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Willingness to Pay for the Conservation of Flooded Forest in the Tonle Sap Biosphere Reserve, Cambodia

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Abstract: This study aimed to determine the stakeholders' willingness to pay (WTP) for the flooded forest conservation (FFC) in the Tonle Sap Biosphere Reserve (TSBR), Kampong Chhnang Province, Cambodia. In addition to estimation of the WTP prices, the factors that affect the farmers' willingness to pay were determined. The possibility of establishing the mechanism for instituting payment for environmental services (PES) was examined. The study adapted the contingent valuation method (CVM) in estimating WTP and multiple regression analysis in determining the factors that affect WTP. Respondents included 157 farmer households randomly selected from the 3 villages, namely: Peam Khnang, Thnal Chheu Teal and Slat. The study found that the sample farmer-respondents have a high level of awareness on the benefits and functions of flooded forest. Sixty-four percent of the respondents were members of the FFC program; the rest did not join the program. Eighty-two percent of the respondents expressed willingness to pay for conservation of flooded forest. On average, the WTP price for a farm household was 2,357 riels per month. The respondents' willingness to pay was affected by factors such as age, income and participation in training program. They were willing to pay for conservation mainly because they wanted to protect the flooded forest as reported by 88 percent of the respondents. In terms of the method of collection, most of sample farmer-respondents would like the community themselves through the village leader to collect the WTP fund. The respondents said that they would prefer to pay the WTP fee monthly.

Keywords willingness to pay, conservation of flooded forest, Tonle Sap biosphere reserve, payment for environmental services, contingent evaluation method

INTRODUCTION

Even though the theoretical foundations of payments for environmental services (PES) were set several decades ago (Coase, 1960), the practical implementation of these market-based instruments for managing natural resources has started rather recently. Forests play a critical role in sustaining the aquatic ecology of the Tonle Sap Lake. A number of factors threaten these natural resources and the populations that depend on them, including deforestation around the lake and in upland watersheds, as well as dam construction. Clearing of over 50 percent of the flooded forests that surrounds the Tonle Sap has reduced the riparian buffer that limits the influx of sediment, and substantially lessens fish breeding grounds (Patrick et al., 2004).

This study aimed to determine the factors that affect the farmers' willingness to pay and examine the possibility of establishing the mechanism for instituting payment for environmental services (PES) provided by the Tonle Sap Biosphere Reserve (TSBR). The results of this study would help policy makers and private sectors in making the users of the environmental services fully aware of the importance of the flooded forest conservation in the TSBR.

METHODOLOGY

The study employed a single-bound, dichotomous choice format in the referendum style for WTP surveys. Household farmers were asked whether they are willing to pay a specified amount on top of the flooded forest program to improve and manage the environmental sector in the study area. The bid prices of WTP were given by 30 participants from different villages and government agencies during Focus Group Discussions (FGDs) and then the pre-test was conducted prior to the main survey.

Community Protected Area (CPA) is of paramount importance for sustainability of a participatory natural resource management initiative. There are four PCAs being developed in Prey Koh Biodiversity Conservation Area. A total of 3,337 local residents have registered as members of the Prey Koh Community Protected Area of which people are living in Thnal Chheu Teal, Peam Khnang, Slat and Kramal Village respectively. The study was conducted in three villages, namely, Peam Khnang with 78 respondents, Thnal Chheu Teal with 59 respondents and Slat with 20 respondents in Kampong Leang District, Kampong Chhnang Province. To compute the sample size of respondents, the researcher used the formula of Yamane (1967) with population size (359 households), and *e* is the level of precision (assumed 94% level of confidence or *e* is equal to 0.06) (Israel, 1992). Thus, the sample size was 157 respondents.

The study used a combination of both quantitative and qualitative methods. The primary data and secondary data were gathered through direct interviews of respondents, and through reports and the summary records of the Department of Environment (DoE), the Department of Agriculture Forestry and Fisheries (DAFF), and other state offices in the study region. In this study, descriptive statistics and comparative means tests involving T-tests were used to compare the significant difference of average values of some variables for the two groups of farmers (FFC members and non-members). Multiple regression was used to determine the factors that affect the dependent variable of WTP using the STATA 8.0 program.

$$WTP = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + u_i \quad (1)$$

WTP is willingness to pay (riels per month) of farmers who are participating in flooded forest conservation. This study aimed to test the general hypotheses that the higher the willingness to pay for environmental services, the higher is the probability that the farmers will enter into natural resource conservation. The specific hypotheses are as follows:

- Age X_1 (Years): Older people are more financially stable and may also attribute a bequest value to conserve the forest. Hence, they are more willing to pay than younger people.
- Educational attainment X_2 (Years in school): Respondents with higher education have more knowledge and in general will be more willing to pay.
- Gender X_3 (1 = male, 0 = female): Male heads are more able to earn money and may also pay more to conserve the forest.
- Household size X_4 (Number of persons in household): The bigger the household size, the more expenses the household has and the less money it has available for additional expenses, much less for forest conservation.
- Household income X_5 (riels per month): Households with higher income have higher WTP price in flooded forest conservation.
- Distance of the farmers X_6 (Kilometres): The farther the family residence and the more inaccessible the location of the flooded forest is, the lower is the WTP price.
- Participation in training course of natural resource management X_7 (1 = yes; 0 = no): Farmers who join such courses are expected to have higher WTP price in flooded forest conservation than non-participants.

RESULTS AND DISCUSSION

Both Flooded Forest Conservation (FFC) members and non-members were asked about the WTP prices. All FFC members are willing to pay for conservation of the flooded forest at different price levels while only half of non-members (51 percent) expressed willingness to pay (Table 1). Results show that the average WTP values of the two groups differed significantly at one percent level with F-value of 13.558 (Table 2). This means that the average WTP value of FFC members is greater than that of non-members. The mean WTP values for FFC members and non-members are 2,560 riels and 842 riels, respectively.

Table 1 Sample farmer respondents who are willing to pay for FFC Program

Item	Willingness To Pay For The FFC Program				Total	
	Yes	Percent (%)	No	Percent (%)	No.	Percent
FFC members	100	100	0	0	100	64
FFC non-members	29	51	28	49	57	36

Table 2 Comparative mean test of FFC and non-FFC groups for WTP prices

Item	Number of Farmers	Mean (riels)	Standard Deviation
FFC members	100	2,560	2,304
Non-FFC members	57	842	1,085
F-value	13.558**		

*Note ** refers to significance at 1% level*

The main reasons for their decisions are given in Table 3.The major reason is desire to protect the flooded forest as reported by 88 percent of the respondents. They also wanted to lead more protection efforts for the endangered species and to protect their community from disaster. They thought that the flooded forest provides many benefits to their lives for their daily livings. Calderon et al. (2004) cited some reasons why people were willing to pay for water supply improvement. Mainly, they wanted a reliable water supply for both present and future generations. This will increase the diversity of the resource species, protect the people from natural disasters, keep the good view of the environment for young generations in the future, and involve themselves in the conservation of the natural resources of the country.

Table 3 The Reasons of Sample Farmer-Respondents for Willingness to Pay Program

Reason[a]	Number	Percent (%)
Want to protect the flooded forest	114	88
Lead more protection efforts for the endangered species	75	58
Protect our community from the natural disasters	74	57
Provide so many benefits to our lives	72	56
Counterpart funding with non-government organization (NGO)	66	51
Keep a good view in the future	66	51
Get more profit if the resources are not depleted	61	47
Live with healthy surrounding and good environment	55	43
This is the valuable resource in the country	31	24

[a] *Multiple responses*

Respondents who were not willing to pay for the conservation of the flooded forest said that they could not afford any additional contribution fees (71 percent on Table 4). Thus, the top reason for being not willing to pay was affordability. Similar to the findings of Calderon et al. (2004) and

Truong (2007), respondents were not willing to pay because they thought the government should have responsibility for water supply improvement and they have income constrains.

Table 4 The reasons of sample farmer-respondents for non-WTP

Reason[a]	Number	Percent
I cannot afford the amount	20	71
The money I pay will not actually be used for conservation	10	36
The government or NGO should be responsible for this	8	29
Conservation of the flooded forest is not worth doing	6	21
The majority of the poor will be affected	5	18
Other resources are more important than forest	4	14
I prefer giving money to humanitarian causes instead	3	11

[a] *Multiple responses*

Given the farmers' willingness to pay (WTP) estimated for the sample farmer-respondents, the determinants of this variable were identified. The sample farmer-respondents included all those who are willing to pay for the FFC and did not distinguish between FFC and non-FFC farmers. The estimated results of the multiple regression model on the farmers' willingness to pay are summarized in Table 5.

Table 5 Results of the multiple regression analysis for the factors affecting the sample farmer-respondents' WTP

Variable	Variable Name	Parameter	Coefficient	Standard Error
	Constant	β_0	951.5926	594.4008
X_1	Age	β_1	18.3509*	10.1925
X_2	Education	β_2	36.5860	48.9088
X_3	Gender	β_3	-235.6883	278.2241
X_4	Household size	β_4	-101.5595	65.9466
X_5	Income	β_5	0.0003**	0.0000
X_6	Distance	β_6	-29.4080	30.0337
X_7	Training	β_7	884.6740**	312.2889
R_2			0.3885	
F			13.52**	

*Note ** and * refer to significant at 1% and 10% level, respectively*

To sum up, the multiple regression model had the value of R_2 = 0.3885 indicates that the variables included in the model are able to explain 38.85 percent of the total variation in WTP. This model is also statistically significant at a one percent probability level based on the F-test.

The coefficient of the age of the sample farmer-respondent has a positive sign significant effect on WTP at a 10 percent probability level. This implies that older people are more financially stable and may tend to attribute a bequest value to conserve the forest. However, the study of Truong (2007) showed that the age of the respondent did not affect WTP. The coefficient of the income of the farmers shows that income is positively associated with the WTP value for each individual. This variable is statistically significant at a one percent level. This result implies that income has a strong positive effect on WTP. This finding indicates that for sample farmer-respondents who agree to pay more for these services, their maximum WTP value is highly dependent on income. The coefficient of the training variable has a positive sign significant at a one percent level. The regression result implies that forest users who understand what the flooded forest is have a greater appreciation of its importance and are willing to pay more for conservation.

Most of the sample farmer-respondents preferred to pay the WTP fee monthly. They thought that it is better to collect the money every month, maybe the first week or last week of the month because they will not forget it and it is easy to keep some money for the project.
In terms of the payment vehicles, most of the sample farmer-respondents (95 percent) would like the community itself to collect the WTP fund (Table 6). They have confidence in the implementation if the community collects the contribution fee. They also prefer the village leader or community leader to collect the money.

Table 6 Payment vehicle for the WTP fee of sample farmer-respondents

Item	Number	Percent (%)
Community collector	122	95
Tax	3	2
Electricity bill	4	3
Total	129	100

CONCLUSION

Findings of the multiple regression model on the farmers' WTP revealed that three of the seven explanatory variables were significantly related to the respondents' willingness to pay. The respondents' was affected by factors such as age, income and participation in training programs. In terms of the method of collection, most of respondents would like the community itself through the village leader to collect the WTP fund. The respondents said that they would prefer to pay the WTP fee monthly.

The following recommendations are aimed at helping to improve flooded forest conservation efforts through a conservation fund which can be set up by determining the farmers' WTP. The funds collected from the use of natural resources must be invested in areas where these originate, be it directly in the areas where the resources are generated or into direct activities which promote sustainable use of resources. Capacity building activities on CNRM to strengthen management and conservation efforts must be undertaken. A conservation fee in the Prey Koh Biodiversity Conservation Area must be imposed and collected.

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Research article

Controlling Citrus Huanglongbing (HLB) for the Rehabilitation of Citrus Orchards in Cambodia

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Abstract Citrus Huanglongbing **(**HLB) has been seriously damaging Cambodian citrus industry in terms of major yield loss, poor fruit quality, and shortened average lifespan of citrus tree. HLB is mainly transmitted by vegetatively propagated citrus seedlings and spread by psyllid vector in the field. HLB pathogen is a non-cultivable bacterium "*Candidatus* Liberibacter asiaticus*"*. Major strains of HLB pathogen have been investigated and the most virulent strain Type-II was commonly observed in Pursat sweet orange, mandarin and pummelo trees in Cambodia. Currently, there are no promising technologies and cultural practices to control HLB in citrus orchards in Cambodia. New health management practices of citrus HLB have been initiated in 2006 under the expert guidance of the National Taiwan University (NTU) and the Food and Fertilizer Technology Center in the Asian and Pacific Region (FFTC/ASPAC). Pathogen-free (PF) seedlings propagated in screen houses of the Royal University of Agriculture were transplanted in the demonstration orchard of Battambang and Takeo Provinces. The supply of the PF-seedlings of major citrus species cannot currently catch up with the demand of citrus growers. According to a preliminary survey, marcotted or grafted seedlings of sweet orange propagated by farmers transplanted in major citrus production areas such as Battambang, Pursat and Siem Reap Provinces were seriously infected by HLB. Up to now, fundamental knowledge and techniques such as identification of major strains of the HLB pathogen and establishment of disease indexing laboratory and pathogen-free nursery system have been conducted. In addition, a variety of relevant techniques and cultural practices to control HLB were transferred to Cambodia, such as technologies for the production of PF-seedlings and transplanting to demonstration farms for their health management, and so forth.

Keywords huanglongbing (HLB), health management, citrus production, pathogen-free citrus seedling

INTRODUCTION

Citrus greening was first reported in 1947 from South Africa, although a similar disease known as "Huanlongbing" (HLB, yellow shoot) was already known in 1943 in Southern China (Cheng, 1943). The HLB disease, locally called "Likubin," was first identified in Taiwan in 1951, six years after the end of World War II. The HLB inoculums might have been intentionally brought into Taiwan from southern China through some infected propagation materials such as citrus scions or seedlings. HLB was first considered as a kind of physiological disorder caused by nutrient deficiency, poor drainage, and so forth. However, HLB could not be controlled by the amendment of soil properties, and has spread rapidly all over Taiwan. Matsumoto and his coworkers initiated etiological studies on HLB in 1956, and they successfully demonstrated in 1961 that the so-called HLB was not a physiological disorder of citrus tree, but was caused by a virus-like microbe transmitted through grafting of diseased scion, and named it Likubin (decline) (Matsumoto, Wang and Su, 1961). This

destructive disease spread all over Southeast Asia during the 1960s, and was locally called leaf mottle yellows, citrus vein phloem degeneration (CVPD), and citrus dieback in Philippines, Indonesia, and India, respectively. In a short period of time, HLB became one of the most devastating diseases for citrus growing areas in tropical and subtropical Asia. Miyakawa and Tsuno (1989) first found HLB in Iriomote, the southernmost island of Okinawa, Japan in 1988. Afterwards, HLB was reported in Brazil (Lopes, 2006) and Florida (Bove, 2006) in 2004 and 2005, respectively. Etiological and epidemiological studies on HLB have been conducted in Taiwan in order to develop effective and efficient management strategy of HLB since 1955. HLB commonly occurs as a mixed infection with citrus tristeza and/or tatter leaf viruses, causing severe yellow mottling and tree decline, and ultimately death of citrus trees. These diseases are generally controlled by integrated control measures. Establishment of a pathogen-free nursery system is of primary importance for reducing prevalence of these diseases in the early stage of tree development. Combination of shoot-tip micrografting (STG) technique and heat-treatment has been successful in establishing pathogen-free foundation stock of citrus cultivars. Along with the said techniques, a precise and rapid indexing technique is indispensable for health management of production and cultivation of pathogen-free citrus seedlings.

Up to present, pathogen-free citrus foundation, nursery system, and disease indexing laboratory were established in RUA through the international collaboration project among RUA, NTU and FFTC/RDF. The on-going project aims to conduct etiological and epidemiological studies of HLB, and technology transfer of health management of PF-seedlings in the demonstration farms established in major citrus production areas in Cambodia.

CITRUS PRODUCTION IN CAMBODIA

Pursat sweet orange seemed to be introduced to Cambodia in Angkor period from China. Sweet orange has been grown only in the surrounding area of houses. After the French occupation in 1954, sweet orange cultivation has been spread nationwide, thanks to technical training on modern citrus cultivation for farmers.

In Cambodia, fruit crop production is the 2nd major crop next to rice production. Within fruit crops, citrus is the second important fruit crop next to mango according to the statistic acreage of fruit crops reported by MAFF, i. e. Areas (ha) of fruit crop, 2009: Mango, 23,734; Orange, 3,553; Custard apple, 3,213; Longan, 2,376; Sapodilla, 2,052; Guava, 1,745 and Milk fruit, 1,216 has. Citrus cultivation provides year-round harvest with suitable income for increasing rural economy from 1954 to 1967 before the civil war. The total growing areas of citrus was 3976 ha (Battambang, 2391 ha; Pursat, 345 ha; Kandal, 246 ha; Kampong Cham, 331ha; and other provinces, 663 ha). During 1968-1969, around 18000 tons of citrus fruits were exported abroad. In 1987 Cambodia was able to produce 40000 tons of citrus fruits.

In recent years, areas of citrus production decreased significantly due to HLB occurrence, i.e. 2556 ha in 2007 (Table 1) decreasing from 3976 ha in 1967. Battambang province holds the highest growing area at 1865 ha, decreasing from 2391 ha in 1967, while Kampong Cham still holds 311 ha without decrease, coming to the second. Citrus areas in Pursat province decreased drastically from 345 ha in 1967 down to 59 ha in 2007 due to HLB epidemic.

Table 1 Production areas of citrus in Cambodia (2007)

Province	Area (ha)
Siem Reap	145
Battambang	1865
Pursat	59
Kampong Thom	74
Kampong Cham	311
Kampot	102
Total	2556

Source: Provincial Agriculture Department of Battambang.

The major citrus species cultivated in Cambodia are sweet orange, mandarin, pummelo, lime and Kaffir lime (Martin, 1971). Pursat sweet orange has been most commonly cultivated. The HLB disease has commonly affected all cultivars.

HLB SITUATION

Citrus trees grown in Cambodia have been affected by many different diseases which are causing considerable damage to citrus production. The most serious threat has been caused by Huanglongbing (HLB) which is known as " Slek Prak " in Khmer language. At present there is not enough technical disease control or prevention capacity for this kind of disease. The HLB disease has been commonly occurring in citrus-growing areas in Cambodia since 1980s. The common symptoms caused by HLB pathogen include yellowing of the veins and adjacent tissue, followed by yellowing with pale-green mottling of entire leaf. With ageing, the diseased leaves become hard, curling outwards and occasionally develop vein corking. The typical symptoms produced on different citrus cultivars e. g., Pursat sweet orange, mandarin and pummelo, and common root-stock cultivar, Rangpur lime, are shown in Fig. 1. However, the symptoms vary with citrus variety, strains of the pathogen, and environmental conditions.

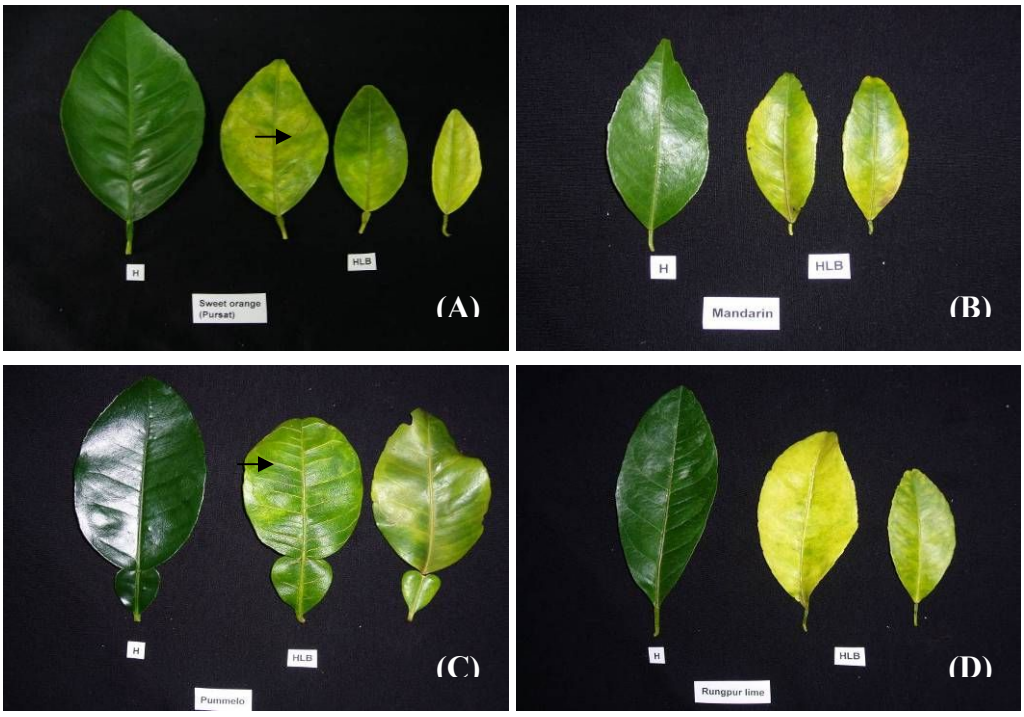

Fig. 1 Symptom expression of HLB in common citrus cultivars, and root-stock in Cambodia

(A) Leaf symptoms of HLB-affected Pursat sweet orange, showing yellowing with pale green mottling of mature leaves (second from left) with vein corking (→) and a newly grown small and slender leaf with yellow chlorosis (rightmost), and one healthy leaf (leftmost); (B) Leaf symptoms of diseased mandarin, showing yellow mottling of mature leaves (right and center) with curling; (C) Leaf symptoms of diseased pummelo, showing yellow mottling on mature leaves (right and center) with curling and severe vein corking (→) on the center leaf; (D) Leaf symptoms of diseased Rangpur leaf (right and center) showing yellow mottling, and a healthy leaf on the left.

The pathogen of the HLB disease in the above-mentioned major citrus cultivars and Rangpur root-stock were detected by polymerase chain reaction **(**PCR) test followed by electrophoresis analysis with primer pairs specific to HLB pathogen (F: CAC CGA AGA TAT GGA CAA CA; R: GAG GTT CTT GTG GTT TTT CTG). The protocol of HLB detection was described in detail in the former publications (Hung *et al.*, 1999; Su, 2008). HLB-infected leaves with typical yellow mottling symptoms, and those without any symptoms were collected from Pursat sweet orange, mandarin, pummelo and Rangpur lime trees for the infected and the control, respectively (Fig. 2A).

The entire leaf samples were subjected to PCR detection of HLB pathogen. Figure 2B presents the PCR pattern of citrus samples tested. The PCR band corresponding to the HLB pathogen (228 bp) could be observed in all the infected leaf samples while all the healthy leaves showed no band at 228 bp. This is the first report to scientifically prove that the citrus HLB disease is commonly and widely distributed in Cambodia.

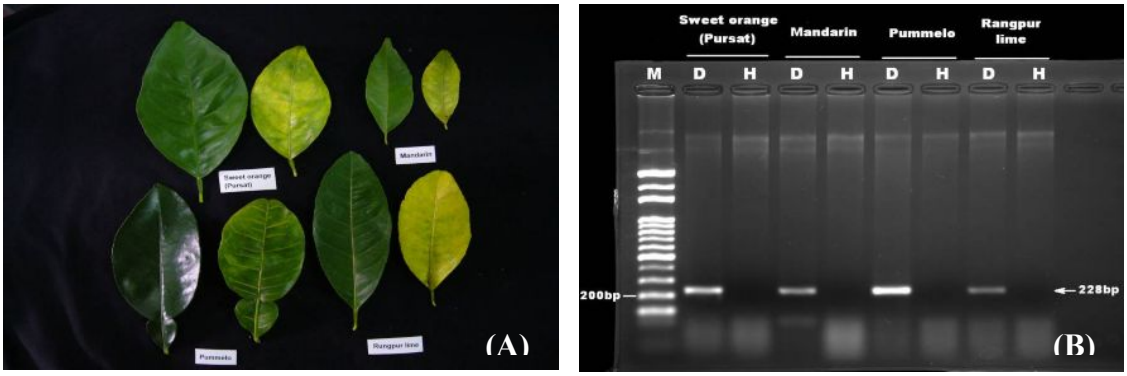

Fig. 2 Detection of HLB pathogen by polymerase chain reaction followed with electrophoresis analysis in diseased leaves of Pursat sweet orange, mandarin, pummelo and Rangpur lime each with a healthy leaf as check

(A). Photograph of PCR-electrophoresis gel showing positive detection of PCR products (228bp) (←) in each diseased leaf and negative detection with each healthy leaf (B). M, markers of molecular ladder. D, Diseased leaf and H, healthy leaf.

The high frequency of HLB is chiefly due to apparent lack of knowledge on HLB infection mechanism namely, insufficient elimination of infected citrus trees and transplanting HLB-infected seedlings. In Cambodia, citrus seedlings are commonly produced in terms of vegetative propagation by marcotting or grafting using buds taken from HLB infected trees in the open nurseries. Cambodia suffers from a serious epidemic of HLB all over major citrus orchards nationwide. Citrus growers, in principle, use uncertified citrus seedlings for their orchards, which are already infected with HLB pathogen, and the HLB symptom appears within 2 or 3 years after transplanting.

STRAIN IDENTIFICATION OF HLB PATHOGEN

The strain of HLB pathogen was precisely examined and four strains have been reported in Taiwan (Tsai *et al.*, 2008). The HLB strains were identified by bioassay and PCR analysis with four differential citrus cultivars of mandarin, sweet orange, pummel and Eureka lemon. According to the pathogenicity and virulence of the pathogen isolates, the four strains were categorized as follows: Strain I infected mandarin and sweet orange only and caused severe symptoms with high titer of pathogen multiplication; Strain II infected all four cultivars and induced severe symptoms with high pathogen titer; Strain III infected mandarin and sweet orange and induced moderate symptom with moderate pathogen titer, and infected pummel by causing mild symptoms with low titer of pathogen; Strain IV infected mandarin and sweet orange only without symptom expression.

In order to clarify the strains of HLB pathogen in Cambodia, the HLB diseased samples were collected from the suspected trees of major cultivars including Pursat sweet orange, mandarin, pummelo, Mexican lime and Rangpur lime grown in the provinces of Pursat, Battambang, Siem Reap, Koh Kong, Sihanouk ville and Kampong Speu during 2005 to 2008. The all citrus samples were subjected to the HLBB detection with PCR test, and the positive samples were selected to be the HLB pathogen isolates. The strains of the HLBB isolates were identified by bioassay of each isolate with the four differential cultivars.

The strain evolution of Cambodian isolates of HLB pathogen was investigated in RUA through international collaboration, and the results are summarized in Table 2. About 16.7% of

citrus samples (351) were found to be infected with HLB pathogen by PCR analysis. The positive diseased samples were subjected to bioassay of strain identification. Strain II could generally infect all the cultivars tested, namely, Pursat sweet orange, mandarin, pummelo, Mexican lime, Rangpur lime and Bargamot bringing about severe symptoms with high pathogen titer. Strain II (93%) was detected in all the citrus-growing areas, and showed its dominance over other strains. Strain I (3.5%) was scarcely detected in Pursat sweet orange grown in Battambang area. Strain III (3.5%) was identified from mandarin tree in Pursat province and wild lime in Siem Reap. A virulent strain IV has not been detected in Cambodia. It was the first time that HLB infection was detected in wild lime, and this means the wild lime is a new alternative host of HLBB (Hung *et al.*, 2001).

Table 2 Strain identification of HLB pathogen in Cambodia

Locality/cultivar	Number of test trees	Number of positive trees	HLBB strains			
			Ⅰ	Ⅱ	Ⅲ	Ⅳ
Ⅰ. Pursat province						
Pursat sweet orange	108	10		10		
Mandarin	19	2		1	1	
Pummelo	14	1		1		
Ⅱ. Battambang province						
Pursat sweet orange	95	9	2	7		
Pummelo	20	3		3		
Rangpur lime	10	1		1		
Ⅲ. Siem Reap province						
Pursat sweet orange	20	7		7		
Mandarin	10	5		5		
Pummelo	7	1		1		
Mexican lime	1	1		1		
Bergramot	3	2		2		
Wild lime*	1	1			1	
Ⅳ. Koh Kong province						
Pursat sweet orange	30	9		9		
Rangpur lime	1	1		1		
Ⅴ. Sihanouk ville province						
Pummelo	9	3		3		
Ⅵ. Kampong Speu province						
Pummelo	3	1		1		
Total number	351	57	2	53	2	0
Percentage (%)		(16.7%)	3.5%	93%	3.5%	0%

**Atalantia citroides, alternative host*

DESEASE CONTROL STRATEGIES

The integrated disease management, which includes propagation and cultivation of PF-seedlings, elimination of inoculum sources, and prevention of secondary infection by vector insects, is highly recommended to control the HLB disease. Establishment of PF- citrus nursery system is primarily important to prevent the disease prevalence (Su, 2008). An insect-proof screen house built in RUA has been utilized as a repository of PF citrus foundation stocks obtained through shoot-tip micrograft technique (Fig. 3). The first author, Mr. Setha, has been in charge of the PF citrus foundation program. Production of PF seedlings has been promoted by using the PF scion/bud derived from the foundation trees in RUA. Field demonstration of PF citrus seedlings which includes Pursat sweet orange, mandarin and pummelo has been conducted by Dr. Bunthan of RUA Rector in Battambang and Takae provinces. The PF citrus seedlings grow vigorously and started to bear fruits luxuriantly within 2 years after transplanting.

A healthy citrus orchard planted with PF seedlings may outlive the grower. Healthy citrus has a great potential for sustainable high yield over many decades, provided appropriate horticultural and disease management practices are followed. Accordingly, production and cultivation of PF and high-quality nursery trees are fundamentally important components of HLB management. In a screen house nursery, effective preventive measures to control disease caused by Phytophthora spp., nematodes, and bacterial canker disease have to be practiced. Budwood increase blocks are established ahead of the production of PF citrus seedlings. The blocks contain certified parent plants propagated by using budwood from foundation trees and maintained in screen houses. These trees must be reindexed periodically, and used for the bud-supply up to 3-5 years to avoid reinfection and mutations on the propagated saplings. New budwood increase blocks must be periodically established with clean buds from foundation trees. The PF citrus rootstock seedlings are produced in screen houses well-constructed with 30 mesh screen and double doors (Su, 2008).

Citrus orchards transplanted with PF-seedlings have been vigorously grown, resulting in good fruit-setting. The PF citrus trees can be fruiting as early as 2 years as long as appropriate health management and cultural practices such as watering, fertilization, and pruning are provided after the orchard establishment. Health management of pathogen-free citrus seedlings in orchards needs to be properly performed using the following strategies: 1) Prompt elimination of HLB-diseased citrus trees and alternative host plants as inoculums sources to prevent spread of HLB to adjacent healthy citrus trees, 2) Protection of pathogen-free trees from vector transmission of the HLB pathogen by effectively spraying insecticides at critical sprouting periods, and with IPM strategy such as natural enemies 3) Providing the orchards with physical barriers for avoiding the vector invasion and giving natural enemies the habitants.

Fig. 3 Pathogen-free citrus foundation stock kept in the insect-proof screen-house repository in RUA

The author (L) stood nearly the second author (R), inspecting PF foundation plants

CONCLUSION AND FUTURE PERSPECTIVES

Citrus HLB disease caused by uncultivable pathogenic bacteria was observed in most of the common citrus cultivars of Cambodia. HLB is mainly transmitted to citrus seedling by vegetative propagation and spread by vector psyllid in the field in the same manner as in other Asian countries. HLB has become a serious epidemic in many citrus growing areas in Cambodia. The integrated control measures such as elimination of inoculum sources, cultivation of PF seedling, and control of vector-insect by insecticide spraying, are generally applied for combating the disease.

Production and health management of PF seedling are primarily important for rehabilitating citrus industry. Pathogen indexing technique is indispensable for HLB management. The above mentioned facilities and technology have been already established and transferred to the Royal University of Agriculture, which is able to enhance production and healthy management of PF seedling to meet increased farmers' demand in the future. The techniques of health management have to be improved and readjusted to local conditions through more intensive epidemiological studies and well applied to protect PF trees from re-infestation of HLB and others virus diseases effectively.

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Research article

Breeding and Rearing Giant Freshwater Prawn Larvae in Tanks Using Different Salinity

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Abstract While the population grows, and in order to keep food secured in rural areas, the possibility of "Breeding and Rearing Giant Freshwater Prawn Larvae in Tanks Using Different Salinity" was tested. The experiment aimed to (1) Analyze the potential for reproducing a gonad somatic index of freshwater prawn broodstock, (2) Analyze the protein levels of artificial foods for rearing freshwater prawn larvae in tanks, and (3) Compare the survival rates of freshwater prawn larvae until the post-larvae level using different salinity. There were three treatments using different levels of salinity: 9‰, 12‰, and 15‰. There were three more replicates to check for accuracy, and each replicate was put at 50 larvae/per litre. The amount of water per tank was 60 litres. There were two kinds of feeds, *Artemia Nauplii*, which was provided in the morning and at night time, and an artificial feed consisting of 10g of baby powder, the yolk of a chicken egg, 3% of oyster oil, and 1.5% of lecithin for each 1kg of the food. The artificial feed was given three times a day (10 am, 1 pm and 2 pm). The analysis showed that an average of 1g of gonad weight was equal to 610.63 eggs and therefore 100g of gonad weight was equal to 61,063 eggs. The amount of protein, furthermore, provided daily to the prawn larvae was 25.15%, lipid 49.46% and ash 3.98% respectively of the feed. We compared the survival rates and the first treatment, with 9‰ of salinity, was observed to enable a survival rate mean of 5.44±0.18%. The second, with 12‰ of salinity, enabled 13.68±0.50%, and the third enabled 7.23±0.24% with 15‰ of salinity. Therefore, freshwater larvae adapted best with 12‰ of salinity, which was the most suitable brackish water to nurse and rear the freshwater larvae to post-larvae level.

Keywords giant prawn breeding, *Artemia nauplii*, gonad somatic index, salinity

INTRODUCTION

Increasing human population is one of the main concerns to the world as a cause of food supply shortages. Recently, in part at least due to population pressures, water ecological systems have been changed by human activities to serve various ends. Cambodia is one of the Asian countries which have a huge fish population. However, the size of this fish population has sharply decreased in recent years. As a result, domestic food supply and nutrition may not be enough for the Cambodian people. Giant freshwater prawn (*Macrobrachium rosenbergii*) is one of the freshwater species which are not only edible but are also high in protein. Because of decreases in the freshwater prawn population, the price has risen to the extent that many poor people cannot afford them. Due to this decrease the Royal Government of Cambodia, as well as other governments, has been pushing to increase freshwater prawn population through reproduction and aquaculture.

Currently, the giant freshwater prawn is not widely consumed in Cambodia but many countries throughout the world are looking at ways to increase their numbers through both aquaculture and increasing natural stocks. *Macrobrachium rosenbergii* has a body size of between 25-30g after 4-5 months of aquaculture and when it is cultured for a year, its size increases to 80-100g. This kind of freshwater prawn enjoys both clear and dirty water. The males are mostly found in small streams, rivers, and some lakes but the female enjoys surviving in the slightly brackish waters in which the current flows to the salt water (Sovannry, 1992).

Information about the breeding and rearing of the giant freshwater prawn (*Macrobrachium rosenbergii*) has not to date been investigated and there is relatively little understanding of it. This experiment, namely: breeding and rearing giant freshwater prawn larvae in tanks using different salinity, was conducted to identify and compare survival rates in different conditions and also to analyze the possibility of reproducing a gonad somatic index of freshwater prawn broodstock.

METHODOLOGY

The experiment was conducted in the fish farm of the Faculty of Fisheries at the Royal University of Agriculture, Cambodia, and was composed of three treatments, each using different levels of salinity. The first used 9% of salinity, the second 12% of salinity and the third 15% of salinity. Each treatment had 3 replicates to check for accuracy, and each replicate was put by with 50 larvae/litre. The amount of water per tank was 60 litres, so each tank needed 3,000 freshwater prawn larvae to conduct the experiment. The prawn breeders to be reproduced were collected from natural waters located in Nakleung, Peam Ror district, Prey Veng province. To find out the number of eggs in the breeders, gonad somatic index was taken into account. It was referred to as the number of eggs in a giant freshwater prawn breeder. Therefore, each breeder gonad was balanced and cut various 1g samples for count; then was calculated for average of number of eggs in a breeders. The breeders were in good health and had good movements, and none were injured. There were two kinds of feeds to be provided for freshwater larvae in the tanks. The first, called *Artemia nauplii*, was provided two times per day, in the morning and at night time. The second was an artificial feed which was comprised of 10g of baby powder, a chicken egg yolk, 3% of oyster oil, and 1.5% of lecithin for 1kg of feed. This composed feed was given by exact amounts to each treatment three times daily (at 10 am, 1 pm and 2 pm).

RESULT AND DISCUSSION

Brooder weight and number of eggs in the somatic index of giant freshwater prawns

The extent to which it was possible to reproduce a gonad somatic index of freshwater prawn broodstock was assessed with various types of brooders for freshwater prawns. The calculation of 100g of brooder weight was made in order to analyze how many larvae could be provided for 100g of giant freshwater prawn. Although the experiment took into account the various kinds of brooder weights, the count was balanced to a gram of total amount of somatic weight. In table 1, the brooder weight and average number of eggs in the somatic index of giant freshwater prawns is shown and the various brooders which were taken to estimate the larvae which were expected to provide 100g of brooders. After the estimation of the average number of eggs in various somatic weights, there were about 61,093 eggs in a brooder, which held 100g of brooders.

Table 1 Brooder weight and average number of eggs in somatic index

Weight of breeders (g)	Weight of somatic index (g)	Number of egg/gram	Egg of a 100g breeder
50	5.85	4,962	58,056
52.20	6.02	5,245	60,489
67.20	7.80	4,727	54,863
69.30	8.05	4,645	53,957
70	7.85	5,866	65,783
50.65	6.00	4,867	57,655
70.145	7.98	6,269	71,320
65.15	7.24	4,706	52,296
53.145	6.15	5,546	64,179
72.025	8.13	6,408	72,332
Total Average			61,093

Protein level in the composed feed

There were, as already noted, two kinds of feeds provided for the freshwater larvae in the tanks. The first was called *Artemia nauplii* and was provided two times per day, in the morning and at night time. The second was composed of feed which consisted of 10g of baby powder, a chicken egg yolk, 3% of oyster oil, and 1.5% of lecithin for each 1kg of feed. This composed feed was given by exactly the same amount three times per day (at 10 am, 1 pm and 2 pm). As can be seen in table 2, the protein levels in the composed feed was around 25%, lipid was about 49.46% and ash 4%.

