you from using the canal? If so, what then would need to be done to allow you to use it?
8. What type of rice do you sell? Why did you choose to grow and sell that rice (Prices, easier to grow, suggested by others)? Do you grow types of rice for your own consumption that is different from the ones you sell? Why?
9. Are you ever without enough rice to eat within your household?
10. Where did you find financial support to assist you in adopting your current intensification system? What was the interest? Was it easy to get, and was it dependable? What would you have done differently?
11. Have you ever visited an agricultural extension officer? Can you visit one? If not, what keeps you from visiting an agricultural extension officer?

Thank very much for your time and active participation!

Appendix 6: Done activities in the field

Done activities	Respondents
Questionnaires	15 with farmers in TTKT, 15 with farmers in PTO
Semi-structured interviews	1, village chief of TTKT 1, village chief of PTO 1, vice village chief of PTO 1, ADDA local representative 1, extension officer 1, local facilitator of rice group
In-depth interviews	3 with farmers in TTKT, 3 with farmers in PTO
Focus group discussions	1 with farmers in TTKT, 1 with farmers in PTO
Soil samples	3x3 on dry season rice fields, 3x3 on rainy season rice fields

Appendix 7: Results of soil analysis

- **pH, EC (mS/Cm), Al (mg/l), P Olesen (ppm)**

Name	Plot	pH	EC (mS/cm)	Al (mg/l)	Al (Alg/100g soil)	P Olesen (ppm)
RSR						
Yon Tol (Rich)	1	5.4	0.04	3	0.0015	0.7
	2	5.16	0.05	6	0.003	4
	3	5.23	0.04	6	0.003	0.4
	Mean	5.26	0.04	5	0.0025	1.7
Poat Dan (Medium)	1	5.15	0.05	6	0.003	0.4
	2	5.18	0.04	6	0.003	0.225
	3	5.27	0.03	6	0.003	0.3
	Mean	5.2	0.04	6	0.003	0.308
La Lov (Poor)	1	6.77	0.06	0.1	0.00005	0.55
	2	5.23	0.03	2	0.001	0.4
	3	5.36	0.03	3	0.0015	0.4
	Mean	5.78	0.04	1.7	0.00085	0.45
DSR						
Long Horm (Rich)	1	7.09	0.11	0.1	0.00005	7
	2	5.34	0.05	3	0.0015	7
	3	6.2	0.04	0.1	0.00005	7
	Mean	6.21	0.067	1.07	0.000533	7
Oum Mann (Medium)	1	5.41	0.04	3	0.0015	4
	2	5.87	0.05	0.1	0.00005	5.5
	3	5.76	0.01	0.5	0.00025	7
	Mean	5.68	0.033	1.2	0.0006	5.5
Logn Yen (Poor)	1	5.55	0.01	3	0.0015	5.5
	2	5.33	0.02	2	0.001	0.3
	3	5.64	0.03	0.2	0.0001	3
	Mean	5.51	0.02	1.73	0.000866	2.93

- **%C, %N, and C:N ratios of sampled farmers**

Name	Weight (g)	% Carbon	% Nitrogen	C:N Ratio
Rsr_poat_dan_1	33.159	0.1046	1.0875399	10.17208413
Rsr_poat_dan_2	31.76	0.09923	1.0876504	10.13806309
Rsr_poat_dan_3	31.048	0.1096	1.0886775	10.31021898
Mean	**31.989**	**0.104476667**	**1.087955933**	**10.20678873**
Rsr_la_lov_1	32.457	0.05965	1.0858699	10.61860855
Rsr_la_lov_2	34.542	0.1184	1.0847065	10.49856184
Rsr_la_lov_3	34.871	0.1043	1.0857047	10.52892562
Mean	**33.95666667**	**0.094116667**	**1.085427033**	**10.54869867**
Rsr_yon_tol_1	36.869	0.121	1.0859559	10.28382214
Rsr_yon_tol_2	34.632	0.1057	1.0875238	10.19529294
Rsr_yon_tol_3	35.96	0.09985	1.0872672	9.30786268
Mean	**35.82033333**	**0.10885**	**1.086915633**	**9.928992587**
Dsr_oum_mann_1	41.551	0.01806	1.0892383	10.13898917
Dsr_oum_mann_2	33.651	0.0554	1.0865479	9.396437995
Dsr_oum_mann_3	35.798	0.03032	1.0841971	9.539780138
Mean	**37**	**0.034593333**	**1.0866611**	**9.691735768**
Dsr_long_yen_1	42.718	0.05367	1.0837032	10.16790123
Dsr_long_yen_2	31.118	0.081	1.0830026	10.49856184
Dsr_long_yen_3	32.484	0.07352	1.0872104	9.903427639
Mean	**35.44**	**0.069396667**	**1.084638733**	**10.18996357**
Dsr_long_horm_1	31.863	0.03882	1.0850524	11.23647604
Dsr_long_horm_2	37.187	0.05953	1.0866585	10.38300017
Dsr_long_horm_3	32.993	0.04672	1.0865647	11.49828767
Mean	**34.01433333**	**0.048356667**	**1.086091867**	**11.03925463**