Table 2 Protein levels in the composed feed

Composed feed	Protein level	Lipid level	Ash
	25.15%	49.46%	3.98%

Survival rates of giant freshwater prawn larvae until post-larvae

There were several factors affecting the survival rate of the larvae. The experiment was conducted with three treatments, including three replicates for each. Larvae were put in the 80 litre tanks using different salinity in each treatment. In table 3, the number of larvae put in tanks is shown.

Table 3 Number of larvae in each treatment

Treatment	Replicates	Salinity	Density of larvae/tank
T1	T1R1, T1R2, T1R3	9%	3,000
T2	T2R1, T2R2, T2R3	12%	3,000
T3	T3R1, T3R2, T3R3	15%	3,000

The number of larvae lost in tanks was due to various factors. Siphoning was one of the problems as well as the change of water quality in tanks, which led to the larvae being stressed and dying if the feed was given improperly. Another problem was the difference in larvae growth in tanks due to uneven feed intake. In fig. 1, the survival rate of larvae in tanks was compared for each treatment using different salinity levels and it showed statistical significance at all levels ($P < 5\%$).

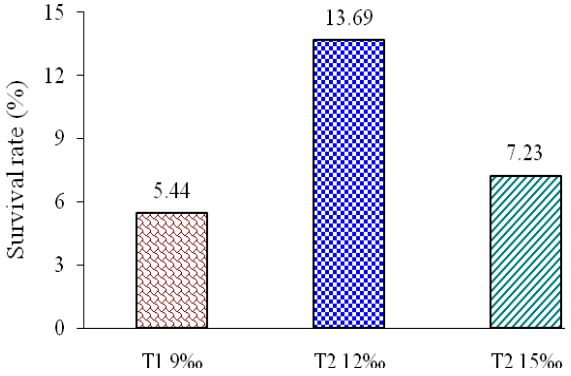

Fig. 1 Survival rate of giant freshwater prawns using different salinity levels

The survival rate of larvae to post-larvae depended on the various salinity levels. The study shows that the average survival rate in the three treatments was from 5.23% to 14.16%. The survival rate was about 5.44 ± 0.18%, 13.68 ± 0.50%, and 7.23 ± 0.24% for T1, T2, and T3 respectively. The survival rate of T2 using 12% was therefore the highest one compared to the other treatments. This was consistent with Dingchung. (1999) who reported that giant freshwater

prawns matured and survived best in brackish water from 8-14% and that the most suitable level was from 10-12%; therefore, T2 of the experiment had the highest survival rate of larvae.

Water quality in tanks for rearing giant freshwater prawn larvae until post-larvae

Looking at the water quality for rearing the larvae, there were three main factors to be observed. Temperature, pH, and dissolved oxygen were daily observed in order to analyze how they changed. In Table 4, the change of temperature for rearing larvae was observed twice daily, in the mornings and in the afternoons. It was shown that all treatments were statistically significant at $P < 5\%$. The temperature for each treatment was not different from the others for both mornings and afternoons.

Table 4 Temperature change

Observation	T1	T2	T3
	Mean ± SD	Mean ± SD	Mean ± SD
Morning	27.42±0.45	27.43±0.45	27.42±0.40
Afternoon	30.79±0.32	30.76±0.32	30.86±0.30

The temperature was observed since the first day of the experiment, and in the morning it was 27.42 ± 0.45^0C, 27.43 ± 0.45^0C, and 27.42 ± 0.40^0C for T1, T2, and T3 respectively while in the afternoon the temperature change was about 30.79 ± 0.32^0C, 30.76 ± 0.32^0C, and 30.86 ± 0.30^0C for T1, T2, and T3 respectively.

Apart from temperature, pH as a determinant for water quality was also analyzed. In table 5, the pH change is observed and analyzed for each treatment. There were two times daily for collecting the data, mornings and afternoons, and It was shown that it was always statistically significant at $P < 5\%$.

Table 5 pH change for rearing giant freshwater prawns

Observation	T1	T2	T3
	Mean ± SD	Mean ± SD	Mean ± SD
Morning	8.30 ± 0.91	8.33 ± 0.82	8.33 ± 0.98
Afternoon	8.27 ± 0.59	8.31 ± 0.71	8.31 ± 0.68

Apart from temperature and pH, dissolved oxygen was also observed in order to analyze the water quality. The observation was taken twice, in the mornings and afternoons. Each treatment shows little difference from each other at all significance levels ($P < 5\%$). In Table 6, the change of dissolved oxygen in the water was observed and the average calculated.

Table 6 Dissolved oxygen change

Observation	T1	T2	T3
	Mean ± SD	Mean ± SD	Mean ± SD
Morning	7.72 ± 0.27	7.7 1 ± 0.25	7.72 ± 0.26
Afternoon	7.80 ± 0.26	7.90 ± 0.31	7.83 ± 0.31

Dissolved oxygen was very important for rearing larvae in tanks. The average level of dissolved oxygen was about 7.72 ± 0.27 mg/l, 7.71 ± 0.25 mg/l, and 7.72 ± 0.26 mg/l in the morning for T1, T2, and T3 respectively. For the afternoon, it was around 7.80± 0.26 mg/l, 7.90± 0.31 mg/l, 7.83 ± 0.31 mg/l for T1, T2, and T3 respectively. The treatments had no statistically significant differences, and it was acceptable for rearing larvae in tanks. This was consistent with Sovannry. (1992) who showed that the dissolved oxygen level in the water for freshwater animals had to be above 3 mg/l.

CONCLUSION

Only healthy gonad freshwater prawn breeders were selected for the study to count the averages for the gonad somatic index. By counting 1g of total gonad weight, the analysis showed that this was equal to 610.63 eggs of freshwater prawn and therefore 100g of giant freshwater prawn weight was equal to 61,063 eggs, which the broodstock could hold in its somatic. Furthermore, the feed analyzed by the veterinarian laboratory for assessing the protein showed that the composed feed provided to the prawn larvae each day was 25.15% of protein level, 49.46% of lipid, and 3.98% of ash. This showed that the composed feed for larvae did not provide a high enough protein level to grow the larvae. After the end of experiment the first treatment, which put 3,000 larvae in 60 litres of water with 9‰ salinity, had a survival rate mean of 5.44±0.18%. The second treatment, which put 3,000 larvae in 60 litres of water with 12% salinity, had a survival rate mean of 13.68±0.50%, and the last treatment which had 3,000 larvae in 60 litres of water with 15% salinity had a survival rate mean of 7.23±0.24%,. We conclude therefore that freshwater larvae adopted with the 12% levels of salinity had the best survival rates. The survival rate in the second treatment with 12% of salinity was the highest. This experiment was designed to find the average amount of eggs in broodstock gonad somatic indices, analyze the protein levels in artificial feed, and compare the larvae's survival rates with different salinity. This was done in order to make recommendations to the next generation and rural farmers who may be willing to grow the giant freshwater prawns in Cambodia as to the best methods of so doing.

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Research article

Effect of Wheat Bran Utilization on the Performance of Finishing Pig at Tang Hang Ly Farm

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Abstract The experiment was conducted at the Tang Hang Ly pig farm, located in Kandal province. 24-crossbred growing pigs were identified initially as T_0, T_1, T_2, T_3 with average weight 49.17±0.75 kg, 49.33±1.37 kg, 49.33±1.63 kg, 49.83±1.47 kg respectively. The aims of this research were, (1) to determine the optimum level of wheat bran in the diet for growing-finishing pig and (2) to evaluate the economic efficiency of using wheat bran in pig diet. The experiment was randomly designed by CRD (completely randomized design) and was divided into four treatments and three replicates. There were two pigs in each replicate and the pigs were offered feed with different levels: 0%, 25%, 35% and 45% of wheat bran in the feed concentration. The results showed that, the average daily weight gain in T_2 (610.4±38.3g) with the 35% concentration of wheat bran was significantly higher than the feed concentrations of 45% in T_3 (570.8±79.7g) and 25% in T_1 (562.1±71.58g). The control diet in T_0 had a weight gain of 558.6±88.62g. The daily feed intake was highest with the 35% wheat bran concentration in T_2 (2.231±0.02 kg/head), followed by lower feed intake with the wheat bran concentrations of 45% in T_3 (2.018±0.11 kg/head). This did not differ from the control diet in T_0 (2.032±0.23 kg/head) and the 25% wheat bran concentration in T_1 (2.023±0.09 kg/head). It was noted that the diet of T_2 with a wheat bran concentration of 35% consumed the most feed compared to the other treatments. Besides, there was a significant interaction with feed conversion ratio ($P<0.05$) in which T_2 (3.66±0.21) were much higher than T_0 (3.65±0.24), T_1 (3.62±0.34), and T_3 (3.55±0.21). This means that wheat bran was more effective if it was used at a lower feed concentration in order to gain 1 kg of meat. In conclusion, the results showed that the T_2 which was fed the 35% concentration of wheat bran could be utilized effectively as basal diet for growing finish-pig, which started from 50 kg to 100 kg, with superior economic returns.

Keywords pigs, wheat bran, feed conversion ratio (FCR), feed intake (FI), weight gain

INTRODUCTION

Pig meats are the main current concern for food of human and food security in rural areas if people did not know how effective and efficient to raise pigs. Therefore, pig raising is a vital part to increase profitability of household income, and because farmers really want to find out new techniques of raising pigs with low spending and suitable level of nutrition, many scientists are trying to develop new techniques for them. As Pok et al.(1998) reported that it would have high demand for human-being in which provide meat account for 58 percent of total meat output, and 31 percent of world meat produce by developing countries in 1980 and would produce 60 percent in 2020.

Currently, the number of farms to raise pigs is gradually increasing in Cambodia meanwhile the demand on pig meats is sharply increased. Looking to the general census 2008 compiled by the ministry of planning, the population in Cambodia has 11,437,656 in 1998 to 13,395,682 in 2008 which has increased by about 1.96 million during the decade 1998-2008, it reach to 15,500,000 people in 2010. This showed that the higher demand increases, the more pigs need to be raised. Anyways, farmers in Cambodia mostly used traditional techniques to raise pigs without analyzing

the economics. For instance, they raised pigs with kitchen wastes and vegetable wastes with rice bran, etc. Also, some farmers had new acceptable techniques to raise pigs efficiently and effectively but they still not knew the benefit of wheat bran with other feed ingredients. The wheat bran had the cellular less than rice bran and it was also good smell and easily melted when the pigs ate (Sodany, 2005).

As consistent with Harris et al. (1982) reported that metabolism energy of wheat bran, calcium, and phosphor was about 2210 kcal/ kg, 0.13%, and 0.81% respectively. For the experiment in RUA (2008), it was about 18.14 for crude protein, 85.35% for dry matter and 9.62% for crude fibre in the wheat bran. These showed that the wheat bran had high benefit for farmers to raise their pigs. Moreover, the effect of wheat bran utilization on performance of finishing pigs was still not clearly investigated.

MATERIALS AND METHODS

There were four treatments to make an experiment at Tang Hang Ly pig farm, where located at Sdaou Kanlaeng village Dei Edth commune Kien Svay district Kandal province around 25km off Phnom Penh city, Cambodia.

Animals and experimental design

24-crossbred growing pigs (Large white x Landrace) were put initially by T_0, T_1, T_2, T_3 with average live weight 49.17±0.75 kg, 49.33±1.37 kg, 49.33±1.63 kg, 49.83±1.47 kg respectively. All pigs were de-wormed and vaccinated before making the experiment. The experiment was randomly designed by CRD (completely randomize design) that divided by four treatments and three replicates for each. There were two pigs to put in each replicate and offered feed by different dietary treatment as shown in table 1.

- T_0: Control (Mize, Broken rice, Soybean meal, Fish meal)
- T_1: Maize, Broken rice, Soybean meal, Fish meal within 25% of Wheat Bran
- T_2: Maize, Broken rice, Soybean meal, Fish meal within 35% of Wheat Bran
- T_3: Maize, Broken rice, Soybean meal, Fish meal within 45% of Wheat Bran

Table 1 Experimental design by CRD

Replicates	Treatment			
1	T_0	T_1	T_2	T_3
2	T_1	T_0	T_3	T_2
3	T_3	T_2	T_1	T_0

Feed and feeding

In table 2, the composition of feed stuffs used for the experiment was focused on maize, broken rice, soybean meal, fish meal, and wheat bran. The diets were formulated by the two growing phases; first, it was from 50-100 kg (phase1) in table 3 and 80-100 (phase2) in table 4. The daily feed allowance was distributed equally into 3 meals per day: morning at 7:00 am, afternoon at 12:00 pm and evening at 5:00 pm.

Table 2 Chemical composition of the feed stuffs used in the experiment

Feed stuff	DM,%	ME (kcal/kg)	% of dry matter		
			CP	Ca	P
Maize	84.70	3350	9.84	0.09	0.14
Broken rice	90.00	2976	7.50	0.20	0.40
Soybean meal	89.61	3757	49.80	0.26	0.67
Fish meal	93.76	3341	64.10	5.10	2.90
Wheat bran	88.90	2210	14.29	0.10	1.10

Table 3 Ingredient and chemical composition of the diets in Phase 1 (50-80 kg)

Ingredient, %	T_0	T_1	T_2	T_3
Maize	48.50	36.00	36.00	36.10
Broken rice	31.00	19.40	10.00	0.00
Wheat bran	0.00	25.00	35.00	45.00
Soybean meal	8.80	8.00	8.00	6.60
Fish meal	10.20	8.60	7.50	7.40
Salt	0.50	0.50	0.50	0.50
Premix	0.50	0.50	0.50	0.50
Minerals	0.50	0.50	0.50	0.50
oil	0.00	1.50	2.00	3.40
Total	100.00	100.00	100.00	100.00
Composition , % in DM (except for ME which is in kcal/kg DM)				
ME	18.00	18.00	18.00	18.00
Crude Protein	3218	3056	3004	3000
Calcium	0.84	0.74	0.68	0.66
Phosphorus	0.50	0.71	0.75	0.80

Table 4 Ingredient and chemical composition of the diets in Phase 2 (80-100 kg)

Ingredient, %	T_0	T_1	T_2	T_3
Maize	54.00	44.00	39.00	29.00
Broken rice	30.00	16.00	11.00	10.50
Wheat bran	0.00	25.00	35.00	45.00
Soybean meal	6.00	5.00	5.00	5.50
Fish meal	8.50	7.00	6.00	5.00
Salt	0.50	0.50	0.50	0.50
Premix	0.50	0.50	0.50	0.50
Minerals	0.50	0.50	0.50	0.50
oil	0.00	1.50	2.50	3.50
Total	100.00	100.00	100.00	100.00
Composition , % in DM (except for ME which is in kcal/kg DM)				
ME	16.00	16.00	16.00	16.00
Crude Protein	3211	3056	3016	2960
Calcium	0.75	0.66	0.60	0.55
Phosphorus	0.48	0.64	0.69	0.75

Measurements and statistical analysis

Feed consumption was balanced for the amounts given and then subtracted any remaining feed. The remaining feed and given one was recorded by every morning. If the remaining feed was wet, it had to dry up and rebalanced for estimating the intake amount. The pigs were individually weighed for every10 days at 5:30 in the morning before feeding and watering. Economic returns were estimated using current market prices of feed ingredients and lives pigs. Moreover, all data from the experiment were stored in Microsoft Excel and analyzed by ANOVA using SPSS Version 12.0 to analyze on compared mean, daily growth, feed intake, and others.

RESULTS AND DISCUSSION

Average of growing weight every 10 days

Regarding 80 day-experiment in pigs' farm by balancing pigs for every 10 days, there were many records of dietary, feed composition and average weight. In Fig.1 illustrated about the changing comparison between the average growing weights of crossbred pigs for four different treatments: T_0, T_1, T_2 and T_3. The pig growing trend for each treatment was not quite different from each other since the beginning of dietary.

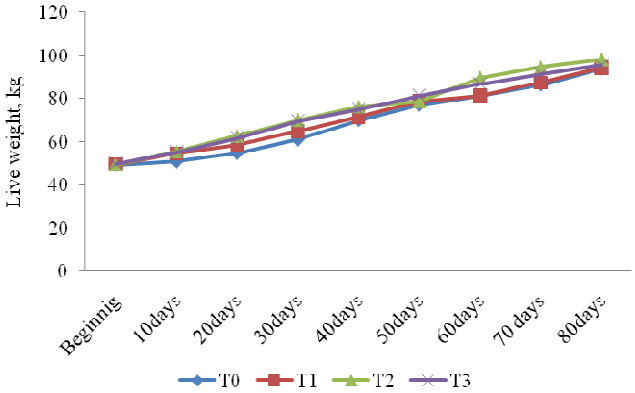

Fig. 1 Average daily growing weight every 10 days of trail

As the start of the experiment which was divided by T_0, T_1, T_2, and T_3 with average live weight 49.17±0.75 kg, 49.33±1.37 kg, 49.33±1.63 kg, 49.83±1.47 kg respectively. After providing the different level of wheat bran, the result for 80 days showed that the growth weigh of the crossbred pigs was exactly the same at all weighing in which was made for every 10days, excluding the second and third weighing at all statistically significant level ($P < 0.05$). Therefore, the average growing weight of crossbred pigs was 93.83±7.41 kg, 94.33±5.71 kg, 98.17±3.82 kg, and 95.50±5.96 kg for T_0, T_1, T_2, and T_3 respectively. However, the highest growing treatment was in T_2, which was put about 35% of wheat bran.

Live weight, feed intake and feed conversion ratio

Feed was the main factor for growing pigs in the farm, but it had to have the fattening and watering in order to get more profits. There were four treatments to be experimented in Tang Hang Ly Farm in which there were four different feed compositions to put for each trial. What the difference was the composition of wheat bran of all trials. In table 5, the effect of wheat bran on performance and intake of crossbred-pig growths was mentioned about the changing comparison of each treatment. Moreover, in fig.2, it was also shown about the net weigh gain of the crossbred pigs in each treatment.

Table 5 Effect of Wheat Bran on performance and intake of crossbred growing pigs

	T_0	T_1	T_2	T_3	Prob.
Live weight, kg					
Initial	49.17±0.75	49.33±1.37	49.33±1.63	49.83±1.47	0.84
Final	93.83±7.41	94.33±5.71	98.17±3.82	95.50±5.96	0.47
Daily gain, g	558.33±88.62	567.50±71.58	610.42±38.30	570.83±79.70	0.59
Feed intake, kg/head					
Total	325.13±36.40	323.73±14.05	356.93±3.24	322.88±18.17	0.23
Daily	2.03±0.23	2.02±0.09	2.23±0.02	2.02±0.11	0.23
Daily gain, g/head	278.75±20.57	219.79±24.64	242.71±9.15	181.14±7.24	0.00
Feed conversion radio, kg feed/kg gain	3.65±0.24	3.62±0.34	3.66±0.21	3.55±0.21	0.95

The wheat bran was used by different level for each treatment. In the table 5 shown that the average daily weight gain for T_2 of wheat bran 35% was about 610.4±38.3g and it was the significantly highest of all treatments while T_3 with wheat bran 45% was around 570.8±79.7g, T_1 with wheat bran 25% was probably 567.5±71.58g, and the control diet in T_0 gained weight about 558.3±88.62g. As Chansery (2004) which was experimented about the wheat bran composition for pig meats by using 10%, 20%, 30% and control reported that there was the effect of wheat bran for the pig growth when the higher input of wheat bran was. So, T_2 using 35% of wheat bran was reasonable to grow pigs effectively.

Daily feed intake was quite different from each treatment. T_2 using the 35% of wheat bran was the highest of daily feed intake and followed by T_0 (control), T_1 using the 25% of wheat bran and T_3 consisting of the 45% of wheat bran. For T_2, T_0, T_1, and T_3 the pig ate about 2.231±0.02 kg/head, 2.032±0.23 kg/head, 2.023±0.09 kg/head and 2.018±0.11 kg/head respectively. This was consistent with Chansery. (2004) reported that the daily feed intake was in the control which had no any wheat bran. However, the experiment resulted that T_2 was not so quite different from T_0 (control). It was that T_2 and T_0 was good for the daily feed intake but maybe not for the weight growth on T_0 in contrast toT_2.

Besides, there was a significant interaction with feed conversion radio at $P<0.05$ in which T_2 (3.66±0.21) were the highest of T_0 (3.65±0.24), T_1 (3.62±0.34), and T_3 (3.55±0.21). It showed that wheat bran was better if it was used less as feed concentration in order to gain 1 kg of pig meat. According to NRC (1988), feed conversion ratio of pig was 3.79, so it had to put 3.79 kg of feed concentration for getting 1 kg of pig meat. Therefore, with this experiment, the feed conversion ratio was in T_2. Moreover, it was really quite better compared to Chansery. (2004) who reported at 30% of wheat bran composition, the feed conversion ratio was about 4.70. Therefore, the result showed that at the 35% of wheat bran, it influenced to the weight growth of crossbred pigs to grow fast but the feed conversion ratio was less. This was consistent with Muir et al. (1992) reported that using the wheat bran for growing pigs was about 30% and 50% for fattening pigs. Also, Godinho (1986) shown that the wheat bran could be added up to 30% for the growing animals.

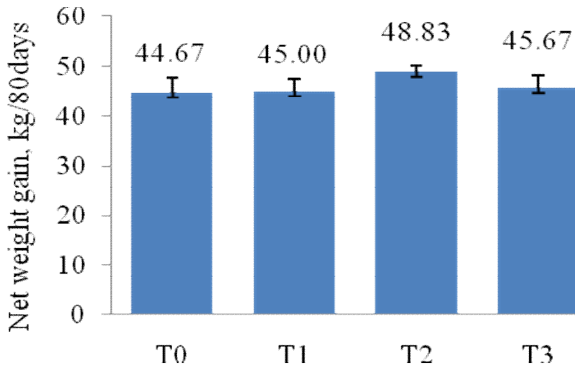

Fig. 2 Net weigh gain during 80 days

Table 6 Economic analysis of the trial with finishing pigs

	T_0	T_1	T_2	T_3
Piglet cost, riel	417,900	419,300	419,300	423,500
Feed cost, riel	547,200	503,700	530,700	481,400
Medicine cost, riel	10,000	10,000	10,000	10,000
labor and depreciation of cage, riel	40,000	40,000	40,000	40,000
Reservation cost 5%, riel	50,700	48,700	50,000	47,800
Total cost, riel	1,065,800	1,021,700	1,050,000	1,002,700
Total finishing growth weight, kg	93.83	94.33	98.17	95.50
Market price/kg, riel	11,500	11,500	11,500	11,500
Total revenue, riel	1,079,045	1,084,795	1,128,955	1,098,250
Marginal over cost, riel	13,245	63,095	78,955	95,550
Economic Efficiency	1.01	1.06	1.08	1.10

After long period of raising pigs, economic analysis was very important to find out how effective and effecient the wheat bran was for growing pigs. As the table above, there were four trials: T_0, T_1, T_2, and T_3. The economic efficiency of T_0 was 1.01 which was meant that if the trial spent 100 riel, the net profit was 1 riel, and T_2 was 1.06 which was better than T_0. The highest one was in T_3 in which economic efficiency was about 1.10. If the trail of T_3 spent 100 riel, the net profit was 10 riel followed by T_2 which was 8 riel. However, the weight gain in T_2 was the highest of all treatments.

CONCLUSION

Raising pigs had to analyze about the growth, weight gain, and economic efficiency, so not just the farmers, many scientist had tried more and more for finding new techniques and dietary nutrition for raising pigs. As the experiment conducted, 35% of wheat bran could be utilized effectively as basal diet for growing finish-pig which started from 50 kg to 100 kg if compared to the other treatments in the trial. These diets significantly improve growth performance without affecting carcass quality with acceptable economic returns. Although its economic efficiency was lower than that of 45% of wheat bran, the weight gain was the highest of all treatments. Thus, the trial in T_2 which composed with 35% of wheat bran was accurately acceptable and it could be recommended for producers.

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Research article

A Study on Field Water Tube's Effectiveness as a Practical Indicator to Irrigate SRI

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Abstract Rice, the staple food of 2.7 billion people as well as prolific user of water, are at risk of severe water shortage and hence food insecurity. To cope with looming water crisis, we must sought water saving technologies to maintain and to increase rice production for meeting world's food needs with less water. A new strategy is the use of field water tube in SRI with AWDI application. A lysimeter scale experiment was conducted at Tokyo University to find out the effectiveness of Field Water Tube for monitoring the depth of ponded water, determining the right irrigation timing. The experimental layout was Demonstration Strip Design with twice replication where 5 different diameters PVC Tube (viz. 5 cm, 7.5 cm, 10 cm, 12.5 cm and 15 cm) were treatment and Hioki meter, tensiometer, moisture sensor, temperature sensor, data logger were used as instrument. When the water level went to 10 cm below the soil surface level then irrigation was applied in the drying cycle of AWDI. Throughout the study period, ponded depth/water level, moisture percentage, pressure, temperature was measured. The study revealed that all the treatments measured the water level perfectly and determined the appropriate time of irrigation in drying cycle of AWDI. The study disclosed that in measuring water depth all the water tube exhibited good relationship (in same diameter maximum r^2 value 0.9955 and minimum r^2 value 0.9876, in different diameter maximum r^2 value 0.995 and minimum r^2 value 0.965) to each other. It is demonstrated that water tube measurement has strong relationship with water level sensor measurement (Hioki Meter) and tensiometer. Field Water Tube proved that it is a water saving technology where AWDI done in SRI based on water requirement of the field not by predetermined interval approach.

Keywords field water tube, ponded depth, diameter of water tube, alternate wetting and drying irrigation, SRI, soil crack

INTRODUCTION

Rice cultivation in system of rice intensification (SRI) with alternate wet-dry irrigation (AWDI) management is generally practiced with 5/7/10 days interval irrigation but the idea of predetermined day's interval approach cannot be treated as the demand driven technology perfectly. Moreover, success of AWDI depends largely on irrigation to the field at the right time when needs water for the rice plant. But determination of right irrigation timing during the dry cycles of AWDI is very hard due to different soil physical properties such as soil structure/ texture, bulk density of soil; soil pore space etc and different soil have different hydraulic conductivity like movement of water, infiltration/percolation rate, and water retaining capacity. Therefore, farmers fail to decide the appropriate time for irrigation and pay penalty as yield reduction for saving irrigated water. To solve the crucial problem of yield reduction, International Rice Research Institute (IRRI), Philippine Rice Research Institute (Phil Rice) and Bangladesh Rice Research Institute (BRRI) recommended 15 cm, 12 cm and 7-10 cm diameter water tube, respectively. The three designated institutions also suggested different re-irrigation timing in drying cycle of AWDI such as based on

varied water ponded depth viz.15 cm or 20 cm below the soil surface re-irrigation time is prescribed by the institutions. In this context, more study is required on Field Water Tube and its diameter size to uncover the effectiveness, accuracy, durability of the instrument as a good practical indicator of irrigation in AWDI management regime.

MATERIALS AND METHODS

Climatic Features and Description of the Study Area

Japan is under temperate climatic region and the climate of the area was warm oceanic that is mild in winter and relatively cools in summer and the climatic data in the experimental site was collected during the rice –season (April to August). Table1 summarized the weather data.

Table 1 Meteorological data from April to August, 2010

Month	Rainfall (mm)		Temperature (hrs)			Sun (hrs)
	Total	Daily Max.	Ave.	Daily Max.	Daily Min.	
April	194.5	48.0	10.9	16.3	6.4	135.7
May	109.5	24.5	17.6	22.7	13.0	213.2
June	109.5	26.5	22.0	27.0	18.1	167.3
July	77.0	21.5	26.6	31.7	22.9	199.9
Aug	8.5	4.5	28.3	33.7	24.6	253.3
Ave.	99.8	25.0	21.1	26.3	17.0	193.9

Source: Abiko Meteorological Station, Chiba

This study was conducted at the roof top lysimeter of the environmental building in Kashiwa Campus, University of Tokyo, which is in Kashiwa city, Chiba, Japan, during the rice season of 2010 (April to August). The experimental site was situated at 35^0 54' North latitude and 139^o 56' East longitude, and at an altitude of 55 m above mean sea level.

Fig.1 Lysimeter utilized in the study installed at the roof top

The size of the lysimeter was 500*160*60 cm^3 (Fig.1) and soil depth was 30 cm. The soil of the experimental site was sandy loam and homogeneous with fairly good soil fertility. Mochigome cultivar, the second major rice variety (sticky rice) in Japan, was used in the experiment.

Experimental Details

Apparatus

5 different sized (diameter) field observation water tubes: 5 cm, 7.5 cm, 10 cm, 12.5 cm and 15 cm diameter tube were used, which height was 25cm, having perforated holes space-2 cm apart and perforated holes diameter was 3mm. The thickness of the tube was 0.5 cm, 0.4 cm, 0.3 cm, 0.25 cm and 0.2 cm for 15 cm, 12.5 cm, 10 cm, 7.5 cm and 5 cm diameter Tubes, respectively. The other instruments are 1 Hioki meter (Water Level Sensor), 4 ECH2O Soil Moisture Sensors, 4 Temperature Sensors, 4 Tensiometers (5 cm, 10 cm, 15 cm and 20 cm), 2 Data Logger, Lysimeter (Reinforce Cement Concrete-RCC Size-500*160 cm^2), Leaf Color Chart and a ruler.

Detailed Area Plan

The lysimeter of 500 x 160 cm^2 or 8m^2 was divided into 5 columns and 17 rows (Fig.3). The distance between each column and row was 30 cm (square shape). The distance from corner of lysimeter to corner column and row were 20 cm and 10 cm respectively. In the experiment, 5 different diameters field water tube were used as treatment and it replicated twice by placing between 2nd-3rd column and 3rd-4th column. The water tubes were installed vertically as its 5 cm remain over the soil surface and 20 cm remain under the soil.

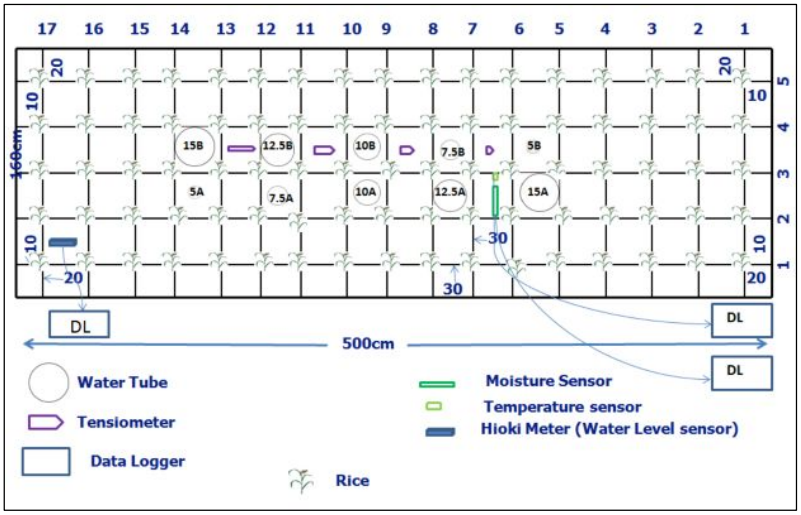

Fig. 2 Detailed area plan of lysimeter scale experiment

There were 4 tensiometers installed between water tubes of line B. 4 moisture sensors and 4 temperature sensors were installed between tubes 12.5A and 15A at the following depth 5 cm, 10 cm, 15 cm and 20 cm. One Hioki meter (water level sensor) was installed in-20 cm depth which soil was taken away. At every joint of column and row, 2 rice plants were planted, or totally, 170 rice plants were transplanted at 85points (17*5).

Irrigation Management

This was one of the most important features of the experiment. When determining the irrigation schedule, major emphasis was laid on critical stages of water requirement in the given climatic situation. AWD irrigation was applied after 1 day of transplanting and continues up to whole experiment period (102 days). AWD Irrigation management was divided into two regimes:

a. Irrigation for 10 days after transplantation (1 Day Interval AWDI)
b. Irrigation for 11 days to 102 days after transplantation (AWDI with Field Water Tube)

The methodology of irrigation (with Field Water Tube) was when water level would go to 15 cm depth of 15-A water tube then re-irrigated the field but due to the climatic conditions and to fulfill the main objective (Effectiveness of Field Water Tube) of the experiment, AWD irrigation was done.

Parameter observed

Field water tube, moisture sensor, temperature sensor, tensiometer was observed at 12 hours interval (9 am and 9 pm) and Plant growth was observed at 7 days interval throughout the experiment period. Each Field water Tube was attached with a ruler to measures the water Level in the field and data collection was started at DAT1 and it continued up to DAT102.

RESULTS AND DISCUSSION

Comparison among water tubes

It was indicated that water depth of all water tube is similar with some small difference when water remains around soil surface but when water goes to under the soil surface. When water level goes to 10 cm below the soil surface then water level difference among the water tube varies greatly (Fig. 3). It is also observed that among the five different diameter water tubes, the narrower diameter water tube shows lower ponded depth than the wider diameter Water Tube.

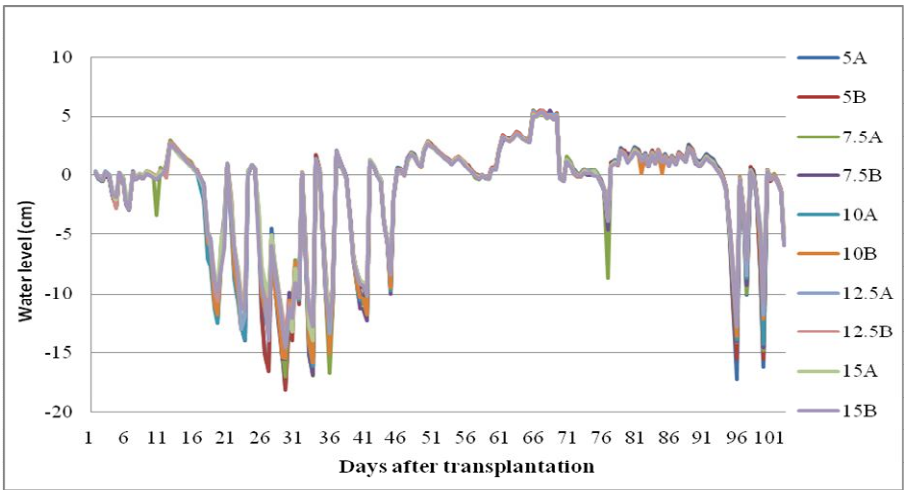

Fig. 3 Ponded depth of all water tubes in the experiment period

The lowest or extreme ponded depth is shown by 5B and that is -18.1 cm below the surface level and minimum lowest ponded depth is -13.5 cm in 12.5B. The difference between these two water level points is 4.6 cm and it is very significant for AWD irrigation management in rice field.

It is found that AWD irrigation after long days, the decreasing trend of water level is very high. It is observed that water level decreasing rate is maximized in small diameter water tube than larger diameter tube. Highest water level reduction is happened in 5B Tube and that is -8.2 cm and lowest reduction in 15A and that is 7.1 cm. It is observed that the highest maximum water level reduction in 24 hours is happened in 7.5B Water Tube (-15.4 cm) and less maximum water level reduction in 15B tube (-11.5 cm). It is found that all the tubes show good relationship to measure ponded depth.

Comparing in same diameter water tube, maximum and minimum relationship is shown by 10 cm and 15 cm diameter water tube which are 0.9955 and 0.9876 (r^2 value) respectively. In different diameter water tube, maximum and minimum relationship is exhibited by 12.5B-15B and 5A-15A water tube which are 0.995 and 0.965 (r^2 value) respectively. From these findings it can be said that if variation of diameter of the tube is small then measuring water level is close and vice versa.

Water tube and Hioki meter

It is found that Hioki meter (Water Level Sensor) measurement goes side by side with water tube ponded depth measurement (Fig.4) and proved that it is very accurate.

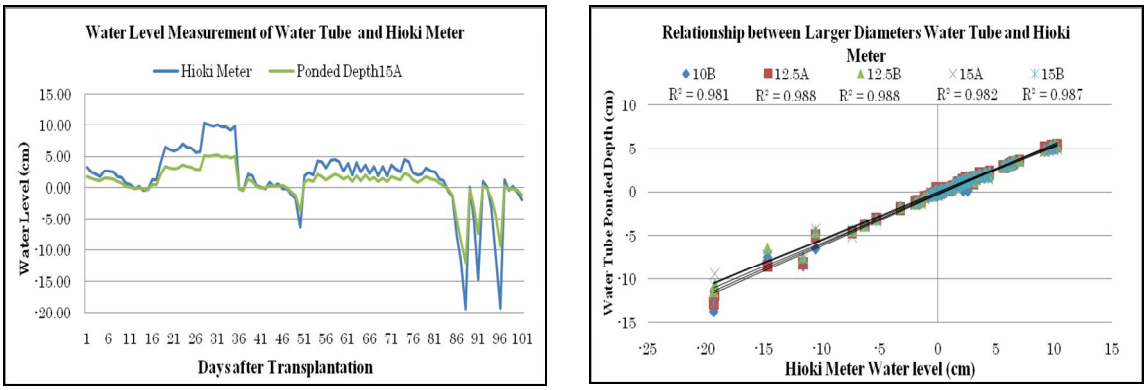

Fig. 4 Water level measurement by water tube and Hioki meter and their relationship

It is found that water tube measurement has strong relationship with Hioki meter measurement and especially larger diameter water tube has better relationship with Hioki meter (Fig.4). Maximum relationship between water tube and hioki meter is 0.9884 (r^2 value) by 12.5B tube and minimum relationship is 0.9575 (r^2 value) by 5A tube.

Water tube and tensiometer

Relationship between soil pressure and different diameter water tube has been investigated and it is found that maximum relation (r^2=0.547) prevails between soil pressure at 5 cm depth tensiometer and 5B water tube and minimum relation (r^2=0.4594) is identified in 15B water tube. It is also observed that no pressure prevailed above -4.3 cm (15A Tube) depth of the soil and maximum pressure (-14 kPa) is found on DAT 35 by 5 cm depth tensiometer.

Water tube, moisture sensor and temperature sensor

In the experiment, it is not found that moisture presence has relationship with ponded water depth measured by water tube. Only 20 cm depth moisture sensor has shown 0.21 relationships with water tube measurement and others has shown very much insignificant result which is less than 0.1.

It is investigated that there is very insignificant relationship between temperature sensor and water tube by using water level decreasing data of drying cycle of AWDI and temperature data on that particular observation. 15 observations data on maximum decreasing of ponded depth has been counted and considers temperature on that time and find that there are less than 0.2 relationships between temperature and ponded depth. Therefore, from this investigation it is not found that higher temperature increases more transpiration and decreasing water level rapidly.

Water requirement and soil physical condition

Total water applied in the field is 77.8 cm of which 45.8 cm comes from irrigation and 32 cm water comes from rainfall which is 59% and 41% of total irrigation. It is investigated that soil crack has relationship with water level. When water level goes to under the soil then soil crack shows maximum width. It is observed that first soil crack is formed on DAT 6 and the maximum size of the crack is 3.5 cm on DAT29.

Crop measurement

It is identified that plant growth curve is S-shaped and number of tiller/shoot growth and leaf growth shows exponential growth curve in this experiment. The number of effective tiller is 27.54 which is very good phonological result for rice plant.

Merits and demerits of water tube

It is investigated that the cost of the 25centimetr PVC water tube is comparatively cheap and available at local market in Japan. There is no carrying, installation and maintenance cost. Installation, observation, maintenance is not hard laborious job for using water tube and it does not consume time. Water tube with PVC pipe is not perishable instrument and not affected by heavy rain fall, flooding, high sun shine and its durability is very high. Water tube is also environment friendly and there is no chance of damaging this instrument by other animals. As the water tube technology is very simple, farmer can adopt and apply this in SRI rice field easily due to its high trial-ability.

CONCLUSION

Water tube showed significant performance to measure the water availability as well as water requirement by the plant. It exhibited right timing of irrigation. All the water tubes monitored the depth of the ponded water very successfully in the drying period of AWDI and show the requirement of water in field.

To increase productivity and to produce rice in water-wise way, water tube technology can be very good option for sustainable rice farming which can save valuable water resource and reduce production cost.

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Research article

Processing of *Sraa Sor* (rice liquor) in Takeo Province, Cambodia

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Abstracts *Sraa sor* (rice liquor) is a traditional khmer liquor made from rice with fermentation and distillation processes. The objective of this research is to describe the rice liquor processing in Takeo province. A semi structure questionnaire and observation were used to survey the rice liquor processing with 58 rice liquor producers. Producers learned the method of rice liquor production from their parents. Whole rice of *Srouv Krohom* (rice variety) or broken rice mixed with many varieties and *mé sraa* Vietnam (yeast variety) bought at local markets were used to produce liquor. Rice husk and fire woods were used for steaming or boiling rice and distillation. Producers used pond water or well water for cooking rice and rain water for adjusting alcohol concentration. The producers sold their *sraa sor* to middlemen because they could receive money on site. Amount of cooked rice was 20kg and yeast 500g at one time. Seventy eight litters of water were added after fermenting two over nights. Time spend on distillation was three hours. The alcohol degree was said 30 percent in final production by farmers.

Keywords rice liquor *(sraa sor)*, processing, yeast, fermentation, distillation

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the leading staple crops of the world. There are many alcoholic products made from rice such as sake (Padhye and Salunkhe, 1979), Lao rice whiskey (Hatsadong & Gibson 2006) and *sraa sor*. In Asian countries, rice wine and liquor are popular alcoholic beverages and the given names vary from location to location such as sake, a well-known and popular traditional product in Japan (Iwata et al., 2003). Alcoholic beverages are divided into two categories based on the basis making process including fermenting alcohol beverages (wine, beer, sake, etc.), and combination of fermentation and distillation (whisky, brandy, liquor, vodka, tequila, etc.) (Lisdiyanti and Kozaki, 2003). *Sraa sor* processing belongs to combination of fermentation and distillation.

In Cambodia, rice can be a raw material to many products such as rice starch, noodle and *sraa sor* which is a traditional Khmer liquor and has been produced since long time ago. However, *sraa*

sor processing methods vary from area to area and from family to family. Hence, the objective of this research is to describe the rice liquor processing in Takeo province.

METHODS

This research was conducted in Takeo province, Cambodia. Farmers who produce *sraa sor* were targeted for interviews. The total sample number was 58 in this study. Two kinds of data, primary and secondary, were required for the research. Primary data comprised information from interviews. Semi-structured interviews and observation were used as the method for households' survey through questionnaires. Secondary data were taken from technical papers, book, journals, and other publications. The collected primary data were installed and analyzed with SPSS version 16.

RESULTS AND DISCUSION

Varieties and sources of rice: Table 1 shows the varieties and sources of rice. Forty percent of producers are utilizing broken rice mixed with many varieties, 28% of whole rice of *Srouvkrohom* (rice variety), 25% of whole rice of IR, and 7% other rice for producing liquor. All rice varieties were bought at local markets such as at millers at 18%, village markets 45.5%, own rice 9.1%, neighboring farmers 9.2% and others 17.3%. The broken rice mixed with many varieties and IR rice is cheaper than to the others. Taste was not different between whole rice and broken rice mixed with many varieties.

Table 1 Varieties and rice sources for *sraa sor* production

Types of rice	Percent	Sources of rice	Percent
Broken rice mixed with many varieties	40	Millers	18.0
Whole rice of *Srouvkrohom*	28	Village markets	45.5
Whole rice of IR	25	Own rice	9.1
Others	7	Neighboring farmers of	9.2
		Others	17.3

Types of *mé sraa* (rice yeast): Fig. 1 shows the types *mé sraa*. *Mé sraa* is the conversion of starch into sugar and ethyl alcohol. The producers utilized the *mé sraa Vietnamese* at 56.5%, *mé sraa Chinese* at 4%, *mé Takeo* at 9.5% and *mé sraa Kompong Cham* at 19.5% to produce liquor. *Mé sraa Vietnamese* is better than other *mé sraa* because they produced the high alcohol and quantity production. *Mé sraa Kompong Cham* is good at smell and taste but with low productivity.

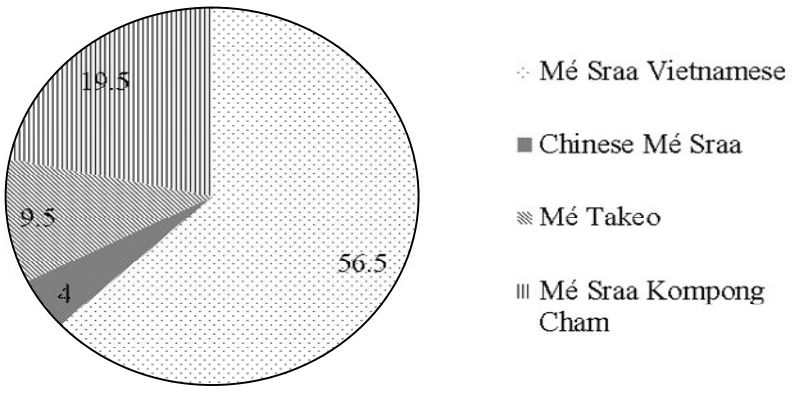

Fig. 1 Types of *mé sraa*

Types of Fuel Consumption: Fig. 2 shows the types of fuel consumption. The producers utilized rice husk at 42.5%, tree leaves 8%, rice husk mixed with tree leaves 18.5%, rice husk mixed with woods 7.5%, tree leaves mixed with woods 10.5% and rice husk mixed with tree leaves and woods 13% for cooking rice and distilling fermented liquid. Rice husk consumption is popular because it is easy to find and to control fire, and cheaper than other materials. The producers collected the tree leaves and woods by themselves.

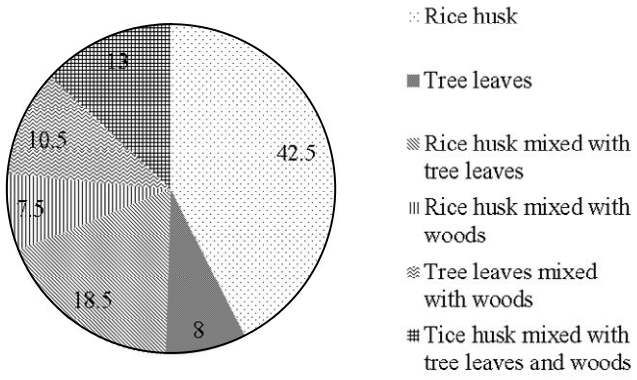

Fig. 2 Types of fuel consumption

Water Resources for Cooking and Fermentation: Table 2 shows water resources for cooking and fermentation. Water for cooking from well was 43%, pond 47% and rainwater 10%. For fermentation, water resources from well was used at 35%, pond 52% and rainwater 13%. Well and pond are normally available around their houses, except the rainwater which can be accessible in the rainy season and utilized to blend the liquor. Taste of rice liquor using well water is better than pond water because pond water have muddy smell.

Table 2 Water consumption and addition in fermentation

Water resources for cooking	Percent	Water resources for fermentation	Percent
Well water	43	Well water	35
Pond water	47	Pond water	52
Rainwater	10	Rainwater	13

Rice Cooking Methods: Fig. 3 shows the rice cooking methods. The cooking methods were boiling 48.3%, steaming 46.5% and mixing fresh rice with water 5.2%. Rice boiling is a traditional method for cooking rice. Rice steaming is acceptable for cooked method because it is non-burn and smoky smell. Method of steaming rice is better than boiling rice because of no burn rice.

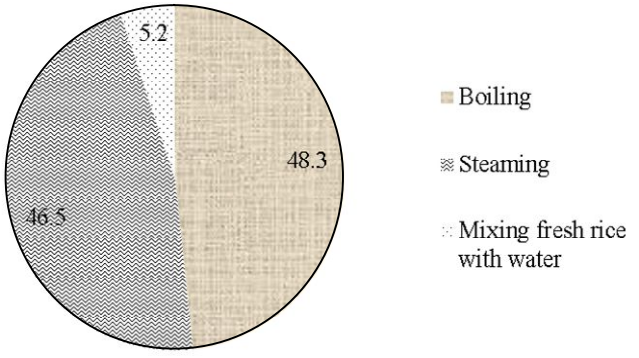

Fig. 3 Rice cooking methods

Methods of processing liquor

Preparation of rice: Materials for making liquor are rice, water and *mé sraa*. Rice was weighed according to the purpose. The rice was washed to remove rice bran and dusty and soaked overnight for water absorption.

Cooking rice: The washed rice was put to boil or steam. During the cooking, stable fire provision is needed because the strong fire causes horrible smell and taste. Therefore, the fire should be controlled from the start till the end of cooking rice.

Mixing cooked rice and *mé sraa:* After cooking rice, the steamed rice was spread from distillation pan to a mat for cooling. After that *mé sraa* was sprinkled and mixed with rice (*mé sraa* 500g / 20kg of rice).

Fermentation: Steamed rice mixed with mé sraa was divided equally into 4 pots which amount of cooked rice mixed with *mé sraa* around 10 to 12Kg per pot. Water around 20 to 24kg per pot was added in the second day (around 48 hours) without stirring the content and it was continued to fermentation for two days. The duration of fermentation lasted 84-96 hours before distillation. This fermentation process produces ethanol as Henderson (2004) stated that the principal metabolic process in winemaking is the alcoholic fermentation, which consists in the biotransformation of grape sugars (glucose and fructose) into ethanol and carbon dioxide. In a standard fermentation, about 96% of the sugar is converted into ethanol and carbon dioxide, 1% into cellular material and 4% into other products such as glycerol (Henderson, 2004).

Distillation: Put the fermented liquid and solid of cooked rice mixing with *mé sraa* and water (*baay sraa*) in the distillation pan. After one hour, *baay sraa* becomes hot. The fire control should be stable. The first drop of clouded liquor with sediment may be in 5 to 10 minutes. After 10 minutes, transparent sraa was observed and it became clouded again. The producers used plastic bottle to keep sraa sor. Usage of glasses or ceramic pots is better than plastic bottle in storage of *sraa sor* because some chemical of plastic can be extracted with alcohol which plastic smell is released into *sraa sar*. Distillation is evaporable liquor from fermented liquid of cooked rice mixing with *mé sraa* and water that the fermented liquid was boiled in a vessel which Verma (1998) showed. The vapor was led to the water cooler to be liquefied and collected to the glass bottles.

Table 3 Good and low quality of *Sraa sor*

Good quality		Low quality	
Items	Percent	Items	Percent
Sweet taste	29.0	Sour smell	43.5
High alcohol	17.0	Low alcohol	19.5
Good smell	30.5	Smoking smell	22.5
Comfortable liquor	23.5	Tasteless	14.5

Good and bad quality of *Sraa sor*: Table 3 shows bad and good quality of *sraa sor*. Good quality of *sraa sor* was sweet taste at 29%, high alcohol 17%, good smell 30.5% and comfortable liquor 23.5%. However, bad quality was sour smell at 43.5%, low alcohol 19.5% smoking smell 22.5% and tasteless 14.5%. Good quality of *sraa sor* was depending on good smell, sweet taste and high alcohol because it was preferred by consumers and easy to drink which opposite with smoking smell, sour smell and tasteless were low quality of *sraa sor*.

Local people used milled rice as raw materials for making *sraa sor*. After quick wash, the milled rice were steam/boil for 60 to 90 minutes, spread on bamboo mat for cooling, and spread of *mé sraa*. After that, put the steamed/boiled rice mix with *mé sraa* in the cups and ferment them without water 2 and with water 2 nights. The product of fermented solution was put into distillation pan and distilled. The alcohol beverage is contained about 50% alcohol. If the farmer sale this sraa to the market, they diluted the product into 30%. The processing of this method of sraa sor was similar to distilled spirit from rice wine in Southeast Asia countries (Lisdiyanti and Kozaki, 2003),

and Lao Lao rice whiskey (Hatsadong & Gibson 2006), but it is opposite to sake (Iwata, et al., 2003) and whisky (Henderson, 2004).

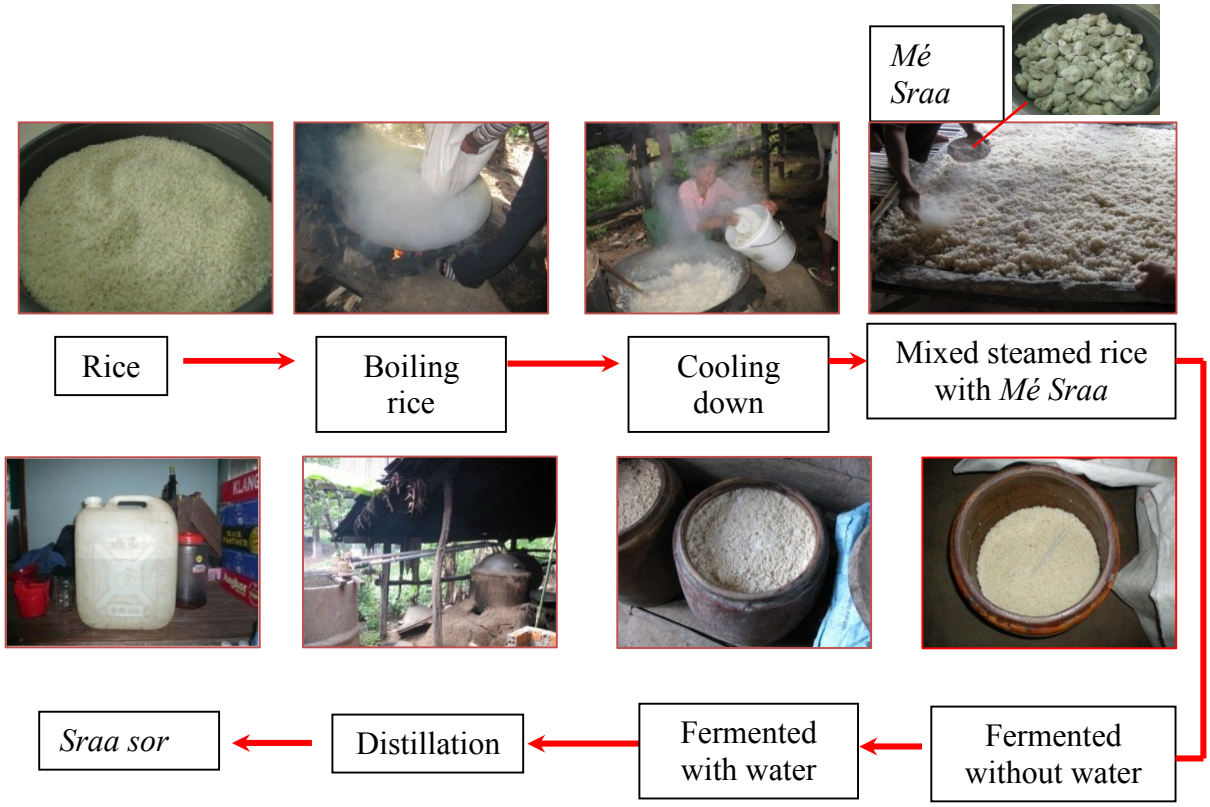

Fig. 4 Preparation process of *sraa sor*

Local people used milled rice as raw materials for making *sraa sor*. After quick wash, the milled rice were steam/boil for 60 to 90 minutes, spread on bamboo mat for cooling, and spread of *mé sraa*. After that, put the steamed/boiled rice mix with *mé sraa* in the cups and ferment them without water 2 and with water 2 nights. The product of fermented solution was put into distillation pan and distilled. The alcohol beverage is contained about 50% alcohol. If the farmer sale this sraa to the market, they diluted the product into 30%. The processing of this method of sraa sor was similar to distilled spirit from rice wine in Southeast Asia countries (Lisdiyanti and Kozaki, 2003), and Lao Lao rice whiskey (Hatsadong & Gibson 2006), but it is opposite to sake (Iwata, et al., 2003) and whisky (Henderson, 2004).

CONCLUSION

In conclusion, rice liquor process is divided into four steps; rice cooking, mixing of cooked rice with *mé sraa*, fermented without and with water, and distillation. Rice liquor processing is the combination of fermenting and distillation based on basis liquor processing. However, most of the *sraa sor* producers faced problems in *sraa sor* business such as a low sale price, high price of a raw material, low quality of *sraa sor*, and cloudy color.

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Research article

Small-Sized Fish Paste (*Prahoc)* Processing in Cambodia

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Abstract Small-sized fish paste call *Prahoc* in Khmer is one of the most popular fermented fish products used as a condiment in Cambodia. It is the main food for Cambodian people, especially the remote poor. *Prahoc* is typically made from small fish such as the common small cyprinids (*Henicorhynchus spp.*) in Khmer *Trei Reil*. It was originated as a way of preserving fish during the longer months when fresh fish was not available in plentiful supply. *Prahoc* is traditionally produced by mixing whole fish with salt at a ratio of 3:1-5:1, and fermented for 3-12 months or longer. Moreover, some problems relating with processing were found and determinded to keep for base line information for the next researchers.

Keywords small-sized fish, low value fish, fish paste (*Prahoc*), processing techniques

INTRODUCTION

Fisheries play a very significant role in providing income, employment and food security to million of rural poor in Cambodia (Zalinge et al., 2001). Hortle et al. (2004 &2005) stated that thousands of tons of small-sized or low-marketed value fish are caught each year in the Cambodia Mekong basin and in the Tonle Sap. Otherwise, the small-sized fish are also used for producing fish, animal meal and for human consumption (Nam et al., 2005).

Prahoc is a crushed, salted and fermented fish paste made from mud fish/small-sized fish such as *Trey Riel, Trei Sleuk Reussey, etc.* (Hortle et al. 2004). It is used in Cambodian cuisine as a seasoning or a condiment. Because of its saltiness and strong flavor, it was used as an addition to many meals in Cambodian cuisine, such as soups. The nickname Cambodian cheese called *Prohoc* has a strong and distinct smell. *Prahoc* is usually eaten with rice in the countryside or poorer regions. Because it is easily stored and preserved, *Prahoc* is often given out for donations to victims of flood or drought by charities and other organizations (Tamimi, 2005). Despite the importance of *Prahoc* in daily food of Cambodia, its processing technologies are not yet well understood or documented. The purposes of this study are to review existing methodologies, determine problems and to analyze economic aspects of small-size fish paste production. The data that has been done is all useful and provided baseline information to improve the agricultural exploration in university and the whole Cambodia.

METHODOLOGY

The study on *Prahoc* processing techniques were conducted in four major provinces namely; Kandal (KD), Kampong Chhnang (KG Chh), Battambang (BB), Siem Reap (SR) in addition to the area in Phnom Penh. The research instrument was represented by using standard semi-open questionnaires with 100 samples (20 samples of micro, small, medium, and large-scale per province/capital). The samples are purposively selected. The collected data was analyzed through SPSS version 12. For economic efficiency, the data was installed and analyzed in Microsoft Excel and the formula of Economic Efficiency = Total Revenue (TR) divided by Total Cost (TC) was used.

RESULTS AND DISCUSSION

Based on the result obtained in the study, the types of *Prahoc* processing are divided into four scales. Those are micro, small, medium and large scale.

Micro-scale: The annual fish input is less than one ton. Production was done using a process usually by a household. The capital used is less than 100 USD. The *Prahoc* was used for home consumption and exchanged for food and other basic supplies. No license is required.

Small-scale: The annual *Prahoc* input is less than 50 tons. Fermented fish paste is made for commercial purposes. The capital is less than 10,000 USD. The permanent workers are about 3-6 persons and the casual workers are about 10-15 persons. A license to run the business is also required and is issued by either provincial or central government institutions.

Medium-scale: The annual *Prahoc* input is more 50 tons to 1,000 tons. It is being produced for commercial purposes by a hydrolysis process, and production involves large investment and relatively high operational costs. The capital is between 50,000-100,000 USD. The permanent workers are about 3-6 persons and the casual workers are about 20-25 persons. Operation requires a license from Ministry of Agriculture Fisheries and Forestry (MAFF), and Ministry of Industry Mine and Energy MIME.

Large-scale: The annual fish paste input is more than 1,000 tons. Prahoc is being produced for commercial purposes by a company process and production involves large investment and high operational costs. The capital is more than 100,000 USD. The permanent workers are about 10 persons and casual workers are about 25-50 persons. A license is required from Ministry of Agriculture Fisheries and Forestry (MAFF), Ministry of Industry Mine and Energy (MIME) and Ministry of Commercial (MoC). This scale has had only in Battambang province.

These four categories of *Prahoc* industries are according to the definition set by MIME (2003) on the enterprises. However, investor and laborers in these studies were not exactly numbered because the system of processing in Cambodia is not yet clarified.

Fish is the raw material for production of *Prahoc*, then salt. As shown in Table 1, fish species commonly utilized for *Prahoc* are those of Trei Reil *cyprinid henicorhynchus Trei sleuk reussey* and other fishes were also used such as bagrid catfishes *(Kanchos)*, barb *(Chpin)*, Thai river sprat *(Bandoul Ampov)*, perchlet *(Kanhchras Thom)*, carps *(Linh, Khnorng Veng, Srakar Sdarm, Kros, Angkok Prak, Chanteas Phluk and Kaek)* and elephant paradiseus fish *(Kompeus)*, river catfish *(Pra)*. However, *Trei Kompleanh* species is only being used in Battambang and Siem Reap provinces.

Table 1 Amount of fish for *Prahoc* production

Kinds of fish	Name of provinces and capital					Total (%)
	PP	KD	KG Chh	BB	SR	
Trei Reil (70-95%)	20	20	20	20	0	80
Trei Sleuk Reussey (5-10%)	20	13	9	17	0	59
Trei Kompleanh (100%)	0	0	0	20	20	40
Other fishes (5-20%)	20	20	19	20	0	79

Table 2 showed the percentage of the amount of salt in *Prahoc* production per ton of fresh fish. About 45% of the producers responded that the salt appropriate for producing *Prahoc* is 300 kg per ton of fresh small-sized fish. Most of the producers (67%) obtained 450 kg net production of *Prahoc* from the fresh fish in one ton. On the other hand, 17% of producers able to produced 550 kg of *Prahoc* per ton of fresh fish.

Table 2 Salt using for *Prahoc* production

Amount of *Prahoc* Production	Amount of salt					Total (%)
	150	200	250	300	350	
≤ 350	0	7	5	2	0	14
≤ 450	3	6	11	37	10	67
≤ 550	1	4	6	6	0	17
≤ 650	0	2	0	0	0	2

Prahoc processing techniques differs depending on the location of factory and the scale of production. Beddows (1985) illustrated that method of processing is fish preservation and a concentrated form of fermented fish (Hortle, 2007). Fish are beheaded and cleaned well to prevent spoiling from their own microorganisms in the slim, gut and gills on their bodies. These microorganisms as well as the enzymes in the fish tissues, bring about putrefying changes in fish when it dies (Parry and Pawsey, 1973). Salt is used as preservative to prevent spoilage and to stabilize fermentation. The smell of *Prahoc* also differs according to the amount of salt used. Watanabe (1982) showed that the characteristic smell of fermented fish is the result of enzymatic and microbiological activity in the fish muscle. Rahayu (1992) recorded that the first salting step takes several weeks to develop its characteristic flavor and texture, and this is followed by a maturation phase. Only one producer in Kampong Chhnang province said that they used chemical substance like insecticides to preserve fish. Unfortunately, these chemicals are taken without any strict control over the safe dosage level. Hence the product, though protected from insects, could be harmful to consumers. In this stage, it is in line with Azeza (1986) and Kofi (1992).

***Prahoc* processing chain for micro scale in the province and capital**

Fig. 1 *Prahoc* Cha-eang processing

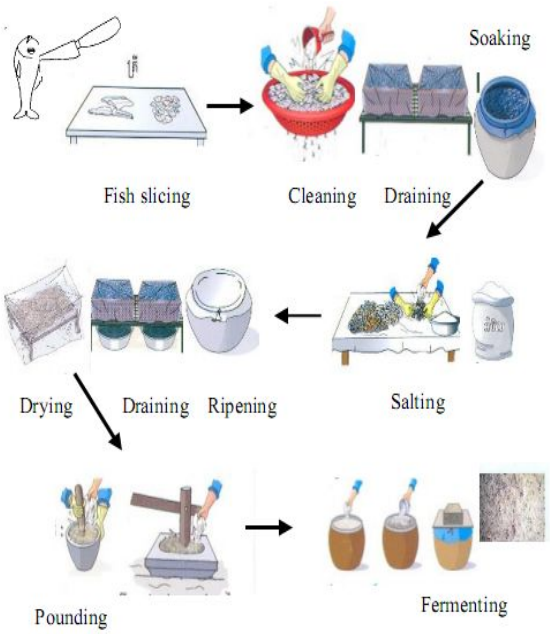

Fig. 2 *Prahoc* Sach processing

***Prahoc* processing chain for small, medium, and large-scale**

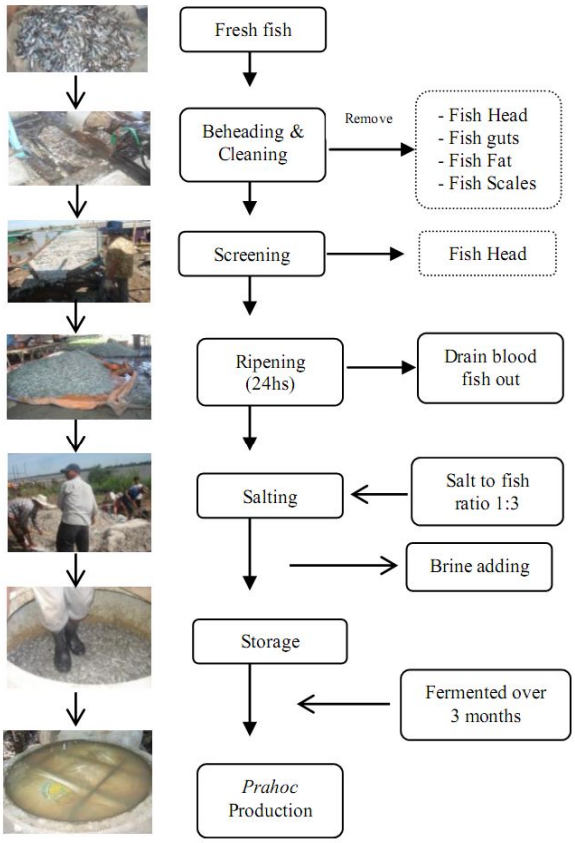

Fig. 3 Processing chain in Phnom Penh and Kandal

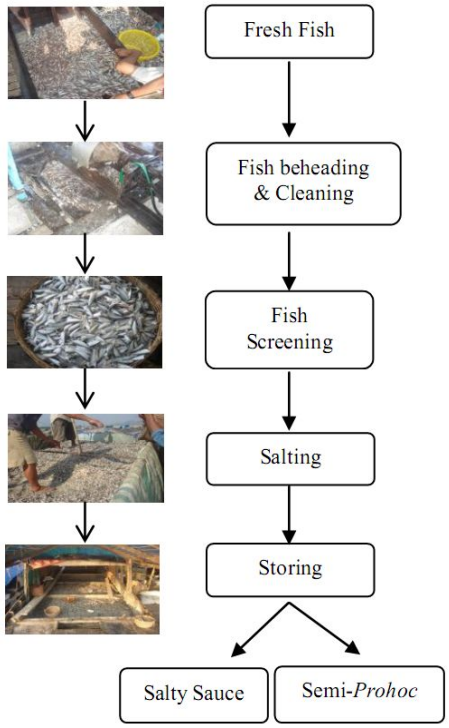

Fig. 4 Processing chain in KG Chhnang

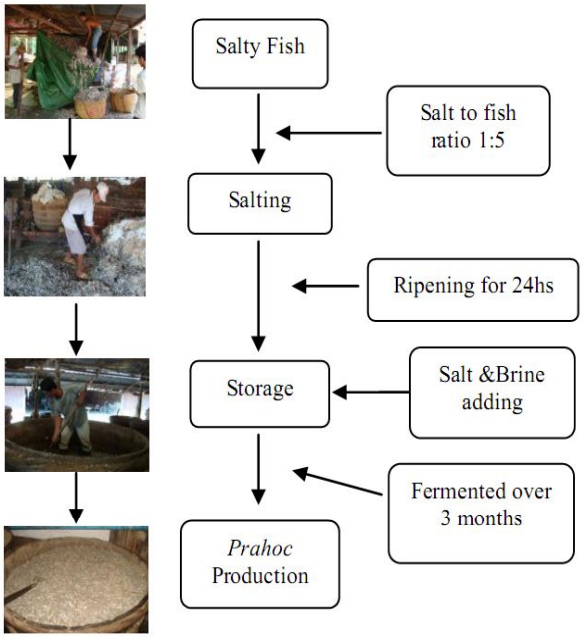

Fig. 5 Processing chain in Battambang

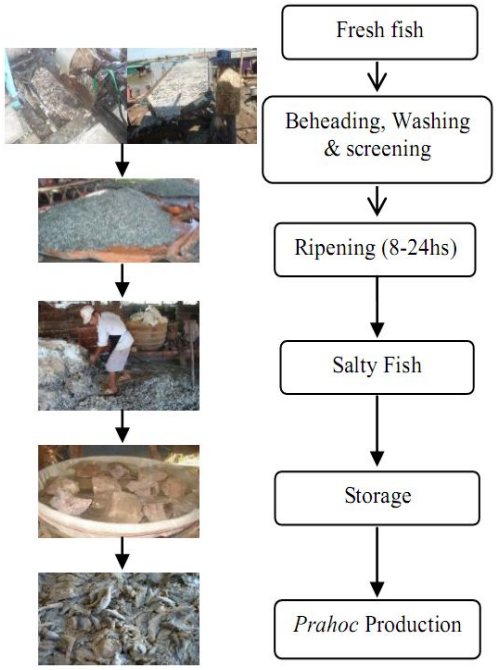

Fig. 6 Processing chain in Siem Reap

The main problems faced by producers were; 1) poor quality and hygienic conditions of inland small-sized fish paste due to the lack of quality control system in Cambodia, leading to fluctuation of demands for export markets and change in price 2) increasing price of raw materials such as fresh small-sized fish and salt indicating an increase of 50% and 75% respectively 3) lack of good information on domestic and foreign sources of technology and equipments/materials, for example: non-existing reasonable grading and packaging materials, leading to underdeveloped export market 4) shortage and lack of working capital to start or expand the business due to a very high interest rate from most local micro credit intuitions or banks 5) low technical skills that are shown by 25% to 40% 6) poor research; and 7) lack of trained human resources in fish processing.

Table 3 Major problems and constrains in *Prahoc* production

Constrains in *Prahoc* production	Name of province and capital					Total (%)
	PP	KD	KG Chh	BB	SR	
Expending on fee and non-fee for authority	0	1	0	19	12	32
Difficulty in determining the market price of final production	3	6	5	0	10	24
Low price of *(Prahoc)*	18	15	3	1	1	38
Affordable competition for fresh fish	5	12	0	20	13	50
High price of salt	12	3	20	20	20	75
Addible water before weight	5	0	0	19	0	24
Unclean processed fish	17	3	2	19	0	41
Rancidness	7	12	7	12	1	39
Salting is not good in the first stage	5	6	5	11	0	27
Lack of workable capital	2	0	9	20	0	31
The company blends the price of fresh fish	0	0	0	16	8	24

Micro scale *Prahoc* production in Phnom Penh, four provinces of Kandal, Kampong Chhnang, and Battambang was minus while the medium-scale *Prahoc* producers have the highest economic efficiency. Meanwhile, producers in Siem Reap were getting suitable profit because of the price, kinds of boneless *Prahoc*, and quality. Producers have kept *Prahoc* for their own consumption due to the intuitions that *Prahoc* in the market are being used with chemical preservative and poor sanitation of *Prahoc* production.

Table 4 Economic analysis of *Prahoc* scales in the provinces and capital

Scales	Economic efficiency				
	PP	KD	KG Chh	BB	SR
Micro	0.67	0.59	0.83	0.72	1.87
Small	1.10	1.06	1.19	1.37	1.81
Medium	1.67	1.62	1.12	1.39	2.34
Large				1.39	

CONCLUSION

According to the production scale of *Prahoc*, there are two kinds of small-sized fish paste processing in Cambodia. First, micro-scale is divided into two types which are bony and boneless (Cha-eang and Sach in Khmer) *Prahoc* processing technique. Second, small, medium, and large-scale are processed as bony *Prahoc*. Bony *Prahoc* processing technique is documented in all five surveyed provinces. It is mostly consumed by the poor who have limited income.

Boneless *Prahoc* processing technique is documented in the surveyed provinces by using 2 species of small-sized fish; the moonlight *gourami trichogaster microlepis* and the three-spot *gourami trichogaster trichopterus*. It is being sold at a higher prices compared to that of bony small-sized fish paste. Moreover, the two main problems encountered in *Prahoc* processing are the

fluctuation of prices of raw materials and lacking of technical skills such as hygienic and food safety practice. Micro-scale *Prahoc* producers gained negative incentive except in Siem Reap province because that they are producing boneless *Prahoc* which could be more profitable in the market. Based on the results on this research, it was concluded that improving the quality, hygiene and safety of *Prahoc* is necessary to be improved in order to increase the demand of *Prahoc* products.

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Research article

The Process of Establishing and Functioning of Farmer Water User Committee (FWUC) of SCIRIP

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Abstract The Stung Chinit Irrigation and Rural Infrastructure Project (SCIRIP) aimed to improve living standard of the local farmers through increasing the size of farmlands and at least 2 times per year in rice farming. However, the total targeted area of 7,000 ha in the wet season and 30% in the dry season reached only 2,960ha and 20-30% respectively (mostly vegetation) and the yield was still low. The FWUC was established, but the project was still a problem for the farmers. The study aimed to: assess the process of the FWUC's formation and its roles and responsibilities in providing services to its members, assess the functioning of the FWUC and its performance compared with the defined roles and responsibilities, and analyse constraints and potentials of FWUC encouraged participation from its members. The researchers selected 10 different villages from 3 communes including 100 households of members and 50 households of non-members, 2 persons from FWUC, 10 village heads and 1WUG in each village, and 1 representative from each PDoA, CEDAC, AFD, GRET and PDOWRAM to be interviewed. The results showed that the project was designed with insufficient study of the location. There was too deep of a drain, too small of a watercourse of tertiary and quaternary canals, unequal land uniformity and poor quality of soil (basalt, young and old alluvium). The formation of the FWUC and its regulation did not involve participation from all its members. Moreover, only 50-60% of the regulations were implemented and these focused a lot on fishing activities, management of cattle and buffaloes, and the use of roads and ox-cart tracks, but less on management, water distribution, irrigation and canal protection. The participation from farmers was poor for the small plots of land they owned, traditional habit of rice field protection, multiple jobs, poor commitment and cooperation amongst farmers in system protection. In addition, pest booklets caused problems. The problem resulted from internal factors; poor project design, poor FWUC's implementation, poor participation from farmers and external factors; pest booklets and poor soil conditions.

Keywords farmer water user committee, participatory, cooperation

INTRODUCTION

The irrigation scheme plays a very significant role in irrigating the fields. It has been a public policy issues and development discourses in Cambodia for long time. Many irrigation schemes in Cambodia were constructed during the Pol Pot regime. However, most of them were deteriorated after the regime was collapsed (Try, 2008). The importance of the scheme is to eliminate poverty through increasing production, the agricultural sector was targeted by the Royal Government of

Cambodia (RGC) to accelerate the development of the irrigation project: 'Development of Water Resources Management and Irrigation Infrastructure are to Increase of Agricultural Productivity'. Moreover, MOWRAM remarkably focused on agricultural sector, one of the four priority sectors in term of assurance of food security and improving living standard (Philippe & Sebastien, 2009).

One of the most biggest irrigation schemes is the Stung Chinit, the fifth largest schemes in Cambodia, felt into a state of disrepair in the late eighties and it was not well operated (FACT, 2004). Up to 1997, the preliminary assessment was considered on the possibility of rehabilitation. In 1999, the RGC proposed to Asian Development Bank (ADB) and Agencies France Development (AFD) to support the existing infrastructure in order to provide supplementary irrigation and reach the target of 7,000 ha in the wet season and 30% in the dry season (Philippe & Sebastien, 2009).

The major difference in SCIRIP was that the output could not reach to 7,000 ha and most of the farmers practiced farming only one time a year during the wet season (ADB, 2009). Moreover, the theory was well applied in the wet season (May to December) varying between 3 to 6 months and less in the dry season mostly vegetation. The productivity was very low (ADB, 2006).

The study proposed to find out what was the issue taken place between the FWUC and the Farmers and explained the process of FWUC's formation and its roles and responsibilities in providing services to its members, the functioning of FWUC and its performance compared with the defined R&R, and the constraints and potentials of FWUC to encourage participation from its members.

METHODOLOGY

The study was conducted in 3 communes; Kampong Thar, Beong Lvea, and Prasat, Santuk District, Kampong Thom Province are the command areas of the SCIRIP and it covered 25 villages, including Banteay Yumreach village that participated after the project was completely finished in 2008.

The selection was including 100 households of members and 50 households of non-members, 2 persons from FWUC, 10 village heads and 1 Water User Groups (WUG) in each village, and 1 representative from each PDoA, CEDAC, AFD, GRET and PDOWRAM was interviewed.

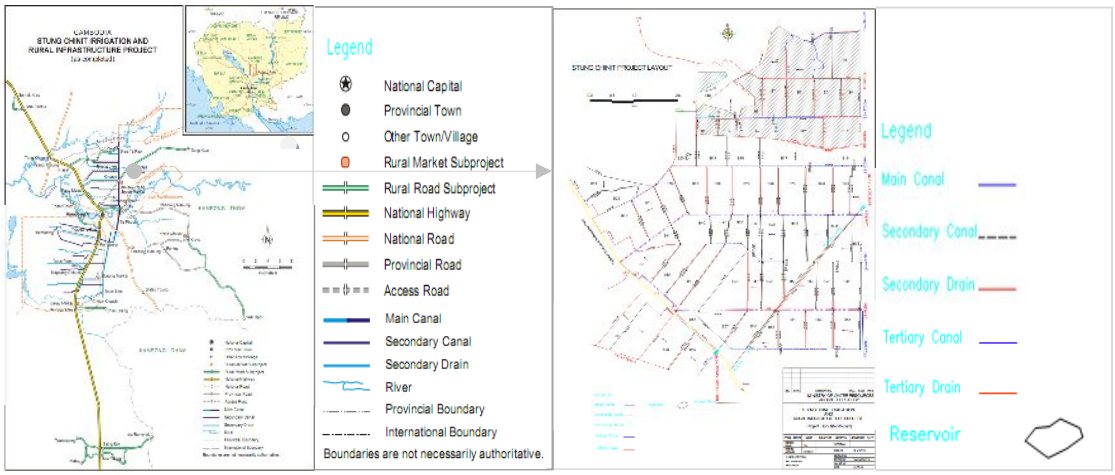

Fig. 1 Map of research zone (ADB, 2009)

RESULT AND DISCUSSION

The project was implemented in 2001-2008. The target area decreased by over half (from 7,000 ha to 2,960 ha) due to the change of scope caused by insufficient study, over-lower estimation on the project cost from $26 million to $23.8 million, improper designing and constructing of

infrastructures (ADB, 2009). However, the project was still running in providing services to the farmers.

First, the meeting was held within stakeholders on the project objectives and benefits then the results were disseminated to the local farmers. Second, the training was held on the functions, roles and responsibilities, organization, rules and regulations of the FWUC as well as the work plan. After that, the election of the FWUC and WUGs was attended by the local farmers around 60-70% in each election. The last election was held on November 18, 2010. Then the FWUC planning was prepared and proceeded. The irrigation was planned to start in August 2004; however, due to the change of scope it was postponed until July 2006. To minimize the impact of delays, the block pilot of 50ha by pumping was implemented. Next, they proposed study tours to Siem Reap province led by GRET and CEDAC in 2002, then to Kamping Puoy, Prey Nub and O Treng to gain experiences as well as to learn the way to manage the scheme from those locations.

Table 1 FWUC' formation and supervision milestones

Milestone no.	9	10	11	12	13	14
OUTPUT SCHEDULE	Project and FWUC concept Orientation	FWUC Election	FWUC Planning	FWUC Management	FWUC Study Tour	Supervision During Defect Liability

The liability of the whole system was supervised by the FWUC in September 2008, but it still needed to be supported from CEDAC and GRET as well as to keep improving the work proceeding for the poor management of the FWUC to the whole system.

FWUC roles, responsibilities and meetings

The FWUC had been led by the 5 committees. The chairman was in charge of general supervision, first vice-chairman was in charge of maintenance and repairing plan, second vice-chairman was in charge of water supply distribution, the treasurers were in charge of finance while all WUGs and members were in charge of report farmers' demand. The executive director was in charge of general management and administration affair.

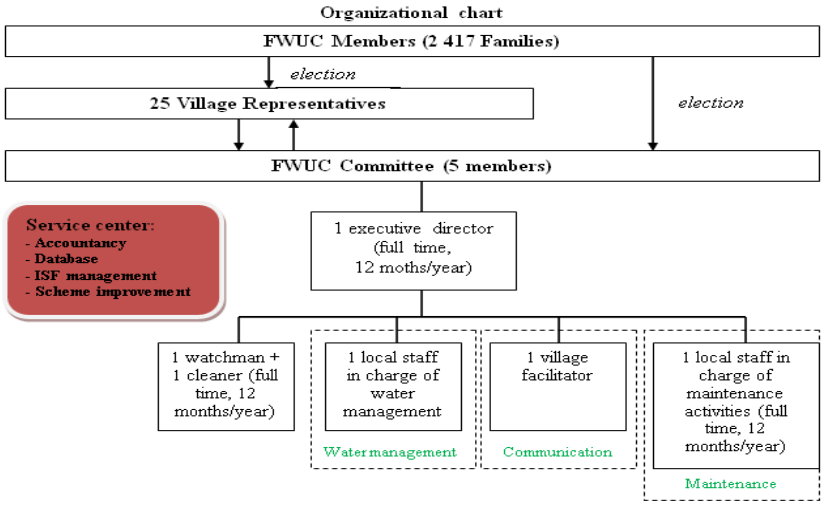

Fig. 2 FWUC`s structure (Philippe & Sebastien, 2009)

There were two kinds of meeting; the general assembly meeting held once a year between FWUC, WUGs and block rangers. General meeting is being held two times a year (in the early and the end of the wet season) including with the local farmers however only members could join to the meetings.

System protection, irrigation service fee (ISF) and water supply

The FWUC took control of the whole system and met the needs of the farmers' demand. There was much control during the wet season when the cultivation season was, but less in the dry season for about 12% of the farmers practiced rice farming. The block rangers did not act in the dry season. In the wet season, the FWUC took actions such as reparation of dikes and canals, managing water flow and solving problems of water distribution, controlling fishing activities mainly during the wet season when the water gate was opened, and the FWUC needed to cooperate with the local polices to take control day and night of the violators, both members and non-members, controlling animal herding (mostly in the wet season due to the canals were wet which was easy to be damaged), managing ox-cart track by avoiding leading it along the Secondary Canal (S.C), Drain Canal (D.C), Farm Drain Canal (FD.C) and S.C bridges. In addition, due to the soil infiltration the FWUC blocked the head end of the farm-drain canals to keep water in the fields. The violators were fined for the system deterioration. The fining was 5,000 riel/time or 5,000 riel/animal. The animals or fishing tools were caught and kept until the owners came to negotiate.

The ISF was started collecting in 2007. The collectors were including village heads and WUGs. They normally blamed by the local farmers due to the insufficient water supply to the farmers' fields. It was shown that 21% of them complained on the high price of the ISF and they wanted the ISF to be lower of 23,889 riel/ha. The FWUC had no choice but to lower the ISF because it was set from the MOWRAM. However, the FWUC tried to supply much water to the farmers' fields. As a result, the ISF collection was achieved by about 70%-90% in 2010.

Water was not supplied well enough to all the fields due to the distant of the fields from the sources, unequal of ground level, too large and deep of the Main Canal (M.C), too small of the head of flume (about 10 cm), which could not be able to allow water flowing through the Tertiary Canal (T.C) and distributing to the Quaternary Canal (Q.C) then flowing into each field. The FWUC tried to provide supplementary water to reach the end of the fields, but the problem was still happened causing the flood of the low land plots.

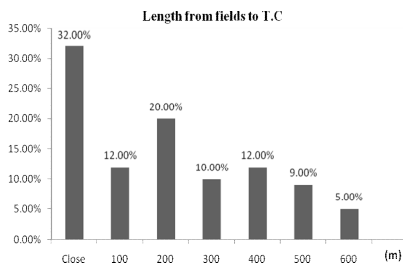

Fig. 3 Length from fields to T.C.

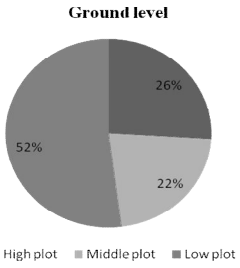

Fig. 4 Ground level

Table 2 Water distribution with land uniform

Water distribution	Low plot	Middle plot	High plot
Flood	18.18%	0.00%	0.00%
Enough	34.85%	23.53%	5.88%
Less shortage	25.76%	52.94%	58.82%
Not enough	21.21%	23.53%	64.71%

Regulation enforcement and participation of farmers

The regulation was well implemented only 50-60% on fishing activities, management of cattle and buffaloes, and the use of roads and ox-cart tracks, but less on management, water distribution, irrigation and canal protection. The problem was caused by poor scheme design and toleration with the farmers. The unqualified staffs within the FWUC established by the parcel election of 5

members a group as well as the short-term mandate (3 years/mandate) affected to the poor system and administration management. In addition, all the income from the ISF and expenditure were not indicated clearly to the farmers, especially expenditure on the canals reparation. The work of the block rangers was 2 times a week and 4 months a year in the wet season; however, in the dry season the block rangers had no tasks in the fields. The wage was very low, 80,000 riel/time which did not encourage the block rangers to well associate with their work.

The participation by the farmers in the scheme was poor even in the meeting, system protection, and cooperation. Only about 30-60% of them participated in the meeting (58% of them came to join regularly and 42% of them came irregularly). The problem was caused by dissatisfaction to the FWUC and business with their jobs. The local farmers (both members and non-members) in the command area had multiple jobs which make them busy with their activities. As a result, they did not want to join the meetings. Moreover, they still adhered with traditional rice farming and other field operations. The farmers left their fields after sowing or broadcasting due to such problem. In addition, the farmers owned small plots of land in the blocks that did not convince them to care much the fields. The poor traditional habit of the farmers of herding and feeding animals in the blocks in the wet and the dry season caused the damages on the scheme. It mostly happened in the wet season.

Table 3 Land area of the local farmers in the command area

Household by land size (%)			Farmland size in the block (Ha)		
<1 Ha	1-2 Ha	>2 Ha	Max	Min	Average
62.79%	30.32%	6.98%	3.00%	0.01%	0.93%

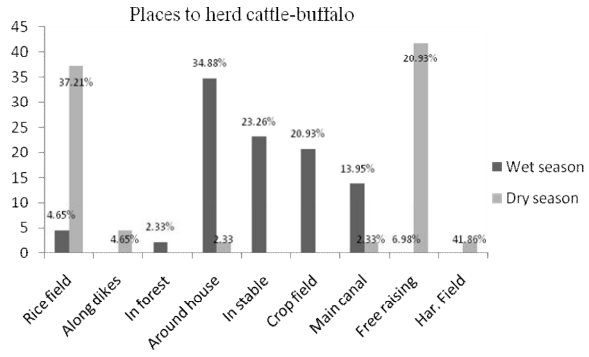

Fig. 5 Places to herd animals

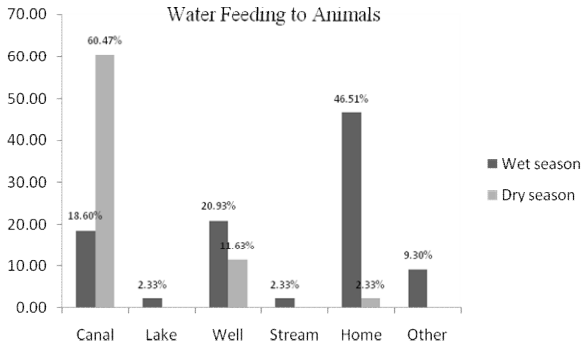

Fig. 6 Places to water feeding to animals

Other factors and potential

Unfertile and sandy soil (basalt, young and old alluvium) could store water in the fields of about 60-70% only compared to the water flow recently (Philippe & Sebastien, 2009). Outbreak of the insect, especially brown hopper come in February and March and destruction by crabs or snakes and so forth caused the defect of the farmers' effort in the dry season.

The FWUC tried to manage the system by cooperating with the farmers to control the whole scheme, particularly revising the Farm-drain Canals (FDC) to keep water in the fields. The farmers were willing to pay the ISF due to good elaboration and receiving water to grow rice earlier compared to other site (Baray district). The FWUC, stakeholders and farmers themselves tried to take action on the risk factors together to improve living standard of the local farmers.

Suggestion to key informants and farmers, advantages and disadvantages of the system

To settle the stated problem, the local farmers should gradually change the season to avoid presenting of brown hopper including changing of rice seed. Also, they should change their

traditional habit of herding animals and fishing activities. Moreover, farmers should grow the same rice seed. The head plots/low plots owners should grow earlier to prevent from flooding. In addition, farmers should make well cooperation all together to build up the farm dikes to keep and share water to other fields; especially, they should actively participate in the system protection. The FWUC should follow much with the farmers' idea to make cooperation closer.

Before the project was started, the old system had benefits such as enough water to all fields, easy to flood and drain the fields, enough rice yields, no ISF, no brown hopper. However, it could not be practiced in the dry season for the lack of water supply, not clear structuring, easy to be damaged by free animal raising and fishing activities due to self management. Whereas, the new configuration scheme had benefits including good structuring, good management, earlier growing, reduction of violators and at least one time a year of rice growing. However, the yield was still low due to too small of T.C, Q.C and head of flumes, ISF collection, and not enough water supplies.

Recommendation

The farmers should change their traditional habit of animals tending and fishing in the blocks as well as change rice farming season started from March avoiding from brown hopper. Moreover, they should join hand together in rice farmers; the same seeds, the low plots/closed plots to the T.C should be grown earlier, build up the dikes, and carry out the regulations. The FWUC and WUGs should actively protect and manage the system and follow the good expression of the local farmers.

CONCLUSION

The quite difference change of the target project area of 7000 ha in the wet season and 30% in the dry season was due to the change of scope. The FWUC and WUGs were established and the roles and responsibilities of the FWUC and the internal regulation were created simultaneously. Actually, the roles-responsibilities and regulation were better in theory, but it could not be well in implementing due to the insufficient study of the real location, looseness of regulation enforcement of the FWUC for toleration to the farmers, and the traditional habit of the farmers in animals herding, fishing activities and careless of rice farming. It also caused by insect, unfertile/sandy soil and soil infiltration. However, the whole scheme had been better since then because the local farmers were getting leant of the regulations and implementation. In addition, the FWUC were willing to cooperate with the farmers in revising and practicing cultivation.

ACKNOWLEDGEMENTS

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Research article

The Role of Gender in Decision-Making in Investing and Managing the Household Livelihood in Stung Chinit Irrigation Common Area, Kampong Thom Province

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Abstract Cambodian populations had 52% of women and 48% of men, where around 80% are farmers living in rural areas. Women are basically influential in generating family income. However women's role on decision-making in household livelihood is commonly ignored. So, the study aimed to assess the social class in every household livelihood, to assess the status of decision-making about household livelihood, and analyze the constraints and opportunities of women in decision-making. The result showed that 10% of households were rich, 50% were medium, 30% were poor and 10% were underpoor. In main jobs, 84% of households planted rainy season rice, 11% were business owners, 3% sell labour, 3% was Governmentt officials, 2% planted dry season rice, 2% did chamka and 1% did other jobs. In sub-jobs, 79% of households raised animals, 37% did chamka, 21% was business owner, 16% sell labour, 6% collected forest product, 1% planted rainy season rice, 1% planted dry season rice, 1% was fisher, 1% was motor taxi-driver and 1% did other jobs. The heads of families were mostly men except for widows and single women, who play very important roles as heads of their families as decision-makers. The constraints of women in decision-making in household livelihood were due to: poor education, poor technical skill, busy on doing house work, weak health, poor self belief, poor self confidence in decision-making, no paticipation in society, traditional culture, and poor recognition on the income received from husband work. In constract, the opportunities were: patient, hardwork, fullfiling works, saving money, joining on decision-making in family and supported by government and NGOs. In conclusion, female participation in decision-making is very necessary for household livelihoods. So, the Government, NGOs, society and women themselves should participate to bring empowerment to women in decision-making, investing, managing and improving household livelihoods.

Keywords gender, decision-making, household livelihood, female empowerment

INTRODUCTION

In regards to its early history, Cambodia is amongst the oldest countries in Asia to have developed a well-known civilization and economy. But since the recent civil war which lasted about 2 decades, Cambodia has suffered losses in almost all sectors, especially in the source of human resources and in the wealth that has the power to move, build and develop the country. Now Cambodia is trying

to rebuild every sector including the agricultural, the economy and especially the human resource sector, which are necessary for Cambodia to be better.

In 2004, the estimated population of Cambodia was 13.1 million. 48.3% were male and 51.7% female "(MP, 2005, CCoC, 2008)". Moreover, the population's annual growth rate between 1998 and 2004 was 1.81%. 85% of Cambodians lived in rural areas and the average household size was 5.1 people "(MP, 2005, CCoC, 2008)". Results given from the March 2008 Census estimate that the country's population was 13,389,000, of whom 48.5% were male and 51.5% female. 80.6% of Cambodians live in rural areas. The average household size is 4.7 people "(Sar Kheng, 2008, CCoC, 2008)". About 42% of Cambodian women and 21% of men above the age of 15 have never attended school. According to NGO reports, women make up 52% of the population, 60% of agricultural workers, 85% of the business work force, 70% of the industrial work force, and 60% of all service sector workers. On average, Cambodian women receive one third less pay than men with similar education and experience for comparable work, 26% of households are headed by women; and only 20% of Cambodian women have access to reproductive health services and products "(PPP, 2004, CCoC, 2008)".

Livelihoods have an important role for developing family and national economies. Farmers have tried hard to work to support themselves even while they are facing the cycle of development. Their system of livelihood will be improved because the Cambodian Government, NGOs and local authorities have encouraged and strongly supported them "(MAFF, 2006)". Around 80% of people living in rural areas are farmers and do works involving agriculture. Thus agriculture has a main role for household livelihoods in rural areas. Cambodian farmers could get good incomes by growing and selling vegetables. However, many farmers cannot exploit this opportunity because they lack the knowledge, good quality inputs, credit, and market information (IDE, 2009). Similarly, most farmers have low incomes because their livelihoods depend strongly on low-yielding rice production. They lack a reliable source of irrigation that would enable them to diversify into fruits and vegetables which are more nutritious and marketable "(IDE, 2009)". In addition, even though women participate in this household livelihood development, the division of roles and levels of participation of genders are not clear. Therefore, to gain knowledge about these unclear points, the researchers conducted a research titled 'The Role of Gender in Decision-Making in Investing and Managing the Household Livelihood'.

This research contains the overall objective of the study, which was to find out the factors influencing the gender participation on decision-making in investment and managment of household livelihoods.

METHODOLOGY

The Kampong Tom province was chosen as the study site of this study due to the interest of the project donors in the subject; Constraints for Farmers in Realizing the Potentials of Stung Chinit Irrigation Infrastructure. The research was conducted around the common areas of the Stung Chinit irrigation in Kampong Thom province. The reseachers selected 144 households, including 72 mens, 72 women; and 10 village chiefs in 10 villages, 3 communes and 1 district in Stung Chinit irrigation commmon areas. To make a good sampling justification, the researcher chose people living in the Stung Chinit Irrigation common area and then selected samples by stratified random sampling. The data was collected from both secondary and primary sources (direct observation, group discussion, in-depth interviews, semi-strutured interviews and case study). The questionnaire was designed to conduct a baseline survey on the current roles of gender in decision-making on investing and managing household livelihood and was divided into 6 sections as follows: general information, household livelihood, gender's form of job analyzing, decision-making of gender in household livelihood, form of managing resources and gaining benefits, and constraints and opportunities in decision-making of women, which were created from the status of household livelihoods and decision-making processes.

RESULT AND DISCUSSION

Head of household

The headship of a household is a very important role. The head is responsible of all the household livelihood and is the one that all the members in the family depend on, respect and love extremely. The research indicated that male head of households had 85% and female head of households had 15%. This showed that the head of households are mostly men except for widows and single woman.

The career of gender in household livelihood

Household's careers can be divided into two parts: main jobs and sub-jobs. Main jobs are the important or very necessary jobs which households thought could provide high incomes to fulfill the demands of the family. Sub-jobs are the jobs that provide incomes to households less than main jobs, but they are important also because all people need both, main and sub-jobs. In this regard, the result in Table 1 showed that planting rainy season rice was the main job of households which had the highest percentage (84%), where women were (44%) and men (40%). In the other hand, in sub-jobs, it indicated that most households breed animals as family standard (79%), where 41% were women and 38% were men. This means that household's livelihood mostly depended on farming. Generally, Cambodian farmers always plant rice during the rainy season so their rice field yield depends only on natural rain. They do so because they have lots of rice fields, rainy rice yields are higher than dry season rice fields, and because it is the tradition for them. Meanwhile, according to the World Food Program (WFP), in 2010, households living in rural areas in Cambodia depended on multiple sources of income for their livelihoods, but they differed due to agro-climatic conditions. Most rural residents still live in traditional ways, primarily cultivating rice and collecting natural resources from water bodies and forests, thus, agriculture, here, includes: crop and livestock production, forestry and fishing activities. This remains the primary occupation for 72 percent of households, yet accounts for only 31 percent of gross domestic product. Thus the crucial importance of off-farm incomes, like remittances, wage labor and non-agricultural self-employment, that are growing rapidly.

Table 1 Main and sub-job of households

Description	Main Job (%)			Description	Sub Job (%)		
	Women	Men	Total		Women	Men	Total
Planting Rainy Season Rice	44	40	84	Raising Animal	41	38	79
Business Owner	8	3	11	Doing Chamka	16	21	37
Selling Labor	1	2	3	Business Owner	16	5	21
Govn't Official	1	2	3	Selling Labor	6	10	16
Planting Dry Season Rice	2	0	2	Collecting Forest Product	1	5	6
Doing Chamka	2	0	2	Planting Rainy Season Rice	1	0	1
Others	1	1	2	Planting Dry Season Rice	0	1	1
				Fishing	0	1	1
				Motor Taxi-Driver	0	1	1
				Others	0	1	1

Averaged income of household per year

Income of households, whether it increases or decreases, is the necessary factor to improve livelihood. Households can gain income by doing many jobs involved with both agriculture and non-agriculture. In this way, as seen in Fig. 1, the highest income of households is from running their own business and women's income was more than men from this job as well.

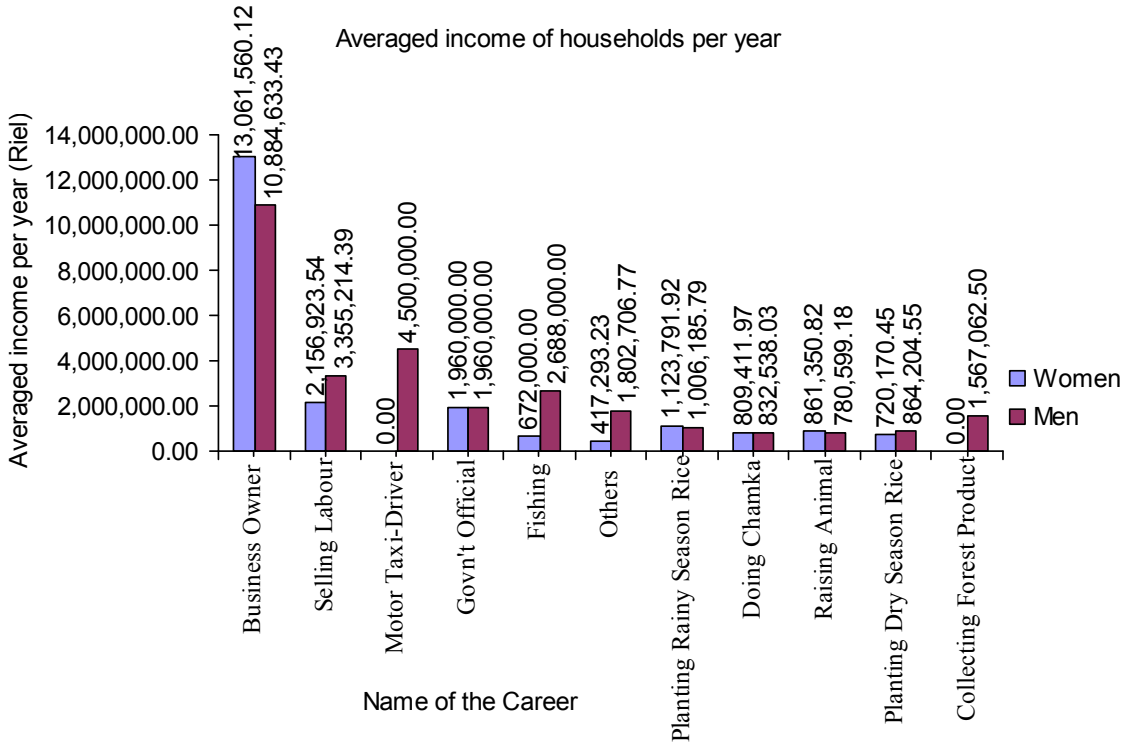

Fig. 1 Averaged income of gender per year

The data in research showed that the income of men was higher than that of women. It clarified that the men in the study area did many jobs involved with agriculture and non-agriculture activities in both rainy and dry season, such as collecting forest products, selling labour, motor taxi-driving, fishing, doing own business and doing other jobs. Income of men was more than that of women, even though; women participated in agricultural activities more than men did. In contrast, women usually could not do extra activities in the dry season like the men did because women were busy doing housework, taking care of the children and managing the house. In addition, women's education was poor and the women could not do the work which was located far from their home, so women could only do small business at home. In the same way, women provided more agricultural labour, especially in rice planting and harvesting, than men. Women have a substantially greater capacity for group work in these tasks, since as many as twelve or fifteen women work together in each other's fields. The important point in this differential work load is that of taking care of the children, preparing food and cleaning the house, none of which is done by men, except for child care during the wife's absence (RGC, IMRC, MWRM, ADB, 2006).

Status of gender's decision-making in household livelihood

Decision-making of gender in livelihood in this study had two parts: primary and continuing decision-making. Primary decision-making refers to initial decision-making in choosing the jobs. Continuing decision-making focused on decision-making on doing the jobs which are being carried on. Table 2 shows that in planting rainy and dry rice, doing chamka, breeding animal, selling labour and doing own business, both women and men made smoothly primary and continuing

decision-making. The reason was that these activities were the traditional ones that all farmers wanted to do. In contrast, in fishing, collecting forest products, motor-taxi driving, government official, selling labour and doing other jobs, the percentage of men in primary and continuing decision making was higher than women because these activities were difficult, demanded full-time labour and were located far away from home too. As a result, women could not participate as men did. But in doing own business, women had higher decision-making than men. To sum up, the initial idea of women in decision-making in family income generation was very important for the improvement of household livelihood because women had indispensable roles in the family. According to Keasa Khun (2006), women's roles in power and decision making are not nationally recognized. Women have to keep silent in every type of circumstance, they are not allowed to make any decision or even take control of power. In the family, men gain all the power and decision making privileges while women just can wait for the arrangement from them. In society, since women have low education, they are discouraged from getting involved in the communities' activities or contributing to the information. In the political aspect, women's participation remains in a slow progress towards real power.

Table 2 Primary and continuing of gender's decision-making in household livelihood

Description	Primary Decision-Making (%)			Continuing Decision-Making (%)		
	Women	Men	Both	Women	Men	Both
Planting Rainy Season Rice	9.3	1.2	89.5	8.1	1.2	90.7
Planting Dry Season Rice	25.0	0.0	75.0	25.0	0.0	75.0
Doing Chamka	9.8	2.4	87.8	9.8	2.4	87.8
Raising Animal	12.5	3.1	84.4	12.5	3.1	84.4
Fishing	0.0	75.0	25.0	0.0	75.0	25.0
Collecting Forest Product	0.0	100.0	0.0	0.0	80.0	20.0
Selling Labor	3.3	46.7	50.0	3.3	40.0	56.7
Motor Taxi-Driver	0.0	75.0	25.0	0.0	50.0	50.0
Govn't-Official	20.0	80.0	0.0	20.0	60.0	20.0
Business Owner	40.5	8.1	51.4	37.8	8.1	54.1
Others	25.0	50.0	25.0	25.0	50.0	25.0

Form of resource management

Some resources in the family are: education of family members, money, works, equipment and land; and getting benefit such as outside income, outside property, main demands, and right in working and political but all these resource were varied in each household and the gender managing these resource was different due to the situation in every family. In Fig. 2 it is showed that women managing the resource in the house are more than men. However, in Fig. 3, men got more benefits than women, except in main demand.

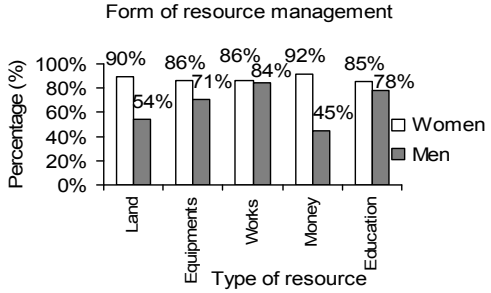

Fig. 2 Managing resources

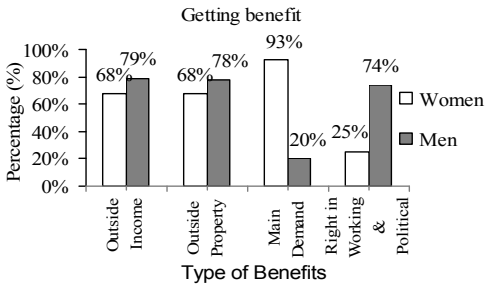

Fig. 3 Getting benefits

Table 3 SWOT analysis of women in decision-making process that were created from such status of household livelihood and decision-making process

Strength	Weakness
Patient, hard work, fulfilling work, keep money, much joining decision-making in family	Poor education, poor technical skill, busy to do house work, weak health, poor self belief, poor confidence in decision making, no participation in society
Opportunity	**Threaten**
Supporting from government and NGOs such as CEDAC, GRET, Women Organization, etc.	Traditional culture, and lack valuing on the income activities from husband

CONCLUSION

In conclusion, there were two parts of household livelihoods: farming and non-farming. In regards to the farming part, there were wet and dry season crops, raising animals, collecting forest products, fishing and selling labour. In regards to the non-farming part, the jobs were owning businesses, selling labour, motor–taxi driving, Government officials, and others jobs. Women participated in all activities in livelihoods, both income and non-income works. Thus, female participation in decision-making is very necessary for household livelihoods. Most heads of the family are men except for widows and single woman, who play very important roles as the heads of their families and as decision-makers in the family; eventhough, women participated actively in income generation. As such, the government, NGOs, society and women themselves should help to empower women in decision-making, investing and managing and improving household livelihoods.

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Research article

Control Measures for the Brown Planthopper Outbreak in Kompong Speu Province

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Abstract The aims of this research were to identify rice cropping systems and measures to control The Brown Planthopper BPH in outbreak areas in Kampong Speu province. In total, 80 households in Prey Vihear and Po Angkrong communes were randomly selected for an interview in 2008. The interviewed farmers did not grow rice all the year round and rice cultivars used were diversified. However, most cultivars are susceptible to the BPH. Moreover, Rice in early rainy season was a potential source for immigrant BPH multiplication. Almost all effective measures, both physical (mosquito net to trap insects and dispatching ducks in the fields) and chemical (Buprofezin, Fenobucarb and Denotefuran) were introduced by the Provincial Department of Agriculture (PDA). Meanwhile, the only one effective measure innovated by farmers was the application of used engine oil. However, this substance was not promoted by the PDA. No farmer lost rice completely in the outbreak year because all households possess small fragmented paddy fields in three different agro-ecosystems, so the periods of transplanting and growing were also different.

Keywords brown planthopper, rice production, outbreak, cropping system

INTRODUCTION

The Brown Planthopper (BPH) was considered as one of the major threats to rice production in Asia in the seventies and eighties. Through the integrated pest management (IPM) program, field schools, insecticide reduction campaigns, and policy changes to reduce the use of pesticides, the BPH has been contained for many years (Heong, 2009). Subsequently, entomological research and planthoppers began to receive lesser attention (Heong, 2008). Since 2005, planthopper outbreaks have affected several million hectares of rice land in countries such as Vietnam, China, Indonesia, Korea, Japan and Malaysia (Heong, 2008; IRRI, 2010).

Many approaches and measures were developed to control BPH based on availability of technology and geography. Ecological field studies, light trap catches and predictive modeling have indicated the possibility of movements within the tropics but the pattern of movement and the separation of migrants from the endemic population have proved to be more difficult to establish (Pender, 1994). Rombach and Gallagher (1994) showed a detailed record of the breakdown of four resistant genes during Philipine Rice Self-sufficiency program.The evolution of chemical control of the BPH is exemplified in some experiences in Japan. The use of whale oil was found to be effective in 1670 and then kerosene began to replace whale oil in 1897 (Suenaga and Nakatsuka,

1958; Matsuo 1961). DDT dust was the first post- World War II insecticide to replace kerosene and it was soon replaced by BHC and after that many insecticides were developed and replaced the old ones (Matsuo, 1961). In tropical regions between 1967 and 1979, BPH developed resistance to several insecticides, including: carbaryl, metolcarb, isoprocarb, malathion, diazinon, and fenitrothion (Heinrichs, 1994).From 1999 to 2000, BPH increased its resistance to malathion, etofenprox and imidacloprid (Nagata *et al.,* 2001). Oka (1979) suggested synchronized planting and crop rotation as a measure to control BPH. However, it is socially unacceptable even if it might be technically useful. The interactions between planthoppers and their natural enemies are believed to be the major factor when controlling the pattern of population growth (Wada *et al.,* 1991). A new approach called 'ecological engineering' was proposed in the aims to reestablish essential ecosystem services through increasing local biodiversity in rice production systems (Heong, 2009).

In Cambodia, before 1984, BPH was a secondary pest. Since then, BPH was epidemic almost everywhere especially the provinces along the Vietnamese border (Heng, 1996). The government began documenting pest outbreaks in 1991 and then BPH outbreak occurs every year (Preap, 2005). In 1996, BPH was recognised to be the main rice insect pest. At that time, some pesticides such as Applaud (Buprofezin), Trebon 10 EC (Ethofenprox), Bassa (Fenobucarb or BPMC), Mipcin (Isoprocarb) were recommended for controlling BPH in 1990s. These pesticides have different effect on BPH and suit to different rice growth stage and certain environmental condition and have less effect on natural enemies (Heng, 1996). To date, Buprofezin are sold in Cambodia under different trade names such as: Lobby 25WP, Apolo 25WP, Butyl 10WP, Asmai 250WP, Applaud 10WP, Pajero 30WP and Ten Cong (Pel, 2009).

Outbreak history of BPH in the Cambodian rice agro-ecosystem was well-compiled from Agronomy Department records by Preap (2005) and he also concluded that the outbreaks were localized and patchy within a field. However, control measures for BPH outbreaks have not been well-documented, particularly at the grass-root level. The aims of this research were to identify rice cropping systems and measures to control BPH in outbreak areas in Kampong Speu province.

METHODOLOGY

Two communes in Kompong Speu province were selected based on administrative borders, where the largest cropped area was infected and/or damaged by BPH outbreak in 2007 (DAALI, 2007), using hierarchical order from provincial to village level. The studied villages were, firstly, scored by the level of damages by heads of agriculture offices of both communes. In total, 80 households in Prey Vihear and Po Angkrong communes were randomly selected for an interview in 2008.The data collection was conducted in three phases. Firstly, the semi-structure was used to interview key informants or persons at different levels to identify the rice production areas affected by BPH outbreak and issues related. Secondly, a structured questionnaire was elaborated to interview individual farmers. Chemical and physical methods used by farmers and their perceptions of the effectiveness of the methods were provided by them based on their own experiences. Thirdly, analyzed data were rechecked and confirmed by key informants or persons at different levels. Data were coded and processed in Microsoft Excel 2003 software and exported to SPSS version 13.

RESULTS AND DISCUSSION

The number of farmers growing early rainy season rice in Po Angkrong was higher than in Prey Vihear.

In both communes, there was a slight increase in the number of households growing this kind of rice (Table1). It may be influenced by high rice price in the local market.

Every household in both communes normally grow three rice cultivars because all households possess small fragmented paddy fields in three agro-ecosystems. The data in Table 2 illustrates the various rice varieties in Prey Vihear and Po Angkrong commune. Percentage of each variety name, as it is called by local people, was calculated from multiple answers of each respondent. The varieties used by farmers in both communes were quite diverse and different from each other, but

some varieties were grown in both regions. In Prey Vihear, farmers nearly grew traditional varieties among which Chmar Prum was easily the most popular. The other like Chamroeun Phal, Kum Ampoa, Kong Sor and Neang Malis were slightly used. Conversely Chmar Prum was not the most frequent used of farmers in Po Angkrong where there were four important varieties including CAR 9 and Raing Chey, which are the improved varieties released by the Variety Recommendation Committee of Cambodia (VRC), as well as two modern varieties, IR62 and IR42. The rests were Senpidor and Raing Chey, also released by VRC and Kabor, the local variety. Most cultivars are susceptible to BPH.

Table 1 Early rainy season rice from 2006 to 2008 in Prey Vihear and Po Angkrong

Early wet season rice	Prey Vihear		Po Angkrong	
	frequency	%	frequency	%
2006	1	2.50	5	12.50
2007	1	2.50	5	12.50
2008	2	5.00	6	15.00

Table 2 Rice varieties used in Prey Vihear and Po Angkrong commune

Variety name	Prey Vihear		Po Angkrong	
	frequency	(%)	frequency	(%)
Ath Chhnos **	2	4.26	1	1.16
CAR9 *	-	-	16	18.60
Cham Roeun Phal	4	8.51	14	16.28
Chmar Prum **	24	51.06	-	-
IR42	-	-	1	1.16
IR62	-	-	1	1.16
Kabor	1	2.13	8	9.30
Kong Kaboth	-	-	1	1.16
Kong Sor	4	8.51	11	12.79
Kra Hom **	2	4.26	13	15.12
Kum Ampao	4	8.51	-	-
Neang Malis	4	8.51	7	8.14
NeangKheng	1	2.13	-	-
Pork Lolok	-	-	1	1.16
Pram Bei Kour	1	2.13	-	-
Raing Chey *	-	-	7	8.14
Sen Pidor	-	-	5	5.81
Total	47	100.00	86	100.00

** Susceptible cultivar (Men et al., 2001); ** susceptible cultivar (Preap, 2005)*

There was a high difference in the number of farmers using agro-chemicals against BPH in the communes. Farmers in Prey vihear commune used fewer agro-chemicals to kill BPH than ones in Po Angkrong, 20% and 77.50% respectively (Table 3), because Po Angkrong was more seriously infested. Agro-chemicals given by The Provincial Department of Agriculture PDA and Oshin 20WP (Denotefuran) were commonly used by farmers. PDA provided agro-chemicals named Bassa 50EC (Fenobucarb), Butyl 10WP (Buprofezin) and Map Judo 25WP (Buprofezin) to control BPH. The two former insecticides were provided by MAFF and Map Judo 25WP (Buprofezin) was provided by An Giang province, Vietnam. Fenobucarb has been used for rice planthopper control in Asia for the last 30 years and it is still in use nowadays. Sriratanasak et al. (2010) reported that there is a different resistance to Fenobucarb from populations of BPH in Philipine, Thailand and China. The BPH population in China was the most resistant, about 53 times and 25 times higher than population in the Philippines and Thailand, respectively. In China, 28-fold resistance to Buprofezin (in comparison to 2004) was observed. So BPH has the potential to develop high resistance to buprofezin (Wang *et al.,* 2008). Wang *et al.,* (2008) proposed a resistance

management program with rotation of buprofezin and other pesticides to delay or slow down the resistance development. Oshin 20WP (Denotefuran) was introduced to farmer by Agrotech Company agency. Wang *et al.,* (2008) examined the susceptibility of BPH to insecticides by using six populations from various sites in China. No resistance was found against Dinotefuran. This result showed that Dinotefuran is effective to control BPH.

Table 3 Chemical methods used by farmers and Farmers' perception of effectiveness against BPH during outbreak in 2007

Chemical methods	Prey Vihear (N=40)			Po Angkrong (N=40)		
	frequency	(%)	FPE(%)	frequency	(%)	FPE(%)
Use chemical(s)	8	20.00		31	77.50	
Oshin	0	0.00	0.00	25	44.64	84.00
Unknown name	3	27.27	66.67	4	7.14	0.00
PDA's insecticides	8	72.73	75.00	27	48.21	66.66
Total	11	100.00		56	100.00	

FPE: Farmers' perception of effectiveness of the method

Apart from applying agro-chemicals, farmers also used physical methods (Table 4) to control BPH. Of those methods, addressing mosquito net to trap the insects and dispatching ducks in the fields were the two common practical method introduced by the Ministry of Agriculture, Forestry and Fisheries (MAFF) through PDA. MAFF also introduced trapping insects by light. Farmers also applied used engine oil to the fields in order to control BPH, but this substance was not promoted by PDA. However, PDA suggested a more convenient method, consisting of mixing sand/rice husk with used engine oil, and then to spread it over the field. Although the used engine oil is effective to kill BPH; it potentially harms human health and environment. Oil Recycling (2006) reported a short term and long term effect of contamination of used oil.

Table 4 Physical methods used by farmers and Farmers' perception of effectiveness against BPH during outbreak in 2007

Physical methods	Prey Vihear (N=40)			Po Angkrong (N=40)		
	frequency	(%)	FPE (%)	frequency	(%)	FPE(%)
Use physical method(s)	3	7.50		28	70.00	
Used engine oil	2	25.00	50.00	27	33.75	74.07
Light trap	0	0.00	0.00	4	5.00	100.00
Mosquito net	3	37.50	66.67	22	27.50	95.45
Flooding the fields	1	12.50	0.00	6	7.50	50.00
Dispatching ducks	2	25.00	50.00	18	22.50	83.33
Introducing cattle	0	0.00	0.00	2	2.50	50.00
Spine twig	0	0.00	0.00	1	1.25	0.00
Total	8	100.00		80	100.00	

FPE: Farmers' perception of effectiveness of the method

To estimate the changes of rice cropped areas, an average of paddy in each commune from 2006 to 2008 was calculated and the annual yield of each year was also assumed (Table 5). The average rice area of each commune has not significant changes ($P>0.05$) within this period of time, but there was a significantly high difference ($P<0.01$) between the average of household rice areas in Prey Vihear and Po Angkrong commune. According to the figures in Table 4, 25 famers in Po Angkrong commune had rice areas as twice as bigger than those in Prey Vihear commune. On the other hand, there was a significant difference ($P<0.05$) in annual rice yield en every commune and

between them from 2006 to 2008. However, there was not significant variation in annual rice yield between 2006, when the rice cultivation condition was appropriate, and 2007, when the BPH was outbreak. If the yields of 2006 and 2007, and that of 2008, when drought was lasted until till mid-September, were compared, the yields were significantly different. This means that drought has more effects to decrease the yield than the BPH outbreak in 2007. In 2007, the water condition was very good at the beginning and the end of the periods of growing season in this study area. There were two reasons that yield did not decrease in the 2007 wet season. Firstly, BPH outbreak mostly on medium rice cultivars and some farmers transplanted again with a good condition of water and without any damage by other pests in late wet-season. The second reason was that farmers transplanted later than the outbreak occurred, whereas some of their paddy fields were transplanted before the outbreak. These destroyed areas could be recovered by re-transplanting with improved varieties, some of those insensitive-photo period varieties, resulting that growing period could extend growing time and produce a satisfactory harvest.

Table 5 Changes in rice yield in both communes from 2006 to 2008

Commune	Year	Household cropped area (ha)	Yield (ton/ha)
Prey Vihear	2006	0.70 ± 0.41 [b+]	1.73 ± 0.71 [a]
	2007	0.70 ± 0.41 [b]	1.67 ± 0.69 [a]
	2008	0.69 ± 0.42 [b]	0.99 ± 0.61 [c]
Po Angkrong	2006	1.13 ± 0.54 [a]	1.78 ± 0.81 [a]
	2007	1.13 ± 0.54 [a]	1.53 ± 0.55 [ab]
	2008	1.12 ± 0.55 [a]	1.18 ± 1.37 [bc]
F		**	**

+ Values in columns followed by the same letter are not significantly different at P<0.05
*** Highly significant*

CONCLUSION

Rice production in studied areas was not year-round and rice cultivars used were diversified. However, most cultivars were reported to be susceptible to the BPH. Moreover, early rainy season rice could be a potential source for immigrant BPH multiplication. Almost all effective measures, both physical (mosquito net to trap the insects and dispatching ducks in the fields) and chemical (Buprofezin, Fenobucarb and Denotefuran) were introduced by PDA. Meanwhile, the only one effective measure innovated by farmers was the application of used engine oil. However, this substance was not encouraged by PDA. No farmer lost rice completely in the outbreak year because all households possess small fragmented paddy fields in three agro-ecosystems so transplanting time and cultivars used were also different.

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Research article

Challenges of Dry Season Rice Production under Irrigation Scheme of Tapeing Thmor Water Reservoir

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Abstract This paper examines the barrier of dry season rice intensification of community's irrigator under Irrigation scheme of Tapeing Thmor Water Reseroir. In total, 61 water using households and water use committees were selected for interviewing. The representatives of FWUC argue the irrigation is functioning quite well but smallholder farmers complain to have no access to irrigation water, supposedly due to inappropriate design and functioning of the canal systems. Some also argue that water management at the community level is not well organized, which leaves part of the smallholders farmers with no opportunities for dry season rice production. Field work also reveals that agricultural extension services are not entirely efficient and not evenly spread out through the community of water using farmers. In addition, the capital and labour needed for smallholder farmers to be engaged in dry season rice production with high purchasing of agricultural inputs usually leads farmers to contract loans from local moneylenders who charge a high interest rate. The paper discusses that further development for dry season rice production under Tapeing Thmor's irrigation scheme should focus on improving agricultural extension services and the provision of affordable access to credit in order to maximize its outreach.

Keywords dry season rice intensification, community irrigator

INTRODUCTION

Rice-based farming systems are the backbone of Cambodia's agricultural sector, which is the main agricultural produce as well as staple food of the country. Rice production contributed a quarter of the agricultural GDP in 2006 and 40.7% of agriculture growth between 2003 and 2006. Most of the agricultural land was dominated by rice cultivation. In 2004, 84.4% of cultivated land was devoted to rice fields. Rice production was estimated at 4.3 million tonnes, with yields averaging slightly more than 2 tones/ha (Bingxin Yu, 2009**)**. Hin Sarith (2003) stated that total cultivation area is 2, 189, 923 ha and for wet season cultivation area around 1,926,004 ha and dry season cultivation area about 259, 919 ha.

The Northwest Irrigation Sector Project placed an irrigation system project to deal with rural poverty by improving agricultural productivities among poorer farmers. The farmers in these project areas will be organized into farmer water user associations and trained on sustainable operations and maintenance of the new irrigation schemes. The project will also train current

agricultural extension workers and place a new group of irrigation extension personnel to help the farmers improve rice production, diversify crops, and integrate livestock and fisheries. It will also help establish rural credit to households (ADB, 2006).

Rice cultivation at dry season usually produces higher yields, but there is a confounding effect with increased fertilizer use. Dry season rice production under an irrigation scheme of Tapieng Thmor Water Reservoir is favorable to intensify rice cultivation in the dry season since water is available. However, the farmer is reluctant to intensify because community water management remains to be the critical issue and it sometimes creates chronic conflict among downstream and upstream water users (David. F et al, 2009).

METHODOLOGY

The universal inquiry of research study has designed both qualitative and quantitative research by collecting information from peasant households, who are the members of irrigation communities. The most qualitative method used was to gather information in water management from the Farmer Water Use Community. Questionnaires were used to conduct interviews with target peasant households and the check-list was designed for collecting information from members of FWUC's committee, staff of NGOs and agricultural officers. Sample selection used a 'Snowball' technique for selecting irrigation members. The size of the sample *(n)* was determined by using Yamane Taro (1967) formula to restrict the number of peasant households for each community. The total number of cultivator for each community at dry season represented for population *(N)* and accuracy level *(e)* was 15%. Two communities were selected among five communities of FWUC of Tapeing Thmor Wate Reservoir. In total, 61 peasant households were selected using the Yamane Taro formula for conducting interview.

Yamane Taro Formula (1967), Equation: $n=N/1+N.e^2$ (1)

The main variable in socio-economic and technical practice was assigned into forms of semi-structure and structure interview for collecting the information from peasant households. For information related to the functional irrigation scheme and management of water distribution, non-structure interviews were used to gather information from the committee of water distribution (FWUC). For the rest of actors in agricultural intervention issue as well as the design of non-structure interviews for the district department of agriculture and ECOSORN. Otherwise, the regulatory framework of water management committees was collected as the document from FWUC to verify the performance of the community in water distribution. Collected data was classified into two kinds of data called quantitative data and qualitative data. Qualitative data analysis has been carried out by synthesis in three dimensions of a theoretical model, a framework design of FWUC, and an application of water distribution to evaluate the performance of community water in water management. The portion of quantitative data has been analysed in SPSS program, and the output has been discussed by using tabulation and cross-tabulation of variables with percentage values and p-values in descriptive statistics.

RESULTS

Labor of family member occupied on cultivated land area

Involvement of labor by family members in their rice cultivation is important for their productions. Normally in rice production of Cambodian peasants, they could intensify a labor into their production depend on amount of labor in their family, so possibility of rice production in a family was determined by a number of labor in their family. Table 1 shows results on peasant households who cultivated on surface area less than 2 ha. The number of working family members involved is significantly rather than the peasant households who has land cultivated area larger than 2 ha. For example: the peasant households who has small scale of land cultivation (<.50 ha) and family

member around 2-3 people, it indicated around 11.9%, so it suggest that small cultivation area, but a labor of family member involved more that the peasant households who have the large scale of land cultivation (3.50 ha) and family member about 2-3 people was revealed only 2.4%. Actually, peasant household who have large scale of land cultivation hired extra labor or machinery to work instead of human labor because they preferred to save time and human labor to do other works.

Table 1 Labor of family member and cultivated land area

		Land Cultivation (ha)				
		<.50	.50 - 1.99	2.00 - 3.49	3.50+	Total
Family Member (labor)	<2	20.0%	80.0%	0.0%	0.0%	100%
	2 - 3	11.9%	71.4%	14.3%	2.4%	100%
	4+	0.0%	66.7%	33.3%	0.0%	100%
Total		11.5%	72.1%	14.8%	1.6%	100%

Intensified labor in cultivated land area

Adoption of high technology in rice cultivation has reduced the need for human labor. However, additional labor force has remained necessary for some peasants who had a large scale farm and faced labor shortage in their family. Regarding this research study, K.Helmers (1997) stated in his report that most of the research found evidence that peasant household frequently experienced labor shortage and they usually hired labor during peak demand. During dry season, labor shortage was not a significant problem during cultivation because the scale of land cultivation area was not too large in comparison to labor in the region. The result of study showed that 33.3 % of small scale farm (less than 0.50 ha) hired additional labor, and large scale farm (more than 3.50 ha), hired 100% additional labor to assist their cultivation. On the contrary, Chi-quire analysis of these interviews demonstrated that the scale of cultivated land area with hiring of additional labor is not significant. Consequently, hiring of additional labor did not depend on the farm scale or cultivated land area.

Peasant's experience of dry season rice cultivation and agricultural intervention

Dry season rice production under Tapeing Thamor irrigation scheme has appeared a couple of years ago, since Democratic Kampuchea regime toppled. The investment by the government in irrigation systems accompanied by the adoption of green revolution ensured food security and doubled rice export as the core policy of Cambodia's government. Tapieng Thamor irrigation scheme has opened access to peasants in intensifying rice production at dry season. Lack of experience in dry season rice production was the problem which peasants faced in their production. An empirical result indicated that (Fig 1) about 35% of a peasant irrigators has never been engaged in dry season rice cultivation. There were 62% of a peasant irrigators has been engaged experience from 1-2 times and only 3% of a peasant irrigators involved in dry season rice cultivation from 3-4 times. Temporarily, all the experiences that they had at dry season were so little to lead the peasant to overcome the challenges they faced. Agricultural extension service offers limited access to the peasants at the community level.

In order to accompany the rehabilitated irrigation scheme, there were many NGOs and government officers involved to provide the agricultural service package for building capacity of peasants. According to the obtained result indicated in Fig 1, 48% of peasants do not have agricultural intervention from the rest. They practiced their cultivation by carrying out an experience at the previous time in wet season or an experience which shared from their neighbour. The peasants who regard agricultural intervention about 52% were target group of NGOs. They regarded agricultural package either service or material such technical support, fertilizer and seeds, but those peasants were not significant to intensify their productions compare to the peasant without intervention, so it's consistent with evolution of the district agricultural department stated

through the speech that majority of peasants couldn't benefit from their production, but some peasant could benefit because the situation of their land cultivation closed to the canal.

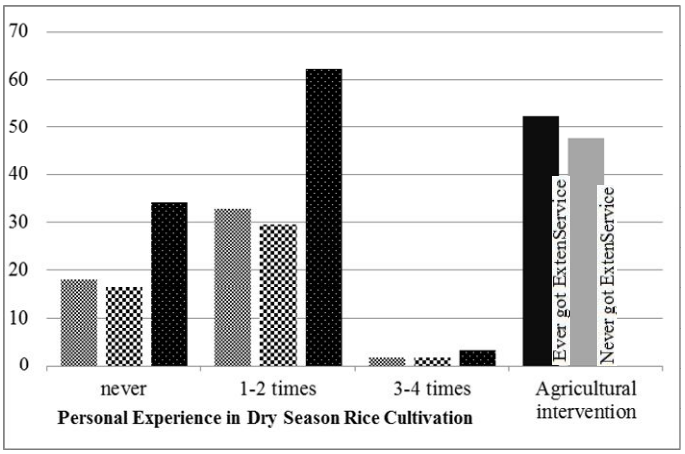

Fig. 1 Experience in dry season rice cultivation and agricultural intervention

Accompanying of technology

Oxen are still the most popularly used for land preparation and transportation. Each pair of animals is capable of plowing between 0.2 and 0.25 ha per day and the average farm area worked per pair is 2 ha, otherwise hand-held walking tractor has an ability to work 4-5 times more compared with a pair of oxen (Rickman et al, 1995). Although, oxen remain the popular power source for peasants, the research result indicated only 44.3% of pair animal are used as dragging animals at one time. On the other hand, hand-held walking tractors are used for cultivation at approximately 75%. In comparison between a hand-held walking tractor and dragging animal, it revealed that around 31% of peasant household used both animal and machine because a hand-held walking tractor could not operate in difficult circumstances. Otherwise peasants who have only a pair animal were approximately 13%. They kept it for transportation and plowing in floating rice area. On the contrary, there was no peasant in the research areas who do land preparation by a pair of animals in dry season rice cultivation. Most of the peasant prefers to plow and harrow with hand-held walking tractor because its task can be accomplished much faster.

Table 2 Using drag animal and hand held walking tractor

		Hand-held walking tractor		
		Yes	No	Total
Drag animal	Yes	31.1%	13.1%	44.3%
	No	44.3%	11.5%	55.7%
	Total	75.4%	24.6%	100.0%

Capital shortage

Adopting modern varieties in dry season needed more requirements of fertilizer, pesticide, and so on. The requirement of agricultural input was required twice as much in comparison to wet season because at that time they could use only traditional variety. In order to increase their production, some peasant household used their capital to buy fertilizer and pesticide, but other peasant households loaned credit because they could not meet to dose of fertilizer application for modern varieties. As the analyzed result, 85% of peasants loaned credit when they began to prepare land for cultivation, 12% when they needed fertilizer during maintenance and only 12% when they harvested.

Accompanying of credit provider

Lack of credit availability is considered to be a major constraint on rural development. Actually, necessary of credit accrued to the peasants, when they begin to practice cultivation, they always loaned credit to fulfil gap in crop cycle. Currently, rural credit services are provided through NGOs and informal institution or in cooperation with NGOs and international organizations. According to empirical result, it demonstrated that peasant loaned money from different channels such as kinship around 17%, nearly 64% from domestic merchants and from the formal credit institute around approximate 19%. Most of the peasant who preferred to loaned money from the domestic merchants don't have a land certificate or are unable to reimburse on time. Interest rates among three channels, most of the peasant loaned from the domestic merchants with an interest rate around 2.05-4.69%. Otherwise, in comparison to the same level of interest rate with a formal institution, it's indicated nearly 15%. If we look back to the percentage of peasant loaned money from the domestic merchants in an interest rate 4.70-7.34% the percentage continued to increase in comparison to different actors of credit provider at the same level of interest rate.

Function of water supply

After Tapieng Thmor Water Reservoir was rehabilitated under the project of Minister of Water Resource and Metrology (MWRAM), its capacity also was enlarged to store water at approximately 160 million m^3 equal to 12000 to 20000 ha of the water body at wet season, and it could supply rice cultivation around 9365.91 ha. For the dry season it has a capacity to store water at a volume around 70 to 80 million m^3 and it has a possibility to irrigate around 7000 ha at dry season. Currently, there are 5 communities registered under Farmer Water Use Community's Tapieng Thmor, but only 4 communities that activated in dry rice cultivation, in total around 897 ha. Theoretically, the volume of water at dry season shows it is possible to irrigate six times what is needed to cultivate the area of the activated communities under an irrigation scheme.

Cultivation and irrigation situation

The Irrigation scheme was rehabilitated only main canal by connecting from the reservoir, but a sub-canal was not constructed to facilitate water distribution. Lack of a sub-irrigation scheme to drain water from main canal, peasants could not expend their paddy plot far away from the main canal because it is difficult to drain water for irrigation. It required more equipment to facilitate irrigation, so the increased production cost could not benefit the peasant. As the result of observation, the peasants in CWU's Tankam cultivated far from main canal in average approximately 137 m. Particularly, peasants are located at CWU's Ponley, and they cultivated an average distance from the main canal to paddy plot approximately 76 m. On the contrary, most of the peasants in CWU's Tankam could use old sub-irrigation schemes. Actually, most of the peasants could practice their cultivation at dry season, as long as their rice field was not far from main canal by more than 1ha.

Water shortage

Crop Irrigation is based on water availability and the situation of rice field or knowledge of peasant. There are some differences of crop irrigation among two communities. CWU's Tankam located downstream are always faced with water scarcity more than CWU's Ponley because of the situation of a canal that is unable to hold water and transfer water properly. Its consequent upon a shallow canal and some part of a physical canal was damaged. Crop irrigation was done when water was available in the community, and sometime they were unable to irrigate because water was unavailable. Although it is a time of crop water demand, it brought water utilization in the community into competition. As the imperial result revealed that 57% of member irrigators never faced with water shortage during their cultivation and 43% has been faced with water shortage

because of the turn of water delegation is not a time for irrigation, otherwise illegal activities of irrigator's irrigator's members at upstream such as blocking water stream. So, those issues have contributed to water inadequate.

Performance of FWUC in water management and distribution

Farmer Water Use Community was organized by Ministry of Water Recourse and Metrology and the regulatory framework was designed and authorized by FWUC and MoWRAM. As the result of verifying using principle design in common pool resources management of E.Ostrom have been published in 1990 as the model theory in order to verify with the regulatory framework of FWUC, which almost consistent with model theory. On the contrary, implementation couldn't carry out to the field work because it lacks of participation from a team members. Only few members worked actively in water management and distribution, so they could not respond at all. The gap in water management and distribution contributed to water usage at the community level into the complexity. Parity of water distribution was not equal access between upstream and downstream. Sometime the peasant who located at the upstream was abused the turn the peasant at downstream, but the relevant authorities never punished the ones who violated operational rule, even the rule was regulated yet. The child experience in water management and distribution of FWUC was the problem of less activation of FWUC. Anyway a lack of financial support as well as the issue that FWUC could not operate water distribution properly to communities.

CONCLUSION

This paper addresses some important aspect of challenges in dry season rice intensification in an area where water command of Tapeing Thmor Water Reservoir. Water body in the reservoir was surplus 6 times in comparison to the cultivated area, but some peasant faced with water shortage for irrigation application, even some part of an irrigation scheme was rehabilitated. The performance of community in water distribution is not organized well because only few members of FWUC, who worked in water action. All the process in their cultivation almost was replaced by machinery, although human labors are significant to intensify their cultivation. Field work also revealed that agricultural extension services are not entirely efficient and not evenly spread out through the community of water user peasants. In addition, the capital needed for small holders peasants to be engaged in dry season rice production with high purchasing of agricultural inputs. It usually leads farmers to contract loan from local moneylenders which charge a high interest rate.

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Research article

The Agricultural Land Use Situation on the Periphery of the Tonle Sap Lake

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Abstract The Tonle Sap Lake and its periphery exhibit many diversified land use patterns, including fishing areas, grass fields, agricultural land and forest land. Since there have been dramatic changes in these patterns, this research was conducted to identify the dynamics of agricultural land use from 2005-2010 and to investigate the farmers' socio-economic status in the Baray and Kampong Leaeng districts of Kampong Thom and Kampong Chhnang provinces, respectively. To achieve the objectives, Spatial Analysis on Aerial Photos in 2005 and 2010, Direct Observation, Semi-structured Interviews and Structured Interviews were used. The results showed that the total agricultural land use in Zone 2 of Baray district increased from 23% in 2005 to 30% in 2010, while agricultural land in Zone 2 of Kampong Leaeng district increased from 46% in 2005 to 67% in 2010. 82.39% of total households in Baray district are farmers, while 86.19% of total households in Kampong Leaeng district are farmers, with an average of 5 members per household who rely on rice, subsidiary and industrial crops cultivations. Farming households owned an average of 2.11 ha of rice land and 0.26 ha of cropland in Baray, while in Kampong Leaeng they owned an average of 1.41 ha of rice land and 0.67 ha of cropland. On average, a household in Baray earned $1,452/year from farming and spent on $1,690/year daily living and agricultural production, while in Kampong Leaeng a household earned $1,568/year and spent $1,840/year. In conclusion, the dynamics of agricultural land use in Baray and Kampong Leaeng districts have reduced the flooded forest areas on the Tonle Sap Lake's periphery. Although farmers have tried to increase their income by extending their productive areas, their income was still found to be lower than expenses. These farmers need to access more job opportunities to support themselves and their families.

Keywords agricultural land use, Tonle Sap lake's periphery, aerial photos, spatial analysis, farmers' socio-economic status

INTRODUCTION

As the main occupation of the majority of the population in Cambodia, more than 75% of rural households rely on agriculture and its related sub-sectors (SAW, 2009). In 2009, agriculture contributed 33.5% of GDP (MAFF, 2010) and the main employment of the majority of the workforce was subsistence farming (SAW, 2009). Agriculture in Cambodia has contributed to the economic growth, poverty alleviation and job employment. Over 70% of Cambodian households are working in agricultural sectors and sub-sectors, leading to a reduction in the poverty rate from

47% in 1994 to 35% in 2004 and recently estimated at 30% in 2007. The poverty rate has been declined by 1% a year, on average (MAFF, 2010).

In 2009, there was drastic growth in the agricultural production and agriculture contributed a high share of GDP. The cultivated area for rice covered about 2.71 million ha, providing an average yield of 2.83 ton/ha, with a total production of over 7.58 million tons. Moreover, the cultivated areas for subsidiary and industrial crops covered on about 0.49 and 0.18 million ha, with total production of over 4.86 and 0.56 million tons, respectively (MAFF, 2010). The consistent growth of agricultural sector in 2009 was due to the decline of the construction industry sector and the services sector since 2008 from the world economic crisis (MAFF, 2010).

The combination of Cambodian population growth from 13.7 million in 2005 (NIS, 2005) to over 14.8 million in 2009 (UNDESA, 2009) together with economic growth and globalization, have resulted in high strains on natural resource, especially critical changes of land use patterns.

The periphery of the Tonle Sap Lake , the main flooded plain area for agricultural production in Cambodia, covers over 1.4 million ha in total and extends to the six provinces between the National Road 5 and 6, included Kampong Chhnang, Pursat, Battambang, Banteay Meanchey, Siem Reap and Kampong Thom. The area is characterized into 3 main Zones: Zone 1, non-flooded areas which are the residential areas and the productive areas of rice and subsidiary crops; Zone 2, flooded areas which exhibit the residential areas, grass fields, forests, rice field, subsidiary and industrial crops; Zone 3, the flooded forest areas and protected areas. From 2005-2009, encroachments on the flooded forest for farming especially in Kampong Thom and Kampong Chhnang provinces led to an increase in the land used for agriculture by 34% and 40%, respectively (TSA, 2010).

The purpose of this research is to identify the dynamics of agricultural land from 2005-2010 and investigate farmer households' socio-economic status in Baray and Kampong Leaeng districts of Kampong Thom and Kampang Chhnang provinces located on the Tonle Sap Lake's periphery.

METHODOLOGY

Due to the limited time and the accessibility of the Aerial Photos, the research was conducted only in Zone 2 of Baray and Kampong Leaeng districts from May to November 2010. The Interpretation of the Aerial Photos in 2005 and 2010 was done using ArcGIS 9.3 to map the agricultural land use in 2005 and 2010 and the changes between the years. Then, Direct Observation was done to verify between the real situation of agricultural land use and the digitized maps, including GPS marking for any unclear interpretation. Moreover, Semi-structured Interviews were conducted with 21 key informants using a checklist to obtain some basic information about the dynamics of agricultural land use and general information about the farmer households' socio-economic situation in the studied areas. Lastly, the Structured Interviews were done randomly with 25 farmer households from Baray district and another 25 households from Kampong Leaeng district. The interviews used a questionnaire to obtain more information on the real situation of the farmer households' livelihood, agricultural activities, agricultural income and expense, housing condition, financial resource, the access to infrastructure development, education and health care, and some problem affect to their livelihood. All the data from the surveys, both qualitative and quantitative data, were stored and analyzed using simple descriptive statistics in Microsoft Office Excel 2007.

RESULTS AND DISCUSSION

Agricultural land use in Baray district

The result of the Aerial Photos Interpretation in Zone 2 of Baray district showed that the total land area in the Zone 2 is 35,380.67 ha and their land use patterns in 2005 included burned forests, forest, free land, grass field, industrial crops, rice fields, subsidiary crops, settlement areas and water. The land use patterns categorized into agricultural land use are rice fields, industrial crops and subsidiary crops. These totaled 8,075.52 ha in 2005. Among these uses, rice fields covered the most at 22.01%, while subsidiary and industrial crops covered 0.51% and 0.30%, respectively. In

2010, the agricultural land increased to 10,560.10 ha with land from burned forests and grass fields. Rice field increased by 30.36% and subsidiary crops and industrial crops by 25.12% and 70.09%, respectively, compared to the areas in 2005 (Table 1). Furthermore, among the increased areas, all of the burned forest was converted to rice fields and the grass fields were mostly changed to rice fields and partially to subsidiary and industrial crops (Table 2).

Table 1 Agricultural land use in Zone 2 of Baray district in 2005 and 2010

Land use patterns	2005		2010		Changed area (ha)	Growth's percent (%)
	Area (ha)	Percent (%)	Area (ha)	Percent (%)		
Rice Field	7,788.48	22.01	10,152.78	28.69	2,364.30	30.36
Subsidiary Crops	179.90	0.51	225.09	0.64	45.19	25.12
Industrial Crops	107.14	0.30	182.23	0.52	75.09	70.09
Total	8,075.52	22.82	10,560.10	29.85	2,484.58	30.77

Table 2 The decrease and increase of land use patterns in Zone 2 of Baray district

		Decreased Grass Field		Decreased Burned Forest		Total (ha)	Percent (%)
		Area (ha)	Percent (%)	Area (ha)	Percent (%)		
Increased land use types	Rice Field	2,187.98	94.79	176.32	100	2,364.30	95.16
	Subsidiary Crops	45.19	1.96	0	0	45.19	1.82
	Industrial Crops	75.09	3.25	0	0	75.09	3.02
	Total	2,308.26	100	176.32	100	2,484.58	100.00

Agricultural land use in Kampong Leaeng district

The total area in Zone 2 of Kampong Leaeng district is 29,562.40 ha and their land use patterns included burned forests, cleared forests, fruits, forest, grass fields, industrial crops, rice fields, subsidiary crops, settlement areas, water, and flooded grass and forests. In 2005, the total agricultural land was 13,700.54 ha among which 31.51% were rice field, while subsidiary crops and industrial crops were 14.30% and 0.53%, respectively. In 2010, the agricultural land increased to 19,776.93 ha, with rice fields increasing by 22.63% and subsidiary crops and industrial crops by 80.60% and 359.29%, respectively, compared to the areas in 2005 (Table 3). In 2010, rice field, subsidiary crops and industrial crops increased with land from burned forests, cleared forests, grass fields, some of forest, flooded grass and forest, and some areas of water. Specifically, the burned forests, cleared forests and grass fields were all changed into rice fields and subsidiary crops (Table 4).

Table 3 Agricultural land use in Zone 2 of Kampong Leaeng district in 2005 and 2010

Land use patterns	2005		2010		Changed area (ha)	Growth's percent (%)
	Area (ha)	Percent (%)	Area (ha)	Percent (%)		
Rice Field	9,316.43	31.51	11,425.13	38.65	2,108.70	22.63
Subsidiary Crops	4,226.68	14.30	7,633.46	25.82	3,406.77	80.60
Industrial Crops	157.43	0.53	718.34	2.43	560.91	356.29
Total	13,700.54	46.34	19,776.93	66.90	6,076.38	44.35

Table 4 Changed categories of agricultural land use in Zone 2 of Kampong Leaeng district

		Increased rice field		Increased subsidiary crops		Increased industrial crops		Total (ha)	Percent (%)
		Area (ha)	%	Area (ha)	%	Area (ha)	%		
Decreased land use types	Burned Forest	1.14	0.05	0.00	0.00	0.00	0.00	1.14	0.02
	Cleared Forest	101.30	4.80	3.60	0.11	0.00	0.00	104.90	1.73
	Forest	975.23	46.25	1,406.45	41.28	83.95	14.97	2,465.63	40.58
	Grass Field	736.35	34.92	222.12	6.52	0.00	0.00	958.47	15.77
	Water	294.68	13.98	743.77	21.83	476.96	85.03	1,515.41	24.94
	Flooded Grass & Forest	0.00	0.00	1,030.83	30.26	0.00	0.00	1,030.83	16.96
	Total	2,108.70	100.00	3,406.77	100.00	560.91	100.00	6,076.38	100.00

Discussion on the dynamics of agricultural land use in the studied areas

As shown in Table 1 and Table 3, total agricultural land use in Zone 2 of Baray district increased from approximately 23% to 30% during 2005-2010. As for Zone 2 of Kampong Leaeng district, it increased from about 46% to 67% in the same period. Although the total area in Zone 2 of Kampong Leaeng is smaller than Zone 2 of Baray, the growth of agricultural land in Kampong Leaeng was higher than in Baray district. The change in agricultural land use in Baray district was mostly in the grass fields since it's covered in most of the area, while in Kampong Leaeng, the agricultural land increased mostly in the forests because it covered almost half of the area. Regarding to the increases, rice fields presented the biggest growth in Baray in contrast to subsidiary crops that presented the highest growth in Kampong Leaeng district (Fig. 1). Fig. 2 shows a map of the changing dynamics of agricultural land in Zone 2 of Baray and Kampong Leaeng districts. The causes of the changes were the population growth in the areas, the high demand of agriculture products, the high fertility of the soil in the areas and illegal encroachment on the flooded forest in the protected areas.

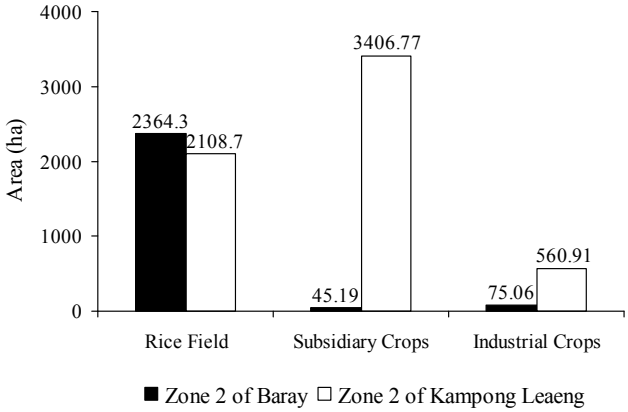

Fig.1 The changing dynamics of land use for agriculture in the two districts from 2005-2010

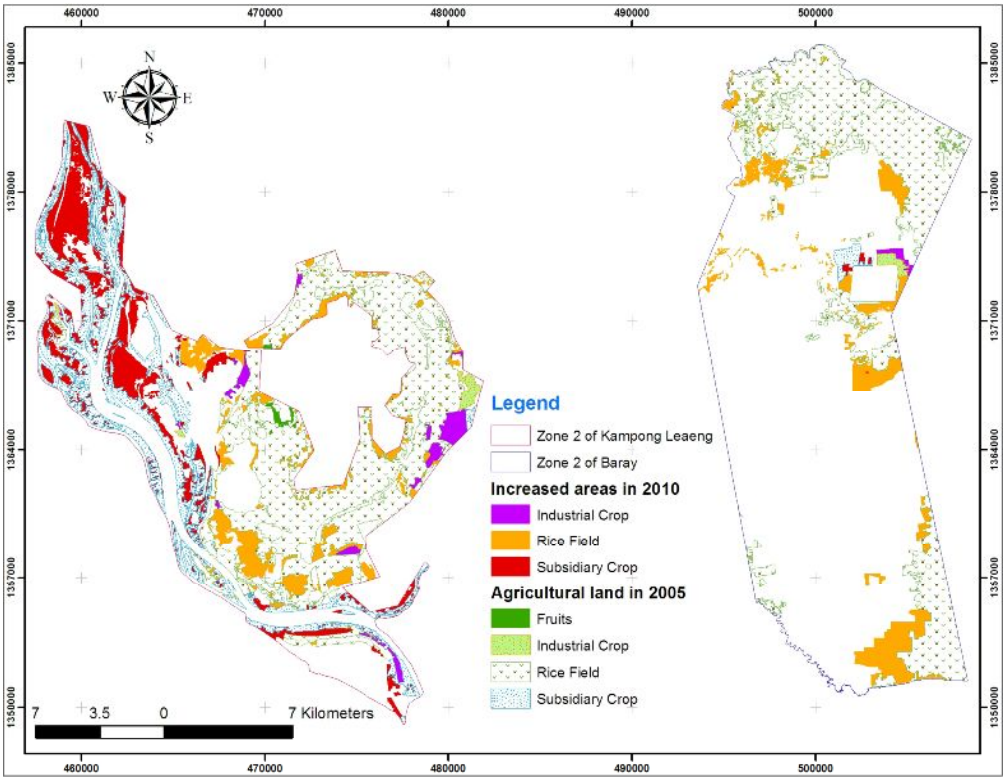

Fig. 2 Dynamics map of agricultural land in Zone 2 of Baray and Kampong Leaeng districts

Socio-economic situation in Baray district

Baray district is comprised of 18 communes and 182 villages with a total population of 181,306 persons in 37,089 households and with an average of 5 members per household. Females make up 51.21% of the total population and people who are aged over 18 years old are 61.81% of the total population, 32.18% of which are female. Women are the head of household in 14.82% of the households. 84.06% of the total households are engaged in the agricultural sector (farming, fishing and animal raising), while the rest are engaged in the service sector, handicraft and integrated jobs with 8.83%, 0.30% and 6.82%, respectively. Furthermore, some members in the households are also employed in public and private sector in which 3.55% of households had members employed in the public sector, while other 10.75% were employed in the private sector.

Even though the people who aged 18-60 years seemed to have their regular occupations in the district, migration was still a problem. 9.94% of the total population migrated outside the district for employment, of which 8.05% were employed in regular jobs and the other 1.89% in irregular jobs.

In the district, six types of houses were found including wooden houses with thatched roofs (30.41%), wooden houses with zinc roofs (19.14%), wooden houses with tiled roofs (49.44%), flat for multi-households (0.32%), concrete houses (0.64%) and villas (0.05%). Furthermore, the access to electricity was still very low in the whole district at 11% of the total houses and for the households who couldn't access electricity used the batteries instead.

Road infrastructure was seen to be better since there were five types of road transport infrastructure such as bituminous roads, paved roads, red-graveled paths, white-sandy paths and mountain trails. The educational situation was more positive since 73.14% of people aged 3-17 years had some education or schooling and 26.86% had no schooling. However, the illiteracy was still a problem. 14.23% of people aged 15-60 years were illiterate, of which 7.37% were female.

The surveyed farming households in the district had an average of 2.11 ha of rice land and 0.26 ha of cropland per household. On average, a household could earn income 1,452 $/year from farming and spent 1,690 $/year on agricultural inputs and daily living.

Socio-economic situation in Kampong Leaeng district

Kampong Leaeng district is comprised of 9 communes and 44 villages, with a population of 47,099 persons in 9,767 households with an average of 5 members per household. Females are 50.26% of the total population and people who are over 18 years old are 51.14% of the total population, 26.34% of which are female. In the district, women are the head household in 15.34% of the households. 93.95% of the total households are involved in the agricultural sector, while the rest are engaged in the service sector, handicraft and integrated jobs with 0.54%, 0.15% and 5.36%, respectively. Moreover, some members in the households are employed by both the public and the private sectors. 4.70% of households had members employed in the public sector, while 6.26% were employed in the private sector.

In the district, migration was also still a problem. 6.57% of the total population who aged 18-60 years migrated outside the district for employment, of which 5.99% were employed in regular jobs and the other 0.58% in irregular jobs.

In the district, four types of houses were found including wooden houses with thatched roofs (47.48%), wooden houses with zinc roofs (41.46%), wooden houses with tiled roofs (10.35%) and concrete houses (0.72%). Furthermore, the access to electricity was still very low in the whole district at 1.59% of the total houses and for those who couldn't access electricity used the battery instead.

Due to the island zone and flooded landscape geography, the Kampong Leaeng district has lacked of road infrastructure. Three types of roads were found to red-graveled paths, white-sandy paths and mountain trails. The educational situation was in positive since 63.28% of people aged 3-17 years had some schooling and 36.72% had no schooling. However, the illiteracy was still the problem. 15.93% of people aged 15-60 years were illiterate, of which 8.35% were female.

The surveyed farming households occupied an average of 1.41 ha of rice land and 0.67 ha of cropland per household. On average, a household could earn income 1,568 $/year from farming and spent 1,840 $/year on agricultural inputs and daily living.

CONCLUSION

The agricultural land use in Zone 2 of Baray district of Kampong Thom province and in Zone 2 of Kampong Leaeng district of Kampong Chhnang province changed dramatically from 2005 to 2010. In Baray district, the agricultural land increased by 7% from the grass fields and burned forests in the Zone 2 and the grass fields, which regarded into the flooded forest area on the periphery of the Tonle Sap Lake, presented a high decrease. Among the increased agricultural land, rice fields showed the highest growth.

In Kampong Leaeng district, the agricultural land increased by approximately 21% from the burned forests, cleared forests, grass fields, forest, flooded grass and forests, and some areas of water in the Zone 2. Along with the increased agricultural land, subsidiary crops presented the highest percent of growth.

The causes of the changes were the population growth in the areas, the high demand of agriculture products, the high fertility of the soil in the areas and illegal encroachment on the flooded forest in the protected areas that increasingly grow from year to year.

The changing dynamics of agricultural land use in both Zone 2 of Baray and Kampong Leaeng districts have devastated the flooded forest areas on the periphery of the Tonle Sap Lake which serves as the main protector of the Tonle Sap Lake and its biodiversity resources. If proper measures are not taken to lessen the illegal encroachment, these will shortly destroy the biodiversity and biosphere reserve of the Tonle Sap Lake.

The changing dynamics of agricultural land use in the areas are closely related to the socio-economic situation of the people. The people have tried to increase their income by extending their productive areas which reduce other land use patterns. However, their income is still shown to be lower than expenses, so they need to access more job opportunities to support themselves adequately. Additionally, in order to take any measures to lessen the impact of the changing dynamics of agricultural land, the socio-economic of farmers needs to be understood well in order to advance the measures effectively and efficiently.

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Research article

Economic Land Concession and its Impact on Local Livelihoods in Kampong Speu Province, Cambodia

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Abstract: Development of private enterprise in the form of land concessions granted for forestry/agro-business has been suggested as the means of development and poverty reduction in the rural areas in Cambodia. The study was conducted in order to examine the necessary economic and social impacts of Economic Land Concession (ELC) development on local community's livelihoods. In Phnom Sruoch district of Kampong Speu province, 66 households were interviewed with qualitative methods applied to make out the five livelihood assets, coping strategies, timelines, and resources map of the area. The results indicated that the development of ELC in the case of Golden Land Development Co., Ltd. in Choam Sankae commune has a substantial negative impact resulting in the loss of access to land and natural resources which are the primary assets of livelihoods for the local people. The results in the survey were indicated that 29.62% of households are landless while 36.67% owned less than 0.5 ha per household. Most of the respondents have more difficulty to find firewood because of privately owned protected lands. To develop an intensive agriculture and agro-industry are among the purposes of ELC. In this study, it was recorded that only an estimated 2-3% of total granted lands had been cultivated. As a result, there were only 1.33% of local labor force had been employed. Meanwhile, the lack of skills and formal training prevent them from the opportunities to adjust in the rapid changes of land transformation. An estimated 62.5% households have migrated to other regions seeking for jobs with higher risks and low income. In conclusion, the local people in Phnom Sruoch district were not prepared to the land transformation. Therefore, this is one of the issues that should be taken into consideration on policy discussion on the role and strategy of land concession whether it could have a significant contribution to the development of the poor.

Keywords economic land concession, economic and social impacts, livelihood, Choam Sangkae, Cambodia

INTRODUCTION

Over 80 percent of more than 10 million Cambodians are currently living in rural areas (NIS, 2008) that depend on natural resources to support their livelihoods. Most are subsistent, relying on one crop that is rice, fish and other aquatic resources, and varieties of forest products (Kasper et al., 2006). The development of private enterprise in the form of land concessions granted for forestry/agro-business has been suggested as a means of development and poverty reduction in the rural areas (Marana et al., 2004).

The specific objectives of land concession are to develop intensive agricultural and agro-industrial activities. Its aim is to generate state or provincial revenues through economic land taxes

and to increase employment in rural area within a framework of intensification and diversification of livelihood opportunities and within a framework of natural resources management based on appropriate ecological system (MAFF, 2010). As a result, there are 65 companies occupying a total land area of 895,176 ha that were contracted by the end of 2008. In Kampoong Speu province, there are 8 companies covering 90,256 hectares.

However, many challenges remain to be addressed on land concession, for instance, the declining access to land, forests and fisheries due to appropriation by other interests. Furthermore, the concessions have generated more land conflicts especially with local communities. It was reported that landlessness is estimated at 20% in rural areas (World Bank, 2010). The land conflicts often have extensive negative effects on economic, social, spatial and ecological development (Babetter, 2008). In addition, farmers that losses access to land resources which were under the ELC have difficulties to find employment in industries and since there is only a very limited job opportunities for them (Padek, 2007). Also, the implementation of ELC became more aggravated due to the lack of communication and consultation between the local communities, local government unit and national government. There is poor communication and consultation between local communities. If any consultations are conducted at all, it is very minimal with mostly decisions regarding the concession taken at the central government level; leaving the local authorities powerless.

METHODOLOGY

Conceptual framework

Sustainable livelihood as a conceptual framework of analysis were reviewed which supported the implementation of the research results. The framework shows the processes and core factors of livelihoods to sustain for local people, especially related to the new transformation which has led to the loss of access to land and natural resources. The review of livelihood and sustainable livelihood are the definition of the United Kingdom's Department for International Development (DFID)'s model base founded in 1999.

The livelihood approach is based on the premises such as the asset status of the poor which is fundamental to understand the options open to them, the strategies they adapt to attain livelihoods, the outcomes they aspire to and the vulnerability context under which they operate (Ellis, 2000). DFID distinguished five categories of assets or capital namely; natural, social, human, physical and financial (Carney, 1998 as sited in Cahn, no date). Livelihood shocks and risks caused by the lack of assets and income opportunities to engage in productive activities. Livelihoods based natural resources, agricultural intensification, non-farm activities and diversification which was reviewed based on the theory of livelihood strategies.

Study sites

The case study was conducted in Choam Sangkae Commune, Phnom Sruoch district, Kampong Speu province located in western part of Cambodia which has a large area entitled for ELC. There are 8 companies covering 90,256 ha of land in the province. Choam Sangkae Commune was divided into 7 villages with 1,104 household families. At present, there are 4,900 ha of the commune land granted to a company in 2004, a Taiwan based company named Golden Land Development Co., Ltd. There were two villages subjected for the case studies which are mostly under in the concession area, the Phnom Cheas and the Doun Proung village.

Data collection

A total of 66 households were interviewed and other qualitative methods that consist of village resources map, transect walks, time lines, seasonal calendar, observations and groups discussion were also applied to make out their five livelihood assets, coping strategies, history changes, and

resources map of the area. An in-depth interviewing method was used to investigate the new adaptation strategies of local livelihoods.

RESULTS AND DISCUSSION

Situation of study sites

The average land size per household in Phnom Cheas and Doun Proung is slightly different having 0.78 ha and 0.86 ha respectively. The number of landless household was 24.7% in Phnom Cheas and 35.0% in Doun Proung. There are banks allowing local villagers to get a credit, particularly those who are wanting to start cottage industries. However, only few of them are adapting to credit accounting 24% in Phnom Cheas and 35% in Doun Proung.

Farming system analysis

Farming system is defined as a population of individual farming systems that have broadly similar resource bases, enterprise patterns, household livelihood constraints and for which similar development strategies and interventions would be appropriate.

Table 1 Livelihood and assets in Phnom Cheas and Doun Proung villages

Description	Unit	Phnom Cheas village	Doun Proung village	Total sample selection
Average member per household		5.14	5.35	5.25
Age active labor (18-60)	%	67.10	64.23	65.67
Average land size per household	ha	0.78	0.86	0.82
Average land per active labor	ha	0.335	0.308	0.32
Landlessness	%	24.70	35.00	29.85
Access to credit ability	%	24.00	35.00	29.50
Saving group formation	%	0.00	27.03	13.52
Migration of household	%	55.20	64.90	60.05
Cattle production (3-6 heads)	%	58.00	54.00	56.00

Based on the results in this study, it was found out that the local villagers rely on rainy season rice based activities, over 71% as main occupation and others are secondary jobs. Livestock productions based activities contribute about 35% as second occupation. Orchard and backyard gardening are undertaken by most household but not for trading purposes. Currently, non-timber forest products (NTFPs) play less important role because there are very few using for daily household consumption. Off-farm based activities contribute about 27%, especially labor migration and a few small-scale businesses.

Table 2 Correlations between land and other factors

		Paddy rice land	Cow number	Migration number
Paddy field area	Pearson correlation	1	.463(**)	-.422(**)
	Sig (2-tailed)		.000	.000
	N	66	66	66
Cow number	Pearson correlation	.463(**)	1	-.323(**)
	Sig. (2-tailed)	.000		.008
	N	66	66	66
Migration Number	Pearson correlation	-.422(**)	-.323(**)	1
	Sig. (2-tailed)	.000	.008	
	N	66	66	66

*** significant difference at 99%*

Table 2 provides figures on correlations between four factors related to household land size which indicate negative relation because the p-value equals 0.000 and the positive strength direction is 0.463. This means that when household have a large land area, a tendency to high number of cows could also be reared, as a significant level of 0.463 was recorded. The paddy field area relates to the number of households' migration which p-value is 0.000 with negative direction of r-value is equal to 0.422. This implied that when households owned a large land area, the number of household's migration will decline.

Impact of ELC on local livelihoods

This section will discuss the impact of ELC on local livelihood of Choam Sangkae commune. The impacts would affect only some category, such as follows; agricultural land, livestock production, household migration, household size and displacement. In the context of economic development strategy of the government, land concessions become popular as it was expected to reduce poverty in the rural areas in Cambodia.

This report indicates the result of field research that was conducted in Choam Sangkae commune in Kampong Speu province of Cambodia. The positive and negative impacts of granting lands from Golden Land Development Co., Ltd. for local livelihoods in the early 2010.

Positive impacts

This section will examine the positive impacts of the granting land from GLD Co., Ltd. to the rural villagers which generate livelihood through non-farm employment and employment transformation. The company provides employment to the local people accounted for about 9% in 2006. However, this number continue to decrease every year until in the year 2010 to 1.99%.

Fig. 1 shows the percentage and types of employment as follows; 42% of the workers were planters, 32% were working on land and forest clearing and 26% were employed as plantation guards. Wages of the workers were about 6,500 riel (1.58 US$) per day. The highest number of employees of local villagers who worked with the company was in 2006 but lasted only 2 to 3 months. From 2007 up to 2010, only about 2% of the interviewed households had been employed.

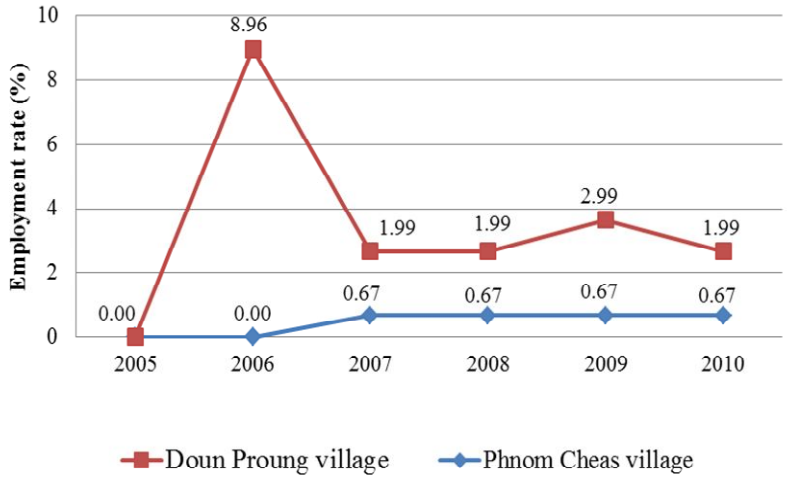

Fig. 1 Percentage of local people employed by the company from 2005 to 2010

Negative impacts

Local people are aware on the importance of agricultural land although only 34.84% of households were granted of land with less than 0.5 ha, 16.67% with 0.5 to 1 ha and 18.18% with land larger than 1 ha. However, there is no assurance that these granted lands are continuously usable for them

once these lands will be conceded by the company. Meanwhile those 30% of the households were not granted though they can have the opportunity to become tenures from other landowners having wide areas of land. On the other hand, about 50% of the interviewed households have their owned land but without land titles. These cases are common in Doun Proung village although most of the land holders have been living and cultivating for more than 15 years but still have no proof documents of land ownership.

In terms of agro-production in Choam Sangkae commune, livestock is the second known agro-production next to crop production. It was noticed that 88% of the local people shifted from cattle rearing to pig breeding. The study revealed that 63.63% of the interviewed people tended to reduce the number of cattle for about 9% in Phnom Cheas and 13% in Doun Proung. It was known that shifting from cattle to piggery production was due to the less availability of grazing land. Contrary to shifting of livestock production from cattle to piggery, 22% of the interviewed households retain the number of cattle. Meanwhile, 14% of the local people tend to increase the number of cattle that made possible by utilizing grazing lands in the nearby villages and village in the boarder.

Firewood and charcoal are also considered as among of the sources of income for local villagers as well as for their own household consumption. It was revealed that more than 92% of the interviewed households had difficulties on gathering firewood even for their own consumption due to the land concession where in forested lands were granted to private companies. About 85% of local villagers can have the opportunity to gather firewood once land clearing will be done on the granted land, definitely not a sustainable source due to the change of land-use in the area. This case had influenced other 14% of local people to move to other distant areas where firewood can be collected.

In the early Cambodians, non-timber forest products were a very important additional source of income to the local people. It contributes an income about 30% to those in the medium income households and about 42% to those in the low income households (CSW, 2006). The NTFPs includes vegetables, fruits, wild animals, vines and barks, tree resins, bamboo, root/tuber crops, bushes as raw materials for handicraft and so on. However, it was found out that NTFPs became less important to the local people with respect to its function as supplement for household income.

Unjustifiable resettlement often happen in Cambodia either in urban and rural areas. In the case of Choam Sangkae commune, 6 out of 66 interviewed households manifested that they were forcefully evicted from their land without compensation in 2006. Many peasants' houses were burned and destroyed by militaries and armies protecting the company's lands. Furthermore, their houses were torched and destroyed at night while they were still asleep. Each family spent for about 420,000 riel (over 100 US$) to rebuild even a low cost housing.

Strategic transformation on livelihood

In the olden days, local people were mostly depending on natural resources for living. The increasing demand of basic needs with the rapid increase of population, and a shrinking pool of natural resource, is a threatening effect, particularly due to land concession, for instance; granting of the state forest land to private companies for industrial use. In this study, strategies that are being practiced by the local communities adapting another form of livelihood are categorized into agricultural base and non-agricultural base strategy.

The study revealed that the local communities are utilizing the granted lands by promoting and developing a sustainable form of agro-forestry and backyard gardening which will be carried out in community level and household level, respectively. These practices belong to an agricultural base strategy. As mentioned, among the purposes of economic land concession (ELC), it is to develop an intensive agriculture and agro-industry. However, the local people are not capable to provide high inputs of labor, material and technical capital. Thus, the local villagers transformed from intensive agriculture to extensive agriculture by producing organic fertilizers, liquid bio-fertilizers, effective microorganisms (EM), organic animal feeds and small scale fish ponds through individual household approach.

Non-agricultural base strategy on improving the livelihood of the local community is by taking sideline jobs during dry season. Common available job that people involve are forest and

land clearing which each person earns from 22 to 35 US$ a month. Also, cottage industry is being carried out by some villagers which is supported both in technical and no interest loan financial from 30 to 50 US$ provided by local non-government organization. However, it was found out in this study that only 11.3% of the interviewed households adapt the cottage industry.

CONCLUSION

The implementation of Economic Land Concession (ELC) could not meet the overall objectives of the government development policy. Granting of state owned land and forest areas to private companies causes the loss of access of local people for fuel and non-timber forest products. ELC also results in the decrease of agricultural land areas for the local people. In addition, granting of land from private companies to the local people result conflicts on land ownership. Nevertheless, granting of state owned land through ELC to private companies is still continuously increases. However, ELC have its positive impact by providing employment of private industrial companies to local villagers. Nevertheless, there were only few of the local people that were employed. Also, the local people learnt on how to utilize the granted land for them from private company through transforming from intensive agriculture to a sustainable form of agriculture which is known as the extensive agriculture.

In conclusion, the establishment of ELC was observed to have more negative impacts to the livelihood in the majority of local people in the study site.

ACKNOWLEDGEMENTS

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Research article

Potential for Developing Tourism in Banteay Chhmar, Cambodia

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Abstract Tourism in Banteay Chhmar have been growing gradually since early 2002 with the assistance of the Banteay Chhmar Community-Based Tourism (CBT), a service provider to the tourists who visit and stay in the ancient historical resort. In 2008, there were 924 tourists visited the Banteay Chhmar tourist site. Due to the slow increase tourists visiting Banteay Chhmar, a field study was done in 2009 to investigate the current management of tourism in Banteay Chhmar. The objectives of the field study are to determine the impact of tourism on the local livelihood and environment, to evaluate the potential of tourist attraction sites and to analyze the constraints and opportunities for increasing tourism in Banteay Chhmar. In order to achieve the objectives, 14 semi-structure interviews, 17 questionnaires, 60 evaluation data sheets, mapping, some participatory rural appraisal (PRA) tools, direct observation and a strength weakness opportunity threat (SWOT) analysis were conducted. The results showed that the Banteay Chhmar CBT plays important roles in tourism management. Since the tourism began, the share of tourism in employment contributes 12 % of the total income and improved people's living standard. Moreover, awareness of cultural and environmental value had also increased. However, the overuse of water from the moat, vegetable gardening and waste disposal inside the temple affects negative impacts in the tourist site. Cultural and historical sites and local traditional ways of life are the main tourist attractions. Aside from the main attraction which is the Banteay Chhmar temple, other CBT services were also enjoyed by many tourists such as exploring the satellite temples, cycling, ox-cart riding and visiting the villages. Opportunities for tourist development were identified, such as increasing tourism through widespread tourism information, new income from visiting the temple and the temple's registration as a World Heritage Site. In contrast, mass tourism versus of CBT be concerned about sexual trafficking issues, and drug smuggling could be constraints for future tourism development. In conclusion, the research suggested that any future tourism development must be balanced in all economic, social and environmental aspects.

Keywords Banteay Chhmar, community-based tourism, tourism development, SWOT, PRA

INTRODUCTION

Tourism is considered as the major sector that contributes to the development of national economy in Cambodia. It provides additional income and employment opportunities that improve the living standard of local people and contribute on poverty alleviation (Tek, 2006).

Cambodia is among the countries in Southeast Asia and around the world that have plenty of natural and historical resorts with ancient culture across the country that plays an important role in tourism. The Banteay Chhmar temple which is located in Banteay Chhmar Commune, Thmor Pouk District, Banteay Meanchey Province depicting the Khmer Kingdom during the Angkorian Period is one of the greatest architectural masterpieces in Southeast Asia. Moreover, it is one of the

Cambodia's top-listed historical sites being nominated for UNESCO's World Heritage (GHF, 2009).

However, the lack of conservation and management results Banteay Chhmar's temples and towers gradually collapse, disintegrated and overgrown with trees. In addition, looting is also occurring in Banteay Chhmar (GHF, 2009) which therefore conservation and proper management are necessarily needed.

The objectives of this study are to investigate the current management of tourism in Banteay Chhmar, to determine the impact of tourism on the livelihood and environment, to evaluate the potential of tourist attractions and to analyze the constraints and opportunities for increasing the tourism in Banteay Chhmar.

METHODOLOGY

In this study, several methods were carried out to achieve the above objectives that include; interviews, questionnaire surveys, participatory rural appraisal, mapping, direct observation and strength weakness opportunity threat analysis. The interviews were conducted with 10 households in which 5 households from CBT members while the other 5 households were non CBT members. Moreover, 4 key elderly people interviews and 21 informal interviews were also done to get better understanding on the tourism in Banteay Chhmar. To evaluate on the tourist attraction sites, 17 tourists were interviewed using the questionnaires and 60 samples of tourist evaluation datasheets from the CBT were used. In addition, Venn diagram was utilized to indicate regarding with the current management of tourism, Pie diagram was utilized to distinguish the impact of tourism on livelihood and environment, Seasonal Calendar, Dream map, and Snake and Ladder of the PRA were to evaluate the constraints and opportunities develop tourism in Banteay Chhmar. Furthermore, GPS mapping were also done to point out the tourist attraction sites during the observation in the studied area, as for SWOT analysis was done after collecting the data.

RESULTS AND DISCUSSION

Roles of stakeholders on tourism management

There are some stakeholders that are strongly involving in tourism development, tourism management and improving the tourism services in Banteay Chhmar such as CCBEN, GHF, CBT.

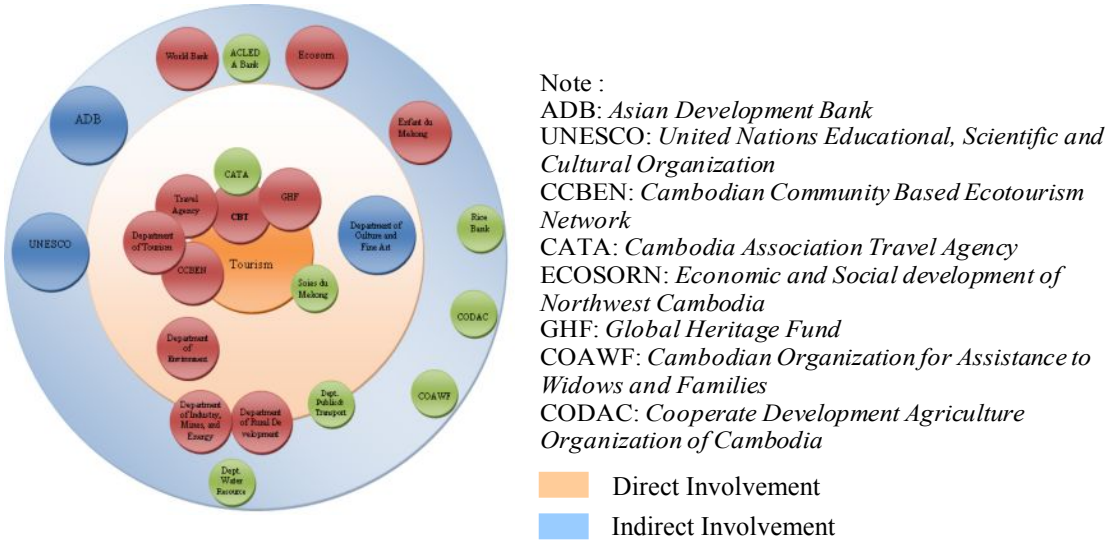

Fig. 1 Diagram of stakeholders' relationship in tourism development in Banteay Chhmar

Impact of tourism on livelihood and environment

The impact of tourism on livelihood is the change of income sources of CBT members indicating a share of 12% in the total income after involving in tourism (Fig. 2). The income from tourism has played important role of CBT member's expenses not only reinvestment in tourism but also investment in the existing activities (Fig.3). Moreover, CBT income from tourism also contributes 13 percent in Local Development Fund (Fig.4). Tourism in Banteay Chhmar is increasing the people's awareness on the environment. Now the environment is not yet polluted because it's under control of CBT, however, the main problem is the overuse of water from the moat, vegetable gardening and waste managing around the main temple. To prevent any problems, the zoning system has been proposed to manage future development effectively and efficiently.

a) b)

Fig. 2 Changes on daily activities of CBT members a) before and b) after involving in tourism industry

Fig. 3 The diversified expenditure on the income from tourism

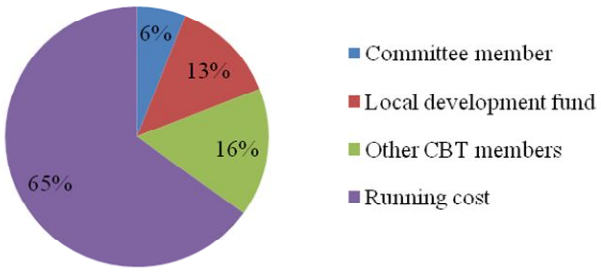

Fig. 4 The benefit sharing from tourism income in Banteay Chhmar CBT

Tourist attraction scheme

Tourist attraction scheme was analyzed through the data sheet from CBT. General tourist attractions were ranked from 1 (lowest satisfy) to 5 (highest satisfy). Among those attractions as shown in Fig. 5, cycling, visiting the temples and ox-card riding are the most attractive activities for tourists.

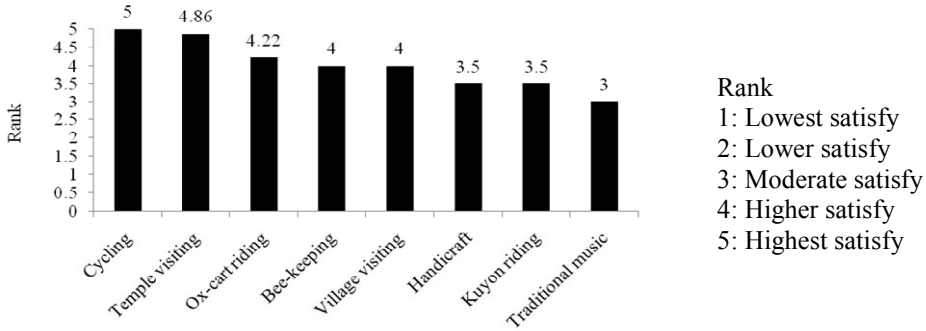

Fig. 5 Rank rating on different tourist attractions in Banteay Chhmar

Tourist attraction mapping

The tourist attraction mapping helps to identify the specific areas for the tourists to enjoy in the tour offered by the Banteay Chhmar CBT. With this map, tourists will be able to discover the place where they prefer to visit firstly or where the local guide could accompany with them. The tourist attraction mapping consists of the cultural attractions (the main temple and satellite temples), historical attractions (Choeung Kruos Water Reservoir) and traditional attraction (bee keeping and silk handicraft). The main temple is Banteay Chhmar, which was built on the area of approximately 4.75 ha in over 800 years ago. Having the Bayon prototype and surrounded by forest, these are the main attraction for the tourists. Moreover, other 9 satellite temples such as Chenh Choem Trey, Yeay Korm, West Samnang Ta Sok, East Samnang Ta Sok, Ta Prum, Balang, Me Bun, Yeay Chour, and Ta Em, are also regarded as the tourist attraction in area. Most of the satellite temples are covered by forest and the most attractive temples are Ta Prum, and Me Bun temples.

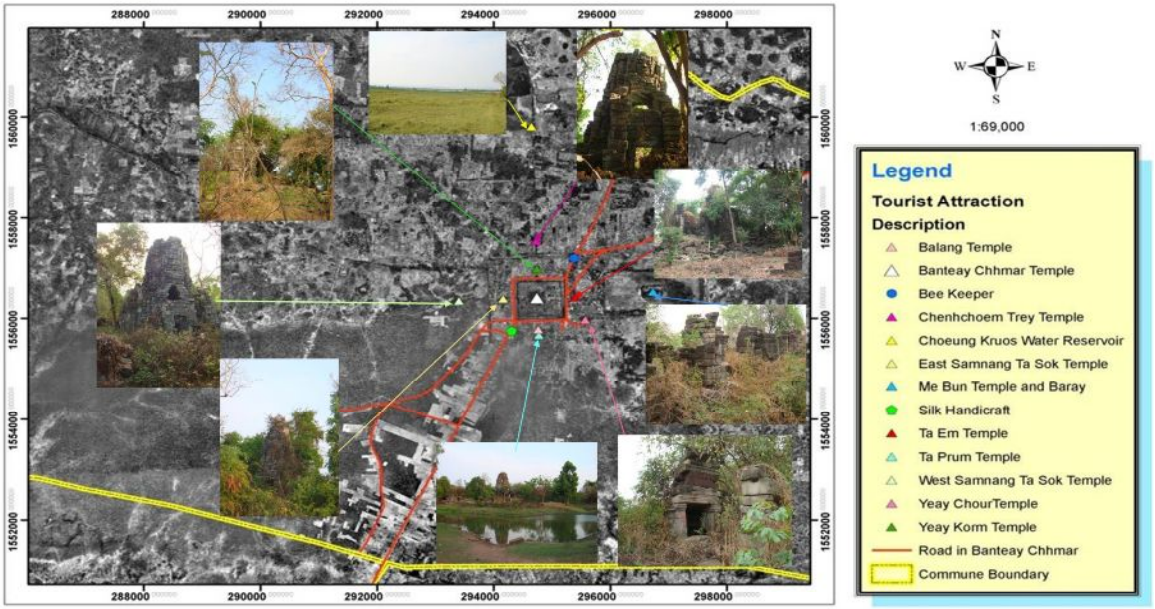

Fig. 6 Tourist attraction temple and landscape in Banteay Chhmar, Cambodia

Choeung Kruos Water Reservoir lies in large open green areas. It was built during the Pol Pot (Khmer Rouge) regime in the purpose of agricultural use. There is a great view of grassland and the Dangrek Range/Mountain that can be seen in the south-west to north-west of the areas.

The Constraints and opportunities

After all data and information in the field were collected and analyzed properly, the SWOT analysis was done to discover some suitable strategies to dealt with the constraints and opportunities for developing tourism in Banteay Chhmar as showed in Table 1.

Table 1 SWOT analysis for developing tourism in Banteay Chhmar

	Strength (S)	**Weakness (W)**
SWOT Analysis for developing tourism in Banteay Chhmar	- CBT provides services to tourists - Having support from GHF CCBEN, ECOSORN - More tourist attractions - Tourism site is close to the Cambodian-Thaiborder - Having master plan for Banteay Chhmar commune - Zone division - Commune development fund from CBT - Having some water resources	- CBT hasn't been recognized by the government - Infrastructure development hasn't done widely yet - Tourism services are not yet diversified and adequate - Lack of controlling on tourist who enter the temple - Limited advertisement of tourism in Banteay Chhmar - Low income from tourism in rainy season - High requirement of being member of CBT - Inadequate fresh water and electricity supply
Opportunity (O)	**Strategies for S&O**	**Strategies for W&O**
- Banteay Chhmar temple will be included in world heritage - Tourist will be increased - Increasing of environment and cultural awareness - New tourist attractions - Increasing in CBT members and job opportunities - Increasing the advertisement of tourism in Banteay Chhmar - New income from visiting the temple	- Effectively implement zoning system to ensure the environment preservation - Training more on the existing CBT members in tourist guide - Diversify food and homestay services - Better infrastructure development to meet the increasing of tourists and improving tourist attractions - More control on the tourists increase income	- Suggest the government to recognize the CBT officially - Increasingly advertise new tourist attractions in the area - Lessen the requirement of being member of CBT - Encourage to have more investment on fresh water and electricity services
Threat (T)	**Strategies for S&T**	**Strategies for W&T**
- Limited funds for CBT running process - Pollution on social, culture environment through migrants - Zoning can affect to people livelihood - Possible conflict between CBT member and Non-CBT member - Temple erosion - Mass tourism will affect on CBT - Losing agricultural labor - Sexual and drug smuggling - Time and money consuming in repairing the temples	- Facilitate the tourism development with CBT - CBT should prepare its own strategy in developing tourism, agreeing with the commune development plan - Local authority have to control carefully the tourists and private services in the area - Find and enable funds for developing the area - Transparency in income distribution to commune development	- Transparently assimilate the zoning division to local people - Urgently recognize the legality of CBT - Increase more job opportunity and availability - Increase seasonal cropping

CONCLUSION

Tourism management in Banteay Chhmar is increasingly improved from year to year through increasing in the tourists numbers. Banteay Chhmar CBT is the main institution which responsible for managing and providing the services to the tourists. However, it still needs more supports for it sustainable running process.

The main stakeholder that can improve sustainable tourism is Royal Government of Cambodia. Besides, some relevant institutions and NGOs such as GHF, CCBEN, CATA and other tourism agencies are also one catalyst in cooperating and advertising the tourism in Banteay Chhmar.

The quality of CBT services is recognized and given the high value by the tourists who welcomed by CBT; however, CBT also got some comments from tourist to improve the services.

Tourism in Banteay Chhmar has really benefited to local livelihood and environment since it's contributed to generate income. Income from tourism has contributed 12 percent of the total income, and by the income, people have enhanced their living standard through modernization of the services and daily expense. Moreover, environment consideration is gradually popular, increasing the awareness of the environmental maintance; however, water using and waste managing are the main problem in the present.

There are many opportunities for developing tourism in Banteay Chhmar base on its tourist attractions and well-managed by CBT, having better coordination with many stakeholders. More advertisement of the tourist site, updating some services, increase the CBT members and awareness of environment, strengthen the existing tradition and development of the tourist attraction sites are also the opportunities. Only permanent traditional activities that can be the attractions to the tourists and these can also preserve the tradition and way of life of the people in Banteay Chhmar.

However, the constraint for developing tourism in Banteay Chhmar is the mass tourism which could have negative impact on environmental, social and economical aspects. Moreover, some threats have to be considered such as isolated management of tourism of the stakeholders, destroy the environment when developing come, pollution to social and culture, and sexual and drug smuggling.

In brief, the main problem that can affect to sustainable development of Banteay Chhmar CBT is mass tourism which will negatively impact on the water resources, waste control, and CBT's benefit sharing to the members. Therefore, avoiding this possible problem, all development aspects have to think of environmental, social and economical sustainability.

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Research article

Agro-forestry System in Salt Affected Area in Khon Kaen Province, Northeast of Thailand

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Abstract One of the severe environmental problems facing in the northeast of Thailand is salt affected soil. In the total area of the northeast region at 16.928 million hectare, 2.848 million hectare is salt affected land, in which the Mahasarakham rock salt layer laid at the depth of 100-200 meters. The salt affected soil is causing various economic and social problems in the rural areas. As the salt affected soil was not so serious during 1940's when the land was covered with forests, attention has been paid to an agro-forestry system, which is one of alternative agriculture combining with forests. It is expected to reduce the intensity of salinity in the area. However, planting trees does not provide short term benefits comparing to growing field crops, so agro-forestry is hardly to be accepted by local people. Thus, the integration of salt tolerant trees and other crops could be the most beneficial for farmers and soil environment. Accordingly, this study was focused on identifying what effective agro-forestry systems are in salt affected area. Existing agro-forestry practices in Khon Kaen Province were investigated in this study. The agro-forestry practices were conducted in patch forests, paddy bunds, plantations associated with animal husbandry, home gardens and vegetable gardens. The dominant trees in these locations were *Sindora siamensis, Shorea obtusa, Eucalyptus camaldulensis, Bambusa bambos* and *Mangifera indica*. Also, the numbers of variety of trees planted in the salt affected areas were lower than that in the non salt affected areas. Based on the investigated results, it was proposed that agro-forestry practices with higher varieties of trees should be made in salt affected area.

Keywords salt affected soil, agro-forestry, Northeast of Thailand

INTRODUCTION

Salt affected soil is one of the severe environmental problems in the northeast of Thailand. The total area of this region is 16.928 million hectare while the salt affected land covers 2.848 million hectare. Salt components have been transferred to soil surface from Mahasarakham rock salt layer at the depth of 100-200 meters (Yuwaniyom, 2003).

Khon Kaen Province is one of the provinces in the northeast of Thailand which faces salt affected soil problem. Around 71.18 percent of the total area of 1.088 million hectare is used for agriculture, in which 8.03 percent is salt affected land and 19.87 percent has rock salt underneath (Table 1). Especially, salt affected soil problem is severe in Phra Yun District, Ban Fang District, Muang District and Ban Phai District (Khon Kaen Province, 2005).

Several organizations in Thailand and overseas have introduced the utilization of salt-tolerant trees and crops to solve or to mitigate this problem. However, local farmers have not adapted planting trees, as it takes long time to gain the profit (Vittayakorn, et al, 1994).

Table 1 Salt affected area of Khon Kaen province

Salt affected	Area (ha)	Percent
Agricultural area	774,864.79	71.18
Salt affected area	87,414.50	8.03
Area under salt rock	216,304.62	19.87
Total area	1,088,599.04	100.00

Source; Land Development Department. 2008.

Agro-forestry, an alternative agriculture, has been practiced in the northeast of Thailand. In this practice, trees are planted together with field crops in various applications. Even after harvesting the crops, the land is still covered with trees providing windbreak, fuel woods, shades, construction materials and foods to local people.

In 2007, Ruaysoongern studied about agro-forestry systems in the northeast of Thailand and categorized into following 25 groups, 1) agro-forestry in home garden, 2) agro-forestry in big paddy bund, 3) agro-forestry around pond, 4) agro-forestry around water edges, 5) agro-forestry surrounding water resource, 6) agro-forestry with water resource, 7) agro-forestry along water source, 8) agro-forestry in backyard, 9) tree plantation with undergrowth crops, 10) trees along natural water way, 11) trees with vegetable garden, 12) vegetable in paddy head land, 13) trees around fence line, 14) garden around farm shelter, 15) trees along ditch construction, 16) trees for farm border, 17) agro-forestry in salt affected area, 18) agro-forestry in flood prone area, 19) integrated trees and fruit trees, 20) bamboo plantation, 21) *Meliantha suavis* plantation, 22) *Meliantha suavis* around pond, 23) integrated vegetable with trees, 24) economic sufficiency practice and 25) orange plantation in arid areas.

While there were some researches regarding agro-forestry system in Thailand, there were few investigations focusing on agro-forestry practices in salt affected area. So, the objective of this study is to categorize the existing agro-forestry practices in salt affected areas in Khon Kaen Province.

MATERIALS AND METHODS

The field investigation on existing agro-forestry practices in salt affected areas was conducted in September, 2009 in Khon Kaen Province, Thailand. Aerial maps were used for identifying the land utilization. After the land utilization was distinguished, agro-forestry practices were categorized based on the plot of 20 m x 20 m. Then, observing plant profiles of each plot were done as well as conducting a hearing survey to farmers regarding their land utilization.

RESULTS AND DISCUSSION

Trees grown with agro-forestry practices on salt affected land can be observed in patch forests, paddy bunds, plantations associated with animal husbandry, home gardens and vegetable gardens.

Patch forest is a small area of natural forest surrounded by naked land (Fig.1). Trees remain in small clusters along the stream or body of water. The villagers can collect fuel woods and foods such as leaves and flowers. Moreover, the patch forest provides other edible plants like mushrooms or shoots. The samples of tree from patch forest were *Sindora siamensis, Dipterocarpus obtusifolius, Xylia xylocarpa* and *Lannea coromandelica*.

As shown in Fig.2, farmers in the northeast of Thailand prefer to keep trees in their paddy bunds for getting shades, foods, medicines and construction materials. All of the trees found in the paddy bunds were considered important due to their commercial value. Farmers realize that they can gain profits from selling these trees in the future. Even the tree's product like resin is commercially valuable. *Shorea obtusa* was the dominant tree found in the paddy bunds.

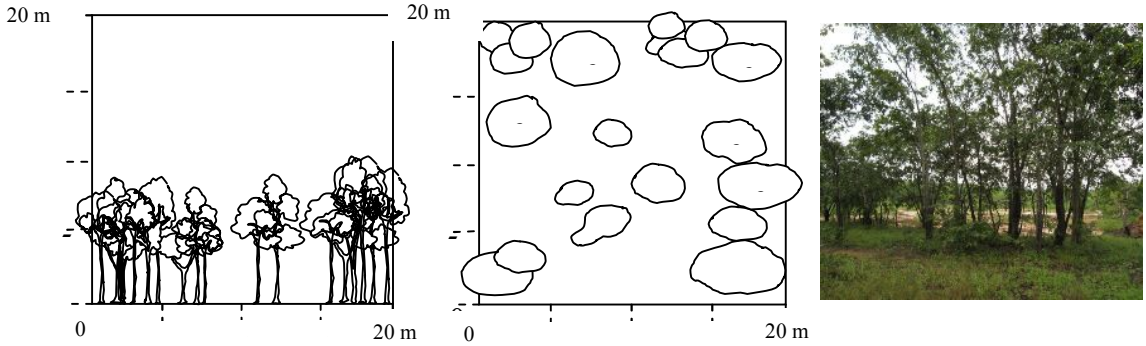

Fig. 1 Trees in patch forests

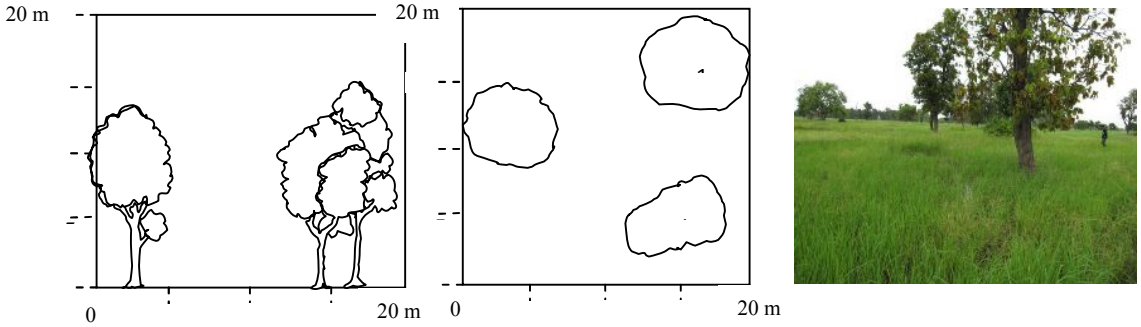

Fig. 2 Trees in paddy bunds

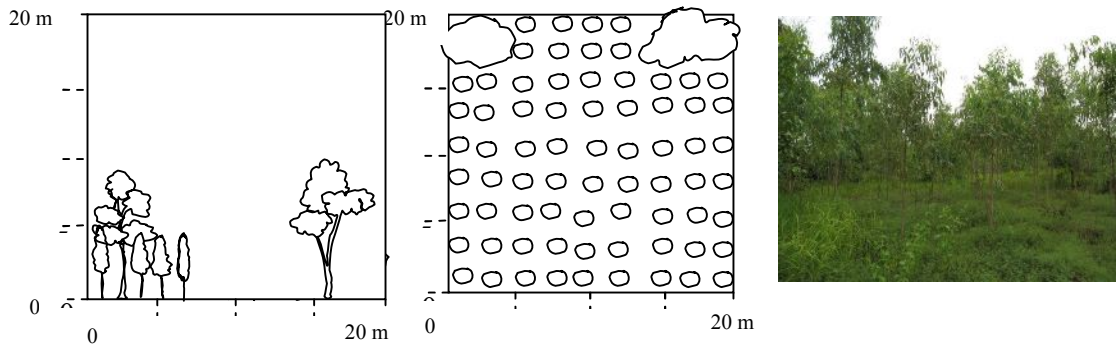

Fig. 3 Trees in plantations associated with animal husbandry

Some farmers with large areas of farmland planted certain varieties of tree and let their cows graze in the plantation for weed control (Fig. 3). The cows also provide natural fertilizer, cow dung, for the tree growing in the plantation. The samples of the tree from the plantation were *Eucalyptus camaldulensis, Tectona grandis* and *Pterocarpus macrocarpus*.

As shown in Fig. 4, some farmers who have sufficient area in their home gardens planted several kinds of tree for foods, construction materials, fuel woods, bio-pesticides and herbal medicines. The examples of tree in the home gardens were *Bambusa bambos* and *Thyrsostachys siamensis* for handicraft, garden fences and temporary construction materials, *Sindora siamensis* for construction materials and furniture, and *Azadirachta indica* for construction materials, fuel woods, foods, herbs and bio-pesticides. Similarly, *Annona squamosa* was used for edible fruits, herbs and bio-pesticides. Fast-growing *Anthocephalus chinensis* was for temporary construction materials and *Pennisetum purpureum* for fodder.

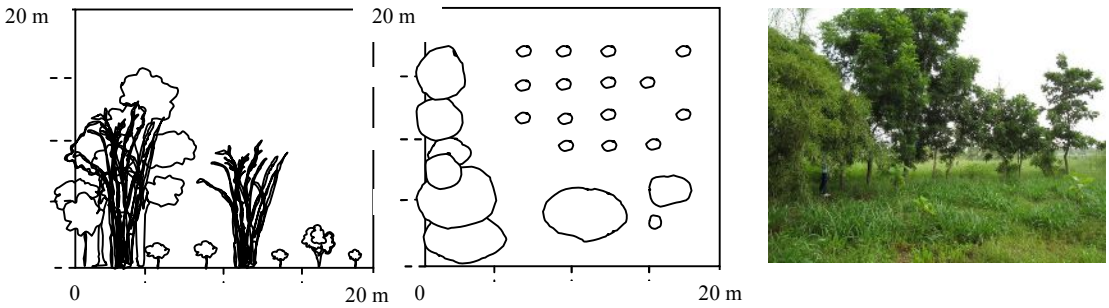

Fig. 4 Trees in home gardens

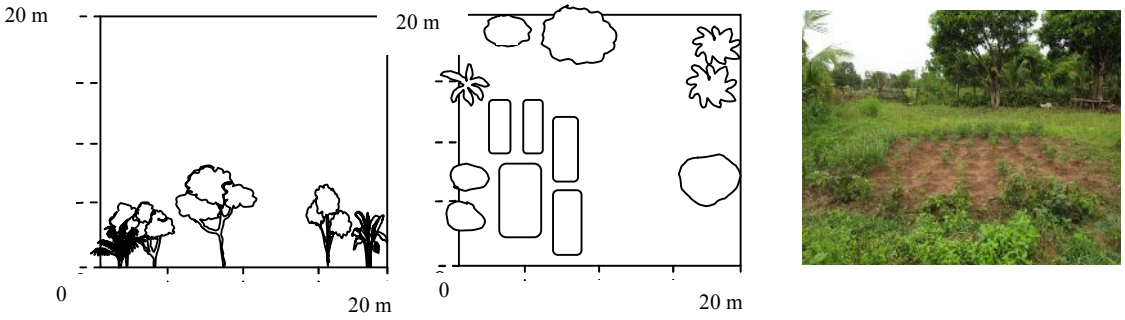

Fig. 5 Trees in vegetable gardens

Table 2 The utilization of dominant trees found in salt affected area

Number	Name of tree	Utilization
1	*Sindora siamensis*	construction
2	*Shorea obtusa*	construction, resin
3	*Eucalyptus camaldulensis*	construction, pulp paper
4	*Bambusa bambos*	construction, handicraft
5	*Mangifera indica*	edible fruit

In small vegetable gardens as shown in Fig. 5, farmers planted several kinds of tree together with vegetables. While waiting for the trees to be commercially valuable, farmers make profits from vegetables. The trees of *Mangifera indica, Cocos nucifera, Musa sapientum* and *Anthocephalus chinensis* were used for edible fruits and temporary construction materials. The types of vegetable planted with the trees were *Capsicum frutescens, Ocimum canum, Vigna unguiculata* and *Cucurbita moschata*.

The results of the field investigation in Khon Kaen Province indicated that tree varieties of agro-forestry practices in salt affected area ranging from 1 to 8 were smaller than that in the north at 16 varieties, the east at 11 varieties or the south at 15 varieties (Phothitai, 1993). So, it was proposed that farmers should increase the diversity of tree specie especially salt tolerant tree together with salt tolerant vegetable or field crop in each agro-forestry practice in salt affected area.

CONCLUSION

Existing agro-forestry practices in Khon Kaen Province were investigated in this study. The agro-forestry practices were conducted in patch forests, paddy bunds, plantations associated with animal

husbandry, home gardens and vegetable gardens. The dominant trees in these locations were *Sindora siamensis*, *Shorea obtusa*, *Eucalyptus camaldulensis*, *Bambusa bambos* and *Mangifera indica*.

Also, the varieties of tree planted in the salt affected area were lower than that in the non salt affected areas. Based on the investigated results, it was proposed that agro-forestry practices with higher varieties of tree should be made in salt affected area.

ACKNOWLEDGEMENT

The authors would like to extend the gratitude to all colleagues at the Association of Environmental and Rural Development, Thailand, as well as the informants in this study.

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Research article

Local Acceptability on Organic Farming in Kampong Cham Province, Cambodia

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Abstract Recently, in Kampong Cham Province of Cambodia, subsistence agriculture is being converted to commercial mono-culture, and the amounts of agricultural chemicals applied to farmlands are increasing every year. There seem to be many cases in which people apply agricultural chemicals without understanding the impact on health and food safety. It is necessary to promote and enhance understanding of sustainable agriculture among local people including farmers. So, this study dealt with the evaluation of local farmers' acceptability on organic agriculture based on the participatory level. The extension activities, such as promoting sustainable agriculture through demonstrating how to make compost box and compost, leader training for their deeper perception on sustainable agriculture, and conducting workshops on sustainable agriculture through composting, were implemented in 2007. In the initial stage of the extension activities, farmers' participation was evaluated as Level 3, participation by consultation, as the farmers participated by answering the questions. Also in 2008, following activities were implemented; introducing the farmers how to make pellet compost, initiating 4 model organic farms, leader training on making bio-pesticide and conducting workshops on sustainable agriculture through applying pellet compost. In addition to the extension activities, the surveys by interview and questionnaire for evaluating local farmers' acceptability on organic agriculture were implemented occasionally. Through a series of the extension activities, the farmers' participation was evaluated as Level 5, functional participation, as the farmers participated by forming the groups to meet the predetermined objectives of the extension project. According to the results of evaluating local farmers' acceptability on organic agriculture based on the participatory level, it was considered that building local farmers' confident through various extension activities is the most important key to increase local acceptability.

Keywords organic farming, acceptability, local farmers, extension, Cambodia

INTRODUCTION

Kampong Cham province, one of the 24 provinces and town of Cambodia, is located in the central region of Cambodia and gets effect from Mekong River basin. The main activity of the people in this area is agriculture, mainly cultivating rice and vegetable, and raising animals. Agricultural activities of the area tend to change from subsistence to commercial mono-culture, and the amounts

of agricultural chemicals applied to farmlands are increasing every year. The applied chemicals in farmlands cause serious environmental problems in downstream, such as eutrophication, unusual growth of aquatic plants, decrease in dissolved oxygen and accumulation of bottom sediments in the water resources (Mihara and Fujimoto, 2000). Also, there seem to be many cases in which people apply agricultural chemicals without understanding the impact on health and food safety. According to Ngo (2009) more than 60% of farmers in Prey Chhor district, Kampong Cham province, had applied agricultural chemicals without understanding the impact.

In order to contribute to solving the problems, understanding of sustainable agriculture, namely organic agricultural practices were promoted and enhanced among local people including farmers. So, the objective of this study was to discuss and evaluate the local farmers' acceptability on organic agriculture based on the participatory level.

STUDY SITE AND METHODS

The study was conducted in Wat Chas village, Baray commune, Prey Chhor district in Kampong Cham province around 105 kilometers from Phnom Penh city (Fig. 1). In Wat Chas village, the farmers mainly grow rice and short-term vegetable crops. The big amounts of chemical fertilizers and pesticides have been applied in their farmlands through all cultivating seasons. The impact of such applied chemical substances on soil fertilities, farmers' health and environment tend to be severer, but the farmers did not understand these problems.

The study was constituted with the extension activities, such as holding workshops with brochure distribution, questionnaire survey, making demonstration models and making field study tour for the farmers. In 2007, the participatory learning workshops were held in the village with 24 main farmers. The main contents of the workshops included i) the introduction to organic and sustainable agriculture practices, ii) the explanation of the principle of composting and iii) the demonstration of making compost box and compost. The farmers were divided into 10 groups, and a concrete compost box was set up to each group constituted with 2-3 members for making their compost. Further guidance explanations and monitoring were conducted regularly in the process of the extension activities. At later stage of 2008, following activities were implemented, i) the workshop on introducing the farmers to make pellet compost, ii) the establishment of 4 model organic farms and iii) the leader training on making bio-pesticide and appropriate way of its application in the model farms.

A questionnaire survey for evaluation was conducted with 79 farmers (80% of the village households) in March 2009. The main questions of the survey were focused on i) their accepted perception on organic farming practices, ii) how change in the amount of chemical fertilizer and pesticide that farmers have applied, and iii) how difference in farming practices before and after the extension activities. Also, some questions concerning the level of the farmers' participation in the organic farming practices were included in the questionnaire sheet.

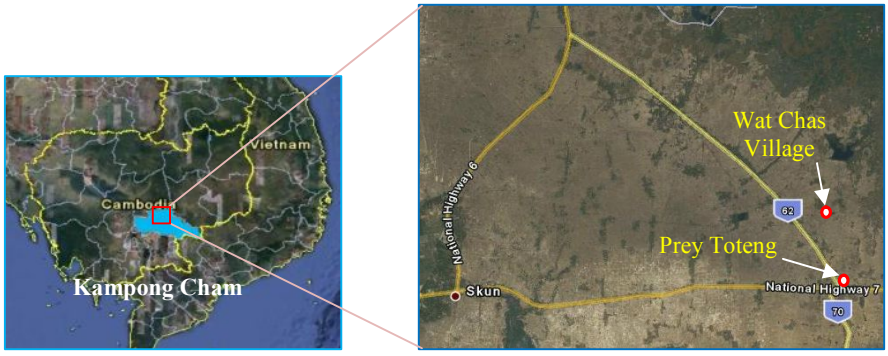

Fig. 1 Location of Wat Chas village in Kampong Cham province

The ways of farmers' participation were evaluated on the basis of the field observation, the content of discussion and the questionnaire survey. The conclusion of the level or degree of their participation was drawn on the basis of the participatory level developed by Pretty (1995) cited in Mihara and Yamaji (2004), which there are seven types of people participation, Manipulative Participation, Passive Participation, Participation by Consultation, Participation for Material Incentives, Functional Participation, Interactive Participation and Self-Mobilization (Table 1).

Table 1 A typology of participation

Typology	Characteristics of each type
1. Manipulative Participation	Participation is simply a pretence, with 'people's' representatives on official boards but who are unelected and have no power.
2. Passive Participation	People participate by being told what has been decided or has already happened. It involves unilateral announcements by an administration or project management without any listening to people's responses.
3. Participation by Consultation	People participate by being consulted or by answering questions. External agents define problems and information gathering processes, and so control analysis.
4. Participation for Material Incentives	People participate by contributing resources. They may provide the fields and labor, but are involved in neither experimentation nor the process of learning.
5. Functional Participation	Participation seen by external agencies as a means to achieve project goals, especially reduced costs. People may participate by forming groups to meet predetermined objectives related to the project.
6. Interactive Participation	People participate in joint analysis, development of action plans and formation or strengthening of local institutions. Participation is seen as a right, not just the means to achieve project goals.
7. Self-Mobilization	People participate by taking initiatives independently of external institutions to change systems.

Source: Pretty (1995) cited in Mihara and Yamaji (2004)

RESULTS AND DISCUSSION

Local farmers' acceptability on compost and pellet compost making

A workshop on how to make compost box, and a few other workshops on making compost and composting were conducted for the villagers in 2007 (Fig. 2). The contents of how to build the compost box, making compost using local materials, compost application and its benefits were explained and demonstrated in these workshops.

Around 25 to 40 farmers participated in each workshop. All participants have found the workshops very important and most of them have understood well about the meaning of the workshops, and responded that they want to participate in next workshops, too. According to the results of the questionnaire survey, 95.6% of the farmers who had participated in the workshops on composting took the compost technology into practices and applied it in their farmlands, and have seen how effective the compost is to their growing crops (Fig. 5). However, among the 4.4% of the participants who did not practice making compost after the workshops, some responded in reason that they cannot afford to make the compost boxes, and the others said to be busy with other works. Also, this survey results showed that around 3 or 4% of other villagers who did not participate in the workshops has learned and made compost and applied it in their farmlands to increase soil fertility. This indicated that the knowledge learned in the workshops has been transferred to other villagers who could not participate directly in the extension workshops. Applying compost, the farmers in Wat Chas village reduced the amount of applied chemical fertilizers around 54% from

135 kg to 62 kg per year (Fig. 6) and can save some money as the materials for making compost are available in or near the village without any charge.

Fig. 2 Farmers attending workshop of composting

Fig. 3 Workshop on pellet compost making with farmers

The workshop of transferring the pellet compost technology was conducted in 2008. Pellet compost has higher resistant from washing out by surface runoff. More nutrients can be supplied to crops and kept in soils for long term comparing to conventional compost (Siriwattananon and Mihara, 2004). The reasons why the pellet compost was developed were explained, and how to make the pellet compost was demonstrated with a small-scale mincing machine delivered to the farmers. The participants surely agreed that the pellet compost is another kind of organic fertilizer which is not so complicated to produce, more comfortable to use, easy to keep, and reduce nutrient loss by heavy rainfall or surface runoff. However, making pellet compost requires the mincing machine, and it is the problem for the local farmers as they cannot afford. According to the questionnaire survey, only 11% of the workshop participants have made pellet compost and applied it on their crops, but the other villagers have never produced pellet compost (Fig. 5). The farmers responded that the donated mincing machine is too small comparing to the amounts of pellet compost they need to apply in their farmlands, so they just applied the conventional compost directly. This survey also showed that there are high possibility to be widely advanced in making and applying pellet compost if a bigger mincing pellet machine could be set up.

Now these local farmers have understood well about the benefits of compost and pellet compost making and its application, and most of them are able to explain this technology to other local people outside the village.

Local acceptability on bio-pesticide

Bio-pesticide is a good alternative to chemical insecticide the farmers used to apply, concerning about the farmers' health, food safety and water conservation. To transfer the knowledge of using bio-pesticide to the local farmers, two workshops were conducted and 4 model organic farms were promoted in Wat Chas village in 2008 (Fig. 4).

Fig. 4 Farmers making bio-pesticide in the workshop (left) and one of the four model organic farm of the farmers (right)

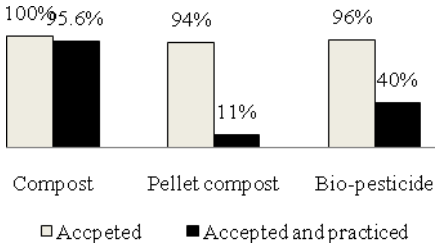

Fig. 5 Percentage of farmers acceptability on organic farming practices

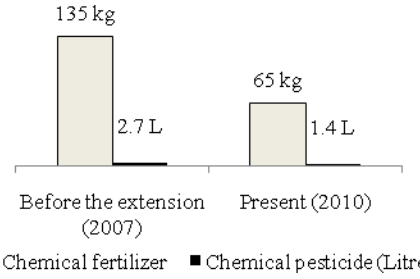

Fig. 6 Reduced amount of chemical fertilizers and pesticides use in household per year

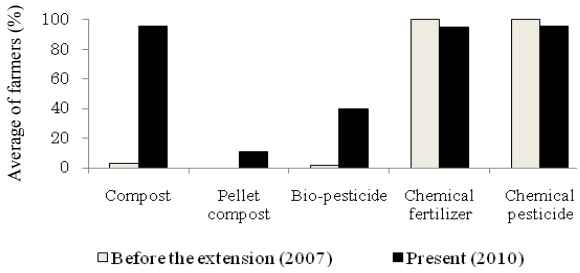

Fig. 7 Change in application with organic farming of farmers before and after the extension activities

The farmers were taught about making and applying bio-pesticide using the available materials in the village. Also, the impact of applied chemical insecticides on health, agricultural products and water resources was shown and explained in the workshops. A bucket was delivered to each owner of the model organic farm for making bio-pesticide. After applying, the farmers saw that bio-pesticide was also effective in chasing or killing the insects, but it required the farmers to spray it more often, 3-4 times per week. Many farmers in the village have learned about the effective of bio-pesticide and known how to make it using local materials. Due to the results of the survey, 40% of farmers who participated in the workshops have made and applied bio-pesticide, but all of them still sometimes applied chemical insecticide. The people answered that they may still apply chemical pesticide because making and applying bio-pesticide need times and require them to spray more often, even chemical insecticide is much more expensive. So, some encouraging activities of using bio-pesticides such as providing some rewards for farmers who apply bio-pesticide or some kinds of promoting the markets for organic products should be considered.

Evaluation of farmers' participation

There are various levels or degrees of farmers' participation. The evaluation of the farmers' acceptability on organic farming of this study was discussed on the basis of the participation levels developed by Pretty (1995), which has 7 levels as shown in Table 1.

In the initial stage of the extension activities, farmers' participation was evaluated as Level 3, participation by consultation as the farmers participated by answering the questions. Also in 2008, following activities were implemented; introducing the farmers how to make pellet compost, initiating 4 model organic farms, leader training on making bio-pesticide, and conducting workshops on sustainable agriculture through applying pellet compost. In addition to the extension activities, surveys by interview or questionnaire for evaluating local farmers' acceptability on organic agriculture were implemented occasionally. According to the results of the questionnaire survey, the farmers' participation was evaluated as Level 5, functional participation as the farmers participated by forming the groups to meet the predetermined objectives of the extension project. This result was similar to the study of Siriwattananon and Mihara (2006), conducted in Khon Kaen of Northern Thailand, and Ngo and Siriwattananon (2009) which showed that in the 1st workshop farmers participation was very low at Level 2 or 3 but this became very high at Level 6 in the 3rd workshop after the farmers understood well about the benefits of the compost. Thus, it was considered that building local farmers' confident through various extension activities is the most important key to increase local acceptability.

CONCLUSION

According to the results and discussions done in this study, it can be concluded that the extension activities for enhancing sustainable agriculture through conducting workshops and model organic farm demonstrations have favorable effect on change in amount of chemical fertilizers and insecticides used by the local farmers. The compost technology was highly accepted by the local farmers, but the pellet compost technology was not widely adapted with the reasons that the mincing machine was too small. The local people found bio-pesticide is really good for the farmers' health, food safety, and environment, but they still continue applying chemical insecticides sometimes as applying bio-pesticides required more times. So, some more encouraging activities on making and applying bio-pesticide such as providing some rewards for farmers who apply bio-pesticide or some kinds of promoting the markets for organic products should be considered. It was concluded that building local farmers' confident through various extension activities is the most important key to increase local acceptability.

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Research article

Sectoral Plans on Natural Resources and Environment: A Study on Pak Phli District, Thailand

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Abstract Since district has an intermediate position to multilevel planning system in almost all developing countries, there is a need to develop and prepare plan at district level incorporating the needs of the people, problems, potentials and developmental issues of the sub-districts to ensure sustainable rural development. With this view, the Regional and Rural Development Planning Programme of the Asian Institute of Technology (AIT) has intensified the planning workshop course to prepare sectoral plans within the district plans for strengthening decentralized planning exercise. This paper focuses sectoral plans on natural resources and environment, Pak Phli district, Nakhon Nayok Province, Thailand. The objective of this study is to clearly focus on need assessment, policy analysis, problems and potentials analysis and finally, identification of development programmes and projects to fulfill sectoral, spatial and clientele requirements. The methodology is developed on participatory planning approach, concept of learning while working, group discussion/interviews, discussion with governmental officials through meetings, brain storming, group exercise and presentation. However, study shows that although Pak Phli is blessed with the attraction of natural resources and renowned with abundant agricultural products, orchard gardens, beautiful water reservoirs and waterfalls but soil backward situation (gravel soil, hard soil, salty soil or acidic soil), severe soil erosion, high soil degradation and improper waste management are the most significant problems while lack of land title, low soil fertility, flooding, non-functioning of community forestry project and water pollution are prioritized as problems in this district. In accordance with several recommendations, this study proposes three projects for developing of natural resources and environment sector: (1) Acid soil management by applying liming and organic farming practices; (2) Strengthening community forestry project by enhancing capacity building of existing community forestry groups; and (3) Improving municipal solid waste management system by involving private sector and community people to carry out community solid waste management.

Keywords sectoral plan, development programme, participatory planning, organic farming, community forestry, solid waste management

INTRODUCTION

Pak Phli district, a district in the eastern part of Nakhon Nayok Province, eastern Thailand is blessed with the attraction of natural resources and also, called as provincial heritage site since it is renowned with abundant agricultural products, orchard gardens; beautiful tourist spots and waterfalls; and graceful with green nature and local culture. However, study shows although natural resources are available but soil backward situation (gravel soil, hard soil, salty soil or acidic soil), severe soil erosion, high soil degradation and improper waste management are the most significant problems while lack of land title, low soil fertility, flooding, non-functioning of community forestry project and water pollution are prioritized as problems in this area.

Since district has an intermediate position into multilevel planning system for ensuring sustainable rural development incorporating the needs of the sub-districts, this paper makes an attention to develop Pak Phli district plan focusing its natural resources and environment sector.

This study does clearly analysis the need, existing national policies and strategic plans, problems and potentials and finally, identifies development programmes and projects to fulfill spatial and clientele requirements of natural resources and environment sector at local level.

METHODOLOGY

The study is conducted by a workshop course offered for five months in every August session by the Department of Regional and Rural Development Planning, Asian Institute of Technology (AIT), Thailand. A preliminary reconnaissance survey is conducted by workshop coordinator in order to select the study area. The computerized village level data base, for example, National Rural Development data base (NRD-2C), 2009 and Basic Minimum Need (BMN), 2009 maintained by a central agency in Thailand (Thammasat University Data Processing Centre, Bangkok) are used to know the development status of study area. Apart from these sources of secondary data and information, a primary sample survey is usually conducted by the faculties, staffs and students through a structured questionnaire to provide additional information on particular sectoral analysis. However, equal emphasis is also given to collect first hand information by using participatory rapid rural appraisal and field research methods (rapid district appraisal). This gives the scope to interact directly with people, different groups, local leaders, government officials at provincial, district and sub-district level and thus facilitates participatory planning procedures (Routray, 1998).

Qualitative research approach is applied for this study because qualitative inquiry is inductive-focusing on practice, perception and interpretation rather than deductive and experimental. For doing this, this study frequently uses some selected techniques such as: secondary data analysis, content analysis, SWOT analysis, problem and proposal matrix analysis and in-depth case study analysis.

RESULTS AND DISCUSSION

Sectoral analysis on natural resources and environment: Pak Phli district

Physical setting, land form and topography

Pak Phli district is subdivided into one (1) municipality (Kho Wai municipality) and seven (7) sub-districts (Ko Wai, Ko Pho, Pak Phli, Khok Kruat, The Ruea, Nong Seang and Na Hin Lad) in Fig. 1, further subdivided into fifty one (51) villages. The total area of this district is 590.46sq.km or 1/6 of provincial area. The land form of Ko Wai, ko Pho, Pak Phli, and Tha Ruea is flood plain whereas the land form of Khok Kruat and Nong Seang is foot hill. The land form of Na Hil Nat is mountain type and height of the land is found within the range of (400m – 1300m) whereas the height of other sub-districts' high land is below 400m.

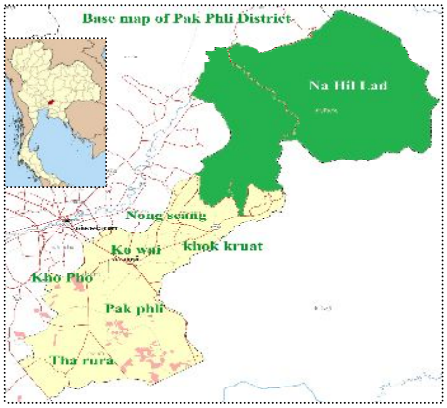

Fig. 1 Base map of Pak Phli District

Land, soil situation, water resource and forest

Pak Phli district is mainly forest area (52%) and agriculture (39%) is the major livelihood occupation comparing others occupations like animal husbandry (1%) and fruit orchard practice (1%) within the district. Water resources have lowest share of total area, only 1% (Land development department, 2009).

BMN, 2009 shows the existence of lack of land title for many people and landless in this area. Na Hin Lad has the highest percentage (93%) of household that has own land whereas Ko Pho has the lowest percentage (31%) of household. It also shows that most of the land is rented by farmers for paddy due to the need for the economy of scale. It is found that Tha Ruea has the highest percentage of household with land greater than 50 rai. Other sub-districts composed of 30% of household with 11-20 rai of land Khok Kruat has the highest percentage of household with less than 5 rai (13.45%). However, Ko Wai and Ko Pho have less than 50% household with rent land.

Pak Phli District has forest of 55% in its whole area while another 45% is covered by several soil series situations. Depending on soil series, the dominant soil types of Pak Phli District are Clay soil, Sandy soil and Loamy soil. Clay soil covers 92,928 Rai whereas Sandy soil and Loamy soil cover 35,901 Rai of total area. Less than 1% of area (313 Rai) in Na Hil Nad is steep mountains (Land Development Department, 2009), Table 1.

Table 1 Soil series situation in Pak Phli District

Soil Series	Location	Area	%	Texture	Filtration	pH	Nutrient	Usage
6	Nong Saeng, Khok Kruat	5,937	2.16	Clay	Low	4.5-5.5	Fe, Mg	Paddy, vegetables
10	Pak Phli, Tha Ruea	3,242	1.18	Clay	Low	4.5	n/a	Paddy, vegetables
11	Ko Wai, Ko Pho, Pak Phli, Tha Ruea	65,958	24.02	Clay	Low	4.5-5.0	Al	Paddy, vegetables
16	Na Hin Lat, Nong Saeng, Ko Wai, Ko Pho, Pak Phli	34,418	12.54	Salty clay	Medium	5.0-6.0	Fe, Mg	Paddy
35	Na Hin Lat, Khok Kruat	3,702	1.35	Sand	High	4.5-5.5	n/a	Upland crops
46	Nong Saeng	2,527	0.92	Clay loam	Medium	5.0-6.0	n/a	Upland crops
56	Na Hin Lat, Khok Kruat	3,733	1.36	Sandy silt	High	4.5-5.5	n/a	Upland crops
62	Na Hin Lat	313	0.12	Rocks	n/a	n/a	n/a	Not suitable for cultivation
Forest	Na Hil Nat	147,157	53.60	n/a	n/a	n/a	n/a	Forestry tress

NRD-2C, 2009 and field survey, 2010 shows that the soil situation of the villages of Ko Wai, khok kruat, Na Hil Nad and Nong Seang are fertile and farmers are using less amount Chemical fertilizer (30%), excess amount of organic fertilizer (chicken /fish) (70%) and organic pesticide. Agriculture learning centers and awareness growing campaign by them on using organic fertilizers, environmental protection, solid waste management, road maintenance and afforestation are available. However, Pak Phli, The Ruea and Kho Pho face high soil degradation due to using excess amount of chemical fertilizer (80%) and pesticide. Severe soil erosion is found in Nong Seang because of it physical soil profile of slop and valley complex.

BMN, 2009 shows that there are 40 Canels/rivers, 75 ponds/swamps and 7 dams are found as natural water resources throughout all sub-districts in Pak Phli district. For ensuring drinking water sources and reserving water for dry season, Khok Kruat has the highest no. of ponds (328) and bowels (21); Na Hil Nad and Ko Wai have 3 and 1 manmade reservoir accordingly. In case of water for agriculture, NDR-2C, 2009 shows that out of data availability of 51 villages, 3 villages (6%) are backward having no water sufficiently for agricultural cultivation, 38 villages (75%) are

moderate having water sufficiently during rainy season, and 10 villages (20%) are progress having water sufficiently for cultivation during all year.

The total forest area of Pak Phli district is 399,381 rai. 397,361 rai of total forest area is reserved and protected with the forest laws regulated by the Royal Forest Department located at Na Hil Lad sub-district, table 2. Presently, government promotes eco-agro tourism activities in this area.

Table 2 Area of forest and plantation (rai)

Sr.	Category	Naung Seng	Ko Pho	Pak Phli	Ko Wai	Khok Kruat	Tha Reau	Na Hin Lat	Total
1	Dense Evergreen Forest	-	-	-	-	-	-	397,292	397,292
2	Disturbed Evergreen Forest	-	-	-	-	-	-	69	69
	Sub-total								397,361
3	Plantation	105	183	38	58	45	646	445	1,520
4	Community forestry	200	100	-	-	200	-	-	500
	Total								399,381

Field Survey, 2010 shows the lake of comprehensive management plan in implementing Community forestry activities. People usually perceive their role as recipients of top-town decision making and therefore only put assignments projects into practice. Consequently, one community forest in Khok Kruat sub-district is about to change into play ground. Also, local governments have planned to cut down the forest and convert it into the sport field following the public demand.

Environmental management, policy and program analysis

NRD-2C shows that Khok Kruat and Na Hil Nad have progressive level of environmental management facing no solid waste management (SWM) problem. Case study of Kho Wai municipality shows that it is responsible to collect waste from household of every sub districts using two vehicles (cab van) (storage capacity 15 Lb.m) per day. These vehicles go to collect waste one time per day. Every day the total of 39.40 liters fuel is used for garbage collection. To get this facility, every household pays 100 baths per month. Kho Wai has own landfill to disposal the waste collected from every household. Every day 3.5 tons waste is disposable in this landfill (Lopa et al, 2010).

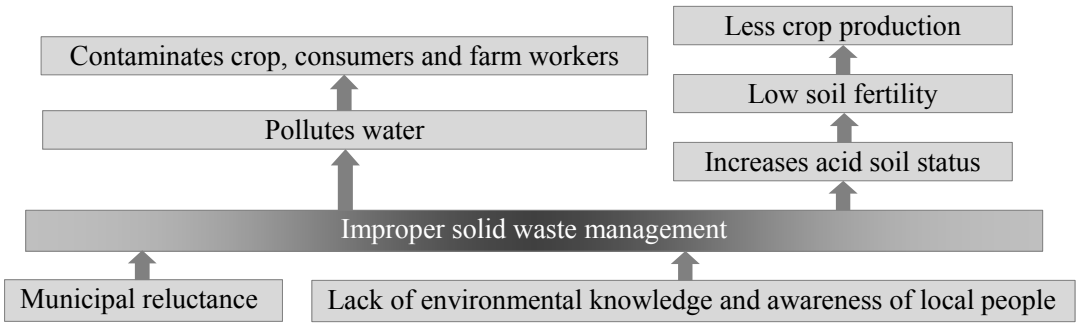

Fig 2 Problem tree analysis of SWM

However, the waste collected from Pak Phli district is also stored in Kho Wai landfill. Every day 500 kg waste from Pak Phli is disposable into Kho Wai landfill. However, field Survey' 2010 shows municipality does not collect waste from all sub-districts. It collects waste but irregular from

those areas which are near about to municipality. This condition is considered a serious and visible environmental problem and public health risk, Fig. 2 (Lopa, 2010).

There is still lack of adequate programmes in line with the national policies and strategies. Farm burning as illegal in national policies but it is widely prevalent in all sub-districts. It has adequately addressed the awareness on environmental pollution and solid waste management system but programs to address the issues are not conducted in the local area. Forest national policies have addressed well but since the forest encroachment and clearance are high, campaigns for awareness raising, and trainings for capacity building, forest reforestation programmes are needed to be intensified as the scope of these activities are found to be very limited.

Problems and prospect analysis

Table 3 Problem matrix

Problems	1	2	3	4	5	6	7	8	9	Score	Rank
Low soil fertility										0	0
Acidic soil status	x									1	2
Severe soil erosion	x									1	2
High soil degradation	x	x							x	3	1
Lack of land title										0	0
Flooding during rainy season										0	0
Improper waste management	x	x		x						3	1
Non-functioning of community forestry										0	0
Severe water pollution										0	0

Table 4 Proposal matrix

Identified Problems	Development Potential	Policy Situation	Project Proposals
1. Low Soil fertility in Ko Wai, Ko Pho, Pak Phli, The Ruea and Na Hil Nad 2. Acidic soil status in Ko Wai, Ko Pho, Pak Phli, The Ruea 3. Severe soil erosion in Nong Seang 4. Lack of land title 5. High Soil Degradation in Pak Phli, The Ruea and Kho Pho 6. Flooding during rainy season in Kho Pho, Kho Wai, Pak Phli, The Ruea, Khok Kruat and Nong Seang 7. Irregular Municipal Waste Management in Kho Wai, Nona Saeng and Pak Phli and illegal waste dumping practice by household in other sub-districts 8. Non-functioning of community forestry in nong Seang, Kho Pho and Khok Kruat 9. Severe water pollution in Pak Phli and Kho Pho	1. Availability of water resources and irrigation & water accessibility project in the district 2. Availability of forest resources (69% of total area) 3. Availability of organized land suitability and land classification data 4. Due consideration for Natural Resource and Environment Issues by Land Development Department 5. Prospect for eco-agro tourism development	1. Promotion local participation on environment management 2. Natural resources and environmental rehabilitation such as community forestry program promotion 3. Political and administrative development such as people's participation, politic and administration promotion	1. Acid soil management by applying liming and organic farming practices 2. Strengthening community forestry project by enhancing capacity building of existing community forestry groups 3. Improving municipal solid waste management system by involving private sector and community people to carry out community solid waste management.

Provincial and district level strategies have adequately addressed the drinking water issue but not for the agricultural purposes. However, presently, they have planned to introduce a large scale

water supply and irrigation project in which Kho wai, Khok Kruat Pak Phli and Na Hil Nad sub-districts cover 27,809 rai for irrigation project and Tha Ruea, Pak Phli & Kho Pho cover 102,776 rai for ensuring water accessibility during the dry season. National and district level strategies have adequately addressed the issue of land reform ongoing only in three sub-districts but the problem is lack of land title in these areas need to address.

From the problem matrix analysis, Table 3, it is found that high soil degradation and improper solid waste management are the most important problems of this area whereas acid soil status and low soil erosion are equally important while non functioning community forestry, lack of land title, flooding, low soil fertility and severe water pollution are least important among these nine core problems. Apart from these problems, prospects for water and irrigation projects, available forest resources and prospect for eco-agro tourism projects, due consideration for natural resource and environmental management are main potentials observed, Table 4.

CONCLUSION

Rapid population growth and increasing agricultural intensity have driven interrelationship between local people and environment which become complex putting high pressure on natural resources ranging from poor soil quality, soil acid, soil erosion, forest encroachment, lack of land title and landlessness. Likewise increasing agricultural and household activities have brought about environmental pollution; like air pollution from burning harvesting, solid waste, and impacts of extensive chemical uses to human and environment. Apart from these problems, availability of community forestry and successful implementation and probability of its promotion in other sub-districts, topographical advantages which can lead to storage of high water and solve the problem of water shortage and promote agricultural productivity and existence of favorable national, provincial and district level policies are some of the potentials of the sector. But these potentials are not fully harnessed.

There exist favorable policies and plans at national, provincial, district and sub-district levels to address the local problems but there is gap in design and implementation of programmes as per the need of local problems. Programs utilizing the potentials and solving the problems of the area should be designed and implemented which need effective coordination among the provincial, district and local level governments of the area.

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Research article

Improvement in Practicing System of Rice Intensification (SRI) Principles by Farmers in Rainfed Area of Cambodia

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Abstract System of rice intensification (SRI) is a rice farming practice developed in Madagascar under irrigated conditions. Recently, SRI has been diffused in rainfed paddy areas of Cambodia. Confirming the reasons for the diffusion will undoubtedly provide clues for improving rainfed agriculture unaffected by green revolution technology. In 2008, the authors introduced SRI to rainfed rice farmers in the Kampong Speu province of Cambodia. Six volunteer farmers unfamiliar with SRI techniques conducted an on-farm trial to compare conventional practices with SRI. The farmers adopted only several SRI principles, and a significant yield difference between SRI and conventional practices was absent. Even though yield did not increase dramatically, all cooperating farmers agreed to continue SRI at least in small-scale trial plots since SRI showed indications of being more efficient such as savings on the cost of seeds. In 2009, the farmers practiced SRI more rigorously following intensive training. The principle of "reducing number of seedlings per hill" was found to be the motivating factor that led to introducing SRI other principles. For example, the farmers were compelled to use younger seedlings. Conventionally, farmers grew a huge number of seedlings in a large nursery area, making it more difficult to grow young seedlings with care. SRI, and its advantage of fewer seedlings requirements, changed this practice and the farmers started using younger seedlings. As a result, yield difference between SRI and conventional practices in 2009 was larger than that in 2008. It was also observed that the farmers instituted several SRI principles in comparison plots for conventional practice, not only in SRI plots. The farmers introduced their own ideas in search of the best combination of SRI principles. Another remarkable result was that the farmers also took the initiative to introduce some SRI principles into their own non-comparison plots.

Keywords system of rice intensification, sustainable rice farming, rainfed lowland paddy, small-scale trial plot

INTRODUCTION

SRI in rainfed lowland paddy areas of Cambodia

System of rice intensification (SRI) is a rice farming practice developed by Father Henri de Laulanı´e, in Madagascar in 1983 under irrigated conditions, and was introduced into Cambodia in 1999 and disseminated by organizations such as the Centre d'Étude et de Développement Agricole

Cambodgien (CEDAC). The distinctive characteristic of SRI in Cambodia is that most farmers are practicing SRI in rainfed lowland paddy areas.

Objectives

Understanding the reasons for SRI diffusion in Cambodia has the potential of suggesting clues for improving rainfed agriculture unsupported by green revolution technology. The objectives of the research are to:

1) evaluate SRI in rainfed lowland paddy areas from the viewpoints of Cambodian farmers,
2) analyze the reasons and mechanism for farmer acceptance of SRI practices, and
3) construct a case example useful for further SRI research and development.

Framework

An on-farm experiment with participatory action research (PAR) concept was conducted for three years. PAR seeks to understand and to improve the world by changing it. Collective, self-reflective inquiry that researchers and participants undertake is the heart of the concept. This, in turn, enables better understanding of and improvement in employed practices and under local environmental conditions. The reflective process is directly linked to action, influenced by an understanding of history, culture, and local context and embedded in social relationships (Baum et al., 2006). The experiment was carried out under the earnest desire and decision making initiative of the farmers with the flexibility to change the design of the experiment. We expected the PAR concept to enable us to gain knowledge of farmer perceptions of SRI.

The experiment has been conducted since 2008 and this article reports the results of the second year of the experiment in 2009.

Results of the first-year experiment in 2008

The experiment started in 2008 with six volunteer farmers in Tboung Angk, Samdach Ov, and Chas villages of Prey Nheat commune, Kong Pisei district, Kampong Speu province in the southwest part of Cambodia. The villages are scattered in the vicinity of latitude 11°22'N and longitude 104°39'E. Results suggested potential advantages of SRI in rainfed lowland rice paddy areas since the farmers were able to maintain yields with fewer resources, at least in small-scale test plots. It was also revealed that the need for fewer seedlings per hill was an important motive for the farmers in applying SRI since seed input can be decreased. (Tsurui et al., 2010).

METHOD

All six farmers during the first year of the experiment in 2008 agreed to continue the on-farm experiment in the second year in 2009. The farmers compared SRI and conventional rice farming practices in small-scale on-farm comparison plots to evaluate SRI effectiveness. It should be noted that no seeds, fertilizer, equipment, agrochemicals, or other physical support was provided to the farmers. It was thought that such physical support might create bias in farmer decisions. Hence, the farmers were provided with technical guidance only.

RESULTS OF SMALL-SCALE COMPARISON TEST

Rainfall

Records of monthly rainfall in Kampong Speu (latitude 11°28'N, longitude104°34'E) report 733 mm of rainfall during June-December 2009, nearly 100 mm lower than a five-year average (2003-2007) of 827 mm.

Layout and size of comparison plots

Two farmers (Farmers B and F) redesignated comparison test plots to closer or larger plots from those used during the first year (see Table 1). All six farmers applied traditional cultivar for the comparison test, but two applied different cultivar for conventional practice and SRI. These farmers were interested in finding a suitable cultivar for SRI.

On average, 39 kg/ha of chemical fertilizer was applied to comparison plots for conventional practice (increased by 5 kg/ha from the first year), and 29 kg/ha was applied for SRI (increased by 6 kg/ha). It was also estimated that about 84 kg/ha (decreased for 33 kg/ha) of chemical fertilizer was applied to non-comparison plots. The farmers decided to conduct the second-year comparison test by increasing the amount of purchased chemical fertilizer slightly while at the same time reducing the amount for non-comparison plots.

Table 1 Outline of comparison test in 2009 (year 2)

Item	Plot	Farmer A	Farmer B	Farmer C	Farmer D	Farmer E	Farmer F
Test plot displacement from Year 1 (2008)		No	Yes (to nearer plot)	No	No	No	Yes (to bigger plot)
Test plot alignments		Same plot without levee	Same plot with levee	Same plot with levee	Separated (50 m distance)	Same plot with levee	Same plot with levee
Plot sizes (a)*	CFP	14.0	13.0	9.5	11.5	3.3	8.9
	SRI	12.6	4.9	3.8	16.4	4.5	20.4
Cultivar**	CFP	Chhma Prum	Champar-meas	Chhma Prum	Beikantam	Lum Ang-Khsach	Lum Ang-Khsach
	SRI	ditto	Chhma Prum	Beikantam	ditto	ditto	ditto
Chemical fertilizer application (kg/ha)	CFP	71	77	11	43	30	0
	SRI	79	61	27	6	0	0

**Size of plots was measured by handheld Global Positioning System receiver.*
***Only traditional cultivars used.*
Note: CFP: Conventional rice farming practice
Source: Authors' data

Adoption of SRI principles

It was confirmed that about 15% of practices equivalent to those of SRI had already been introduced into these farmers even before the farmers learned about SRI in 2008. In 2008, the farmers were introduced to SRI practices and instructed to follow 12 SRI principles as best as possible. However, the SRI adoption rate (ratio of applied SRI principles against total number of SRI principles which is 12) in 2008 was 53% even in small-scale comparison plots for SRI.

In 2009, the farmers were provided intensive training and strongly urged to apply the principles, especially in comparison plots for SRI. As a result, the average adoption rate of SRI principles in comparison plots for SRI increased by 76% (see Table 2). However, SRI principles related to water management were not well practiced.

Unexpectedly, the farmers introduced several SRI principles into comparison plots for conventional practice on their own initiative. In some cases, this might have happened coincidentally because the plots were located very near to SRI comparison plots. The farmers were able to provide natural fertilizer or weeding for comparison plots for conventional practice at the same time as they did for SRI plots. However, transplanting one or two seedlings per hill or other SRI principles were introduced intentionally; that is, the farmers introduced their own ideas in hopes of discovering the optimal combination of SRI principles. The adoption rate of SRI principles in comparison plots for conventional practice was 38%.

Fig. 1 shows changes in SRI adaption rate by individual farmer in the comparison plots for conventional practice. Fig. 2 shows that for SRI both sets of figures indicate that the adoption rate from the first year of the experiment increased among all farmers except farmer E. It is noted that Farmer D applied 96% of principles in the SRI plot in 2009.

Yield

NGO staff or farmers compared the yields of SRI and conventional practice in the same three plots (Farmers A, C and E) from the first year of the experiment by quadrat sampling. In the second year, yields in SRI plot were higher than conventional practice yields in Tbong Angk and Samdack Ov villages, yet the yield increase in Chas village was little. Yields of the conventional practice plots and SRI plots were at an average of 3.1 ton/ha and 3.8 ton/ha respectively.

Table 2 Adoption rate of SRI principles by the six farmers in 2009

SRI Principles	Adoption rate of the six farmers (%)			
	Before 2008	Year 2 (2009)		
		CFP	SRI	NON
Water management				
1) level the paddy field and provide drainage	33	25	50	8
2) keep the water depth in the paddy field shallow	0	17	42	8
Nursery preparation				
3) raise nursery beds or use dry nursery beds	17	25	92	25
4) select dense seeds for sowing without mixing them with other varieties	50	67	83	67
Transplanting				
5) transplant young seedlings (seedlings upto 15 days)	0	17	67	8
6) select big seedlings and transplant them immediately	0	33	92	17
7) transplant one to two plant(s) per hill (preferably only one)	0	50	92	33
8) transplant seedlings at a shallow depth and keep the roots horizontal	17	50	58	42
9) transplant seedlings in square pattern or lines	0	0	100	8
10) transplant seedlings 25-40 cm apart	17	33	83	33
Fertilizing				
11) apply natural fertilizer as much as possible	33	67	83	67
Weeding				
12) weed at least 2-4 times a season	17	75	75	0
Average	*15*	*38*	*76*	*26*

Note: CFP: comparison plot for the conventional farming practice, SRI: comparison plot for the SRI, NON: Non-comparison plot
**Adoption rate was calculated by giving 1 point for "fully adopted", 0.5 point for "partly adopted", and 0 point for "not adopted" to each farmer, and divide the total score by the number of farmers.*
Source: Authors' data

Farming practice in non-comparison plots

One remarkable result in the second year was that four farmers (Farmers A, B, C and D) started introducing some SRI principles in their own non-comparison plots without any instruction from NGO staff; that is, under their own initiative (see Fig. 3). Of special note is that they reduced the number of seedlings per hill from the previous 5-10 plants per hill to 2-4 plants per hill.

DISCUSSION

Participatory evaluation of SRI

The farmers' perception of SRI was confirmed through semi-structured interviews at the end of the first year trial. It was confirmed that the main benefit of SRI for the farmers is "reducing number of seedlings per hill".

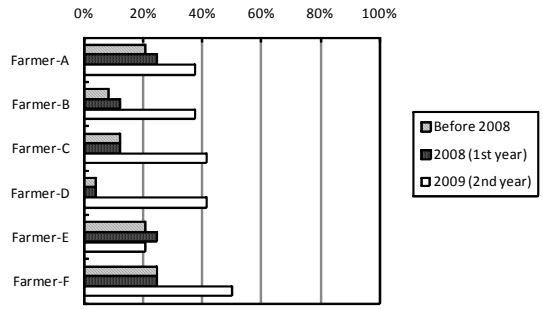


Fig. 1 SRI adoption rate in comparison plots for conventional practice

Farming practice in 2008 was assumed to be same as the practice before 2008 unless any changes were reported by the farmers.

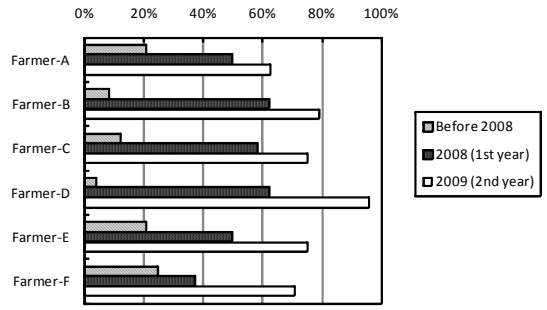
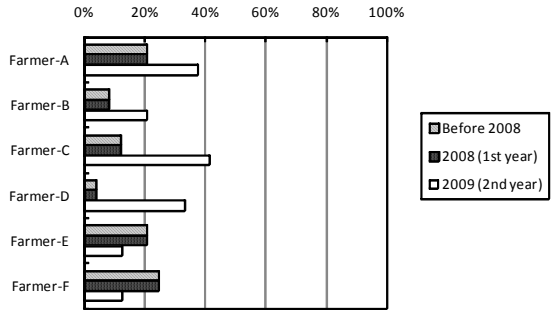


Fig. 2 SRI adoption rate in comparison plots for SRI



Farming practice in 2008 was assumed to be the same as that before 2008.

Fig. 3 SRI adoption rate in non-comparison plots

This enabled the farmers to save seed and consume more rice. The second major benefit is "reducing labor especially for uprooting". Naturally the amount of labor for uprooting could be reduced accordingly by reducing the number of seedlings. The farmers said they needed more labor for transplanting seedlings with lines, but such increment could be balanced out by reducing the labor for uprooting. The third major benefit was revealed to be "increase of yield". As expected, the farmers found larger benefit from reducing resources than increasing yield.

SRI difficulties were also confirmed. The major difficulty is "transplanting seedlings in square pattern or lines". Farmers find it difficult and time consuming to transplant seedlings in lines since they have been accustomed to random transplanting. Not owning rotary weeders, however, may very well prevent the farmers from realizing the significant benefit from line transplanting. Of special note is that no farmer introduced line transplanting in comparison plots for conventional practice though all farmers employed it in SRI plots. Probably this behavior has some symbolic meaning, showing that farmers are practicing SRI. The second major difficulty is "insufficient water". However, this complaint occurred regardless of the rice growing method. The third major difficulty is "additional weeding" and "difficulty in carrying compost from house yard to paddy by ox cart, especially if no proper road is available". Other difficulties included "difficulty in drainage" and "attitude of other villagers (villagers recognized the farmer is doing something strange)".

Finally, farmers commented that they felt (the farmers evaluated SRI as) SRI was an effective method, at least for small-scale plots, since benefits outweighed difficulties. This fact suggests improperness of evaluating SRI only by yield or economic benefit. The farmers might not always think about yield or they might not calculate economic benefit as scientists do. It must be important to include farmers' input and evaluate SRI together with farmers and from their viewpoints.

Process of introducing SRI principles

Regarding the typical process of how the farmers initiated SRI principles, two entry points were observed: "transplant one to two plant(s) per hill" and "apply natural fertilizer as much as possible". These two entry points gave impetus to the introduction of other principles. Fig. 4 and the attached explanation show the process of introducing SRI principles. Solid line arrows show relationships practiced by the farmers, and dotted line arrows indicate conceptual relationships practiced on site. "Reduce number of seedlings per hill" is clearly strongly influenced the introduction of other SRI principles.

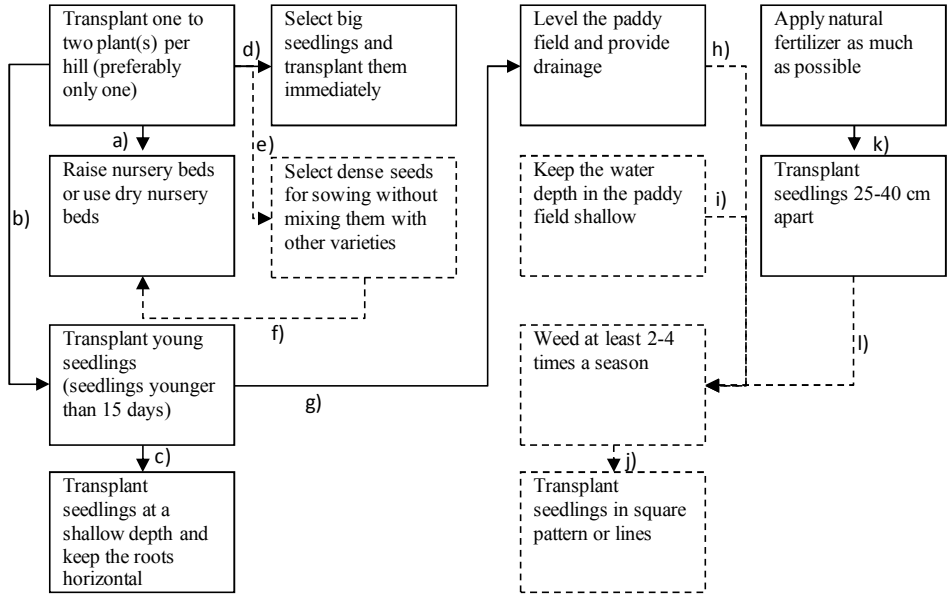


Fig. 4 Typical process of introducing SRI principles

a) Reducing number of seedlings enables introduction of raised bed nursery since a smaller area is required.
b) Reducing number of seedlings enables farmers to seed in July when rain may be infrequent. Farmers can water by watering can if the nursery is small.
c) It is possible to transplant seedlings with shallower depth, only if the seedlings are young. Old seedlings cannot support themselves if they are transplanted into shallow depth because of their weight.
d) Farmers can transplant quickly if number of seedlings are less.
e) Preparation of salt water for seeds selection becomes easier if the required number of seeds is less.
f) Improvement in germination percentage decreases mental anxiety of farmers over sparse seeding.
g) Exhaustive leveling is required to avoid submergence of young seedlings.
h) Amount of weed is increase if water is kept shallower by providing drainage.
i) Amount of weed is increase if water is kept shallower.
j) Transplanting in square pattern or lines is essential for efficient weeding with rotary weeder.
k) Transplant seedlings with wider spacing is a rational option if physical and chemical property of soil is improved by applying natural fertilizer.
l) Amount of weed cover increases if seedlings are transplanted with wider distance.

CONCLUSION

Results of the second year experiment suggest the potential advantages of SRI in rainfed lowland rice growing. Reducing resources (input) produced greater yield (output). Regardless of the type of plot, the farmers benefited. However, the SRI adoption rate remained low in non-comparison plots suggesting the possibility of some difficulty in applying SRI to larger areas. Assuming the farmers can be made to realize the full potential benefits, the researchers expect to continue the experiment and introduce SRI principles in larger plots.

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Review article

Critical Appreciation of Restoration and Conservation of Degraded Mangroves in Thailand

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Abstract This paper provides critical appreciation of the experience of Thailand in restoration and conservation of degraded mangroves. Through literature survey, the constraints that hinder the successful restoration and conservation of mangroves, and opportunities that lead towards achieving such goal were assessed. Results revealed that since the second half of the twentieth century, Thailand lost more than half of its mangrove cover due to shrimp farming and charcoal production. This has raised concerns that led to enhanced efforts to restore and conserve the mangroves. Since Thailand ratified various relevant international agreements, it is obligated to pay serious attention towards the conservation and restoration of these ecosystems. Thus, the government launched various re-plantation projects and established impressive supportive infrastructures to facilitate such efforts. Meanwhile, the Tsunami 2004 also re-sensitized the Thai society to the protective role of mangroves as many communities took *suo motu* initiatives for the conservation of mangroves in their respective areas. However, 'the success' in mangroves conservation has remained very limited, which could be attributed to lack of policy integration and coordination among different agencies, narrow focus on the forest component of mangrove ecosystem, inadequate ecological knowledge and restoration skills among the forest land use managers, and halfhearted departmental support for community participation in mangrove restoration. Therefore, Thai policy makers must revisit the issues and opportunities, and devise appropriate policies to address the structural causes of mangroves degradation and achieve successful ecological restoration.

Keywords mangrove, mangroves restoration, mangroves conservation, mangroves re-plantation, mangrove ecosystem, mangroves in Thailand

OVERVIEW OF MANGROVE LOSS IN THAILAND

Of the 76 provinces of Thailand, 23 are endowed with mangroves along the country's 2,670 km coastline (Aksornkoae & Tokrisna, 2004; NACA, 2005). About 86 percent of the mangroves are found in the southern region (72 and 14 percent on the Andaman Sea coastline and Gulf of Thailand, respectively) while the remaining 14% are found in the eastern and central regions of the country (Aksornkoae & Tokrisna, 2004; FAO, 2007; NACA, 2005). Between 1961 and 1993, Thailand had lost more than 56 percent of its mangroves on account of aquaculture and shrimp ponds development, resettlements, agriculture, urbanization, and ports and road constructions (Aksornkoae & Tokrisna, 2004). Aquaculture and shrimp farming alone is responsible for about 55 to 64 percent of the total mangrove loss until 1986 mostly because in 1980-1986 the industry grew almost unregulated (Ahmed, 1997; Aksornkoae, 2000; Huitric et al., 2002; Macintosh et al., 2002; WRM, 2002). Although afterwards, significant efforts had been diverted towards the restoration and conservation of mangroves but threats like illegal encroachment in mangrove areas still exist that cause Thailand to bear the continued significant loss of mangrove areas each year (NACA, 2005; Sathirathai, 1998). For example, between the period from 2000 to 2004 alone, the country

lost about 8 percent of its mangrove cover (NACA, 2005). The loss of mangroves in terms of area was higher in the southern region since this area contains a huge proportion of the country's mangrove areas, whereas the loss as percentage of regional total was higher in the eastern region of the country (NACA, 2005).

MANGROVE RESTORATION AND CONSERVATION INITIATIVES

Restoration of degraded mangroves in Thailand dates back to the 1960s but the scale and stretch of such initiatives remained considerably low until the 1980s (Havanond, 1997; NACA, 2005; Thampanya et al., 2006). In 1987, the Government of Thailand adopted a zoning policy for the protection and conservation of the country's rapidly dwindling mangrove cover (Aksornkoae, 2000). Under this policy, about 65 percent of the mangrove areas were declared as Conservation Zone where the mangroves were to be maintained in their present condition. The remaining 35 percent were declared under the Development Zone where the mangroves were to be rehabilitated and restored. The task to carry out the restoration was given to the Royal Forest Department (RFD) which identified about 21,200 ha of degraded mangroves and new mudflats as potential afforestation sites (Aksornkoae, 1993; Erftemeijer & Lewis III, 1999). Later in 1991, the Thai Cabinet passed a resolution which prohibited shrimp farming and tin mining in fertile mangrove areas (Aksornkoae & Tokrisna, 2004; Macintosh et al., 2002). Although degraded mangroves were still available for conversion into shrimp and aquaculture ponds, the positive impact of the policy could be in the intensification of shrimp ponds using smaller areas (Aksornkoae & Tokrisna, 2004).

On the same year, the Thai Cabinet also approved a massive scale mangrove restoration and re-plantation program with an overall financial outlay of US$ 30 million, aimed at replanting about 40,000 ha of mangrove areas between 1991 and 1996 (Havanond, 1997; Havanond, 1994). Thus, four mangrove seedling production centers were established in Trat, Phangnga, Nakhon Si Thammarat, and Satun Provinces to support the program (NACA, 2005; Havanond, 1997). However, by 1996 the program was able to achieve only 35 percent of its specified targets as most of the sites identified for re-plantation were still under the concessions for charcoal production and shrimp farms (Havanond, 1997). Even in certain areas where the program was able to intervene, the success rate was still very limited. Confronted with the lack of technical knowledge in mangrove plantation and restoration coupled with poor monitoring and overseeing arrangements, the general survival rate of newly replanted mangroves remained mostly below 40 percent while in some areas it was a complete failure (Erftemeijer & Lewis III, 1999).

Since then, various provincial level mangrove restoration projects supported by national and bilateral agencies were either completed or are still ongoing. For example, most of the mangroves in the Ranong Biosphere Reserve along the Andaman Sea coastline are the outcome of the rehabilitation of former charcoal concession blocks, abandoned tin mining and shrimp pond sites (Macintosh et al., 2002). Various local nongovernmental organizations are also actively participating in the government initiatives for the restoration of degraded mangroves by introducing various medium- and small-scale mangrove re-plantation projects. The five year 'Green Carpet' project supported by Japan Fund for Environment and Keidanren Nature Conservation Fund (KNCF) which is implemented by the Thai Union for Mangrove Rehabilitation and Conservation is one such project, which aimed to plant mangroves in about 1000 ha abandoned shrimp pond areas in Nakhon Si Thammarat Province (Amarasinghe et al., 2009). Another example is the mangrove restoration project assisted by the Organization for Industrial, Spiritual and Cultural Advancement-International which replanted 280,000 seedlings of mangroves in a 150 ha area in Chanthaburi Province (OISCA-Int., 2000). However, despite all the efforts undertaken in 1970-1998, the extent of planted mangrove areas remained below 5 percent of the natural mangrove areas in Thailand (Field, 1999).

Moreover, Thailand has been a signatory to various international declarations like the Ramsar Convention (1971); World Cultural and Natural Heritage Convention (WHS), Paris (1972); United Nations Convention on the Law of the Sea (UNCLOS), Montego Bay, 1982; Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); and Convention on

Biological Diversity (CBD), Rio de Janeiro, 1992. These declarations had made it obligatory for Thailand to pay serious attention towards the rapid degradation of the country's mangroves. The need for restoration and conservation of mangroves was further reinforced after the Tsunami 2004 when the protective role of the mangroves was realized and appreciated in the tsunami affected areas of Thailand. Recently, 21 sites covering an area of 5,810 km^2 which contain significant patches of the mangroves are declared as Marine National Parks (MNP) and Protected Areas. These areas include for example: the Ao Phang-nga National Park, Phang-nga Bay, and other areas along with Tarutao, Surin, Similan and Ao Phangnga MNP which are declared as Ramsar sites. Moreover, the Ranong mangrove areas are also placed under the UNESCO-MAB bio-reserve (NACA, 2005; FAO, 2007).

Similarly, the Thai society also seems to be well sensitized to the importance as well as the degradation of mangroves. Between 1996 and 2000, the Thai Cabinet passed a number of resolutions to abolish and revoke all mangrove concessions (NACA, 2005; Samabhddhi, 2003). The country's National Economic and Social Development Plan 1997-2001 clearly urged all concerned to exert efforts towards maintaining the healthy mangrove cover of not less than 160,000 ha (Havanond, 1997). As a result, a separate mangrove conservation office was established with the Department of Marine and Coastal Resources under the new umbrella of the Ministry of Natural Resources and Environment (Aksornkoae & Tokrisna, 2004). Historically, significant degree of interest had also been expressed by local communities to replant and conserve the mangroves that has been further revitalized after the 2004 Tsunami (Barbier, 2008; Barbier, 2006;). Similarly, the private sector also did not lag behind in re-planting mangroves (Choudhury, 1997). Furthermore, the Government of Thailand has established an international level mangrove research center in Ranong Province while an extensive network of mangrove research and conservation stations exists in all important coastal areas of the country to carry out scientific research on mangroves (NACA, 2005).

ISSUES AND CHALLENGES IN MANGROVE RESTORATION AND CONSERVATION

Despite the commitment and support structure, efforts for the restoration and conservation of mangroves in Thailand had not been very promising. Firstly, the country is confronted with various issues and challenges at both policy and operational fronts which act as major impediments in the successful restoration and conservation of mangroves. One very crucial challenge is on the fact that shrimp farming activities require clearing of mangrove areas. Since the shrimp industry in Thailand is a lucrative enterprise that puts the country as the global leader in shrimp production, the foremost challenge of the country is to make a hard choice between mangrove conservation and mangrove area conversion into shrimp farms (Ahmed, 1997; Goss et al., 2000; WRM, 2002). Supported by various types of direct and indirect subsidies coupled with pathetic regulations on the establishment of shrimp farms, the country's aquaculture industry has maintained an illusion of profitability (Huitric et al., 2002). In general, the productivity of an intensified shrimp farm hardly goes beyond a decadal span (Claridge, 1996; Dierberg & Kiattisimkul, 1996 both cited in M. Huitric et al., 2002). However, due to lack of data on farm abandonment, the industry successfully masks the losses and easily relocates itself in other mangrove rich regions, leaving behind the ruins of the once rich mangrove ecosystems (Huitric et al., 2002; WRM, 2002).

Serious policy flaws and lack of coordination among government agencies had also in many cases reversed all previous efforts and attempts that had been made for the restoration and conservation of the mangroves (NACA, 2005). From 1966 and onwards, about 23 policy statements were declared for the protection of mangroves, but at the same time, aquaculture policies continued to support the expansion of the Thai shrimp industry through various subsidies including subsidized mangrove concessions (Durongdej, 2001). Before the existence of the current ministerial setup, Huitric et al., (2002) observed that even under a single ministry in 1997, the Ministry of Forest proclaimed massive programs for mangrove plantation but also during such time the Department of Fisheries of the Ministry of Agriculture and Cooperatives was offering mangrove leases for aquaculture use. This was a clear violation of all the cabinet resolutions related

to mangrove conservation. As observed by WRM (2002) and Goss et al. (2000), giant shrimp companies operate at higher levels of political hierarchy in the country. Under such set up the industry could often demand for extraordinary favors from the national level policy, on the pretext of the need to maintain the country's global lead in aquaculture. Subsequently, government's favor for the aquaculture like the one endowed by former Prime Minister Thaksin were the *de facto* cancellation of all previous checks to control the industry (Huitric et al., 2002).

While undertaking programs on the restoration and conservation of mangroves, another challenge that confronted Thailand was the hesitation of government machinery to devolve their centralized powers in favor of the local communities (Huitric et al., 2002). Suwannodom, et al. (1998) reported that mangrove restoration programs implemented in the southern region from 1991 to 1996 had achieved certain level of success especially in the areas where the community-based approach was adopted. Various other studies for example those done by Sathirathai and Barbier (2001), Barbier (2008) providing legal support for such endeavors, Sukwong (undated), and Soontornwong (2006) also indicated that local communities living nearby mangroves were relatively more efficient in the restoration and conservation of mangroves than the officially designated government agencies. Although community-based mangrove management has remained a highly controversial issue in Thai policy dialogue for long, it was only in 2007 that the Thai Cabinet approved the Community Forest Bill (CFB) providing legal support for such endeavors. Even much before that, Johnson and Forsyth (2002) noted that many communities were successful in bringing favorable court decrees to stop further encroachment of the aquaculture industry in mangrove areas, by referring to the CFB draft. However in general, the enforcement of CFB had largely remained weak since many officials from the RFD and Land Development Department, and many local elites had strong ties with the actors in the shrimp industry.

Last but not the least, like many other Asian countries, the complex mangrove ecosystem in Thailand is also managed merely as one type of forest. As a result, most of the mangrove restoration initiatives are planned by typical foresters who are mostly armed with naïve principles of ecological engineering and therefore often fail to distinguish between the significance of mangrove plantation and ecological restoration. Ellison (2000) in his global review, while referring to two mangrove restoration projects of Thailand noted that only one species from the available twenty five species had been selected for the re-plantation. Similar observations were made by Field (1999) and Aksornkoae (2000) who found that the main objective of mangrove rehabilitation programs in Thailand had remained to gear towards the production of timber and charcoal with the objective of ecosystem rehabilitation taking the back seat. Such studies further reached similar observation as that of Ellison (2000) which concluded that the main focus for plantation was only on two commercially important mangrove species. Lewis and Marshall (1997) called this type of restoration effort as a "gardening" approach (Lewis III, 2001). Many so-called 'successful' plantations are nothing but the mono-genus and economically valuable stands of selected species. At present, ample literature is available on the principles of ecological restoration, but unfortunately Thailand has yet to learn from such experiences as the country seems to still perceive that mono species plantation is synonymous with the ecological restoration of mangrove areas. Following the conventional forestry approach and under a mixture of objectives aimed at both ecological restoration and commercial exploitation, the country's ambitious plans like planting 1600 to 2000 ha per year with selected mangrove species are still unabated (Aksornkoae, 2000).

CONCLUSION

In order to respond to the various national and international obligations, Thailand has showcased its significant efforts in the restoration and conservation of mangroves. However, the success of those efforts has been largely constrained by various unattended structural causes leading to the degradation of mangroves. First and the foremost cause was the lack of policy integration and coordination among the concerned agencies where on the one hand attempts were being made to restore mangroves while on the other hand aquaculture expansion was subsidized through the concessions of mangroves areas. Success was also equally constrained by the forestry biased view

of the rich ecosystem that was essentially an outcome of the lack of ecological knowledge and restoration skills among forest land use managers. These shortcomings resulted in undermining huge effort that Thailand has made in the plantation of mangroves that better qualifies successful establishment of mono species woodlot than the successful ecological restoration. Finally, the hesitation of RFD bureaucracy to promote community participation despite the fact that community intervened attempts of the restoration of mangrove were more successful than those carried out by RFD itself. Nevertheless, the glass was also half full and significant potentials could be seen. Thai communities had a positive attitude towards mangroves especially after the 2004 Tsunami and that was an opportunity that could be availed to ensure the societal ownership of mangrove restoration initiatives. Furthermore, the half century experiences of the successes and failures in the country's mangrove restoration efforts, a good network of mangrove research institutions were a few of the plus points that Thailand could utilize for the successful ecological restoration of their mangroves.

Based on the above review, the following broader policy implications emerge. Firstly, it is obvious that the desired goal of successful mangrove restoration and management could not be achieved unless Thai policy makers carry out a painstaking analysis of the political economy of mangrove loss and devise policies which can prioritize among short terms gains from coastal aquaculture and the long term benefits associated with the intact mangrove cover. Further policies must integrate the sectoral objectives and engaged multiple agencies in preparation of restoration projects in order to ensure that no previous effort goes as a waste of scarce resources. Secondly, the traditional foresters must be trained and retrained in the area of ecological engineering as it is also one of the most important factors in the successful planning and implementation of mangrove restoration programs. Thirdly, during the appraisal of various mangrove restoration projects, it must be ensured that sufficient analytical process has been conducted and completed, and that all options for ecological restoration are adequately evaluated.

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International Society of Environmental and Rural Development

Philosophy of ISERD:

Recently, in developing countries, subsistence agriculture is being converted to export-oriented mono-culture, and the amounts of agricultural chemicals applied to the farmland are increasing every year. The applied chemicals in farmland cause serious environmental problems downstream such as eutrophication, unusual growth of aquatic plants, decrease in dissolved oxygen and accumulation of bottom mud in water resources. Also, there seem to be many cases in which people apply agricultural chemicals without understanding its impact to health and food safety. Therefore, it is necessary to promote and enhance understanding of sustainable rural development among local stakeholders including farmers.

Sustainable rural development aims to meet human needs while preserving the natural environment. As it should cover not only social and economic development but also natural environment conservation, no single organization can achieve sufficiently the aspirations of sustainable rural development. Collaboration among international, governmental and non-governmental organizations, together with the academe and scientific sector, is indispensable.

The knowledge and intelligence accumulated in universities and research institutions are also expected to make the programs facilitated by the international, governmental and non-governmental organizations more adequately implemented and meaningful to societal development. However, these cases especially those implemented locally have been scattered without having been summarized well or recorded in annals academic or scientific societies.

So, the International Society of Environmental and Rural Development founded in 2010, aims to discuss and develop suitable and effective processes or strategies on sustainable rural development focusing on agricultural and environmental aspects in developing countries. The ultimate goals of the society are to contribute to sustainable rural development through social and economic development in harmony with the natural environment, and to support the potential or capacity building of local institutions and stakeholders in the rural area with academic background.

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In order to enhance the realization of the primary purposes of ISERD, the secondary purposes are;

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