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FISH AND VEGETABLES DIVERSIFICATION IN IRRIGATED RICE FIELDS IN SUMATRA, INDONESIA: A STUDY OF TWO VILLAGES IN THE KOMERING IRRIGATION DEVELOPMENT AREA

Siti Jahroh[1] and Akimi Fujimoto[2]

[1]Department of Agribusiness, Faculty of Economics and Management,
Bogor Agricultural University
[2]International Bio-Business Studies, Graduate School of Agriculture, T
okyo University of Agriculture

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ABSTRACT

Although crop diversification has been one of the major government policies in Indonesia since the late 1980s, it is still not widely practiced by most farmers. This paper aims to analyze the diversification in the rice-based farming system, specifically to (a) identify the existing cropping patterns, (b) examine the factors affecting diversification, and (c) examine optimal crop combination in Karang Sari and Tambak Boyo villages in Komering irrigation area.

In addition to double rice cropping of rice, farmers in Karang Sari and Tambak Boyo have diversified into fish culture and vegetable cultivation, respectively. There are a number of factors affecting fish diversification. They include the level of knowledge, market access and income sources. Results of the study show that level of knowledge is positively related to fish diversification while market accessibility and income sources are negatively related. In Tambak Boyo, the factors influencing farmers to diversify into vegetable production include availability of irrigation water which is reflective of the stability of water supply, availability of family labor, and availability of manure for fertilizer, respectively. These three factors have a positive influence on vegetable diversification. In Karang Sari, the optimal combination was rice-fish-rice-fish which gave the highest annual net income while in Tambak Boyo, the optimal combination was (rice+spinach)-rice. Results of the study show that diversification into fish and vegetables production provided additional employment and made a positive contribution to household economy.

Key words: Cropping pattern, logit function, and linear programming.

INTRODUCTION

The crop and food diversification program was one of the major programs of the Fifth Five-Year Development Plan (1989-1994) of Indonesia. This encouraged the planting of a wider range of commodities which was considered important in attaining rice self-sufficiency, (MA, 1994). The calorie and protein intake from rice can be reduced and substituted by increasing the consumption of other foodstuff such as fruits, vegetables, meat, eggs, fish, etc. However, it appears that diversification is still not practiced by most farmers. The Komering Irrigation Project is one of the most important irrigation projects in South Sumatra. It aims to improve people's welfare by providing a constant supply of irrigation water from Komering River to the rainfed rice fields in Ogan, Komering, and Tulang Bawang Basin (DPPW, 2004). The first phase of the project was in 1991 and continued to the second phase in 1996. In addition to increasing cropping intensity, some farmers had diversified their farm businesses by cultivating vegetables and raising fish in their rice fields.

A farm household survey was conducted from June to October 2005 in three villages: Hamlet I of Karang Sari village, Hamlet I of Tambak Boyo village, and Hamlets I and II of Rasuan Baru village with 105, 105, and 102 farmer-respondents interviewed, respectivel. The villages of Karang Sari and Tambak Boyo villages were chosen as the study sites because diversified rice farming is commonly practiced in the area given its relatively stable water supply. Among the farmers

interviewed, only 72 farmers were considered as they had access to irrigation in Karang Sari. In Tambak Boyo, only 49 farmers were considered because the rest still planted rice once a year due to the condition of new irrigation system. The existing cropping patterns, factors affecting diversification, and optimal crop combination were identified and examined.

CHARACTERISTICS OF THE VILLAGES SURVEYED

Two villages were chosen for the study, Karang Sari representing a well-irrigated rice field in Stage I and Tambak Boyo representing a newly-irrigated rice field in Stage II Phase 1. In Karang Sari which is located in the Stage I area of the Komering Irrigation Project, there are still some rainfed rice fields. A river divides the village area into two distinct ecosystems, irrigated and rainfed rice fields. Karang Sari is located 290 kms. from Palembang, 95 kms. from the capital city of OKU district, and 15 kms. from the capital city of Belitang sub-district. The village consists of 5 hamlets and 14 neighborhoods. The total land area is 1,246 has., with 850 has. considered as agricultural. The area for the well-irrigated, semi-irrigated and rainfed rice fields are 336 has., 56 has. and 270 has., respectively. At the time of the survey, there were 984 households with a total population of 3,830 people, of which 2,929 people were engaged in agriculture. There were 1 KUD (village unit cooperative), 12 Kelompok Tani (farmers groups) and 1 P3A (water users' organization). The P3A in Karang Sari was well organized and considered to be one of the best in the country.

The second study area, Tambak Boyo, is one of the villages in the Stage II Phase 1 area of the Komering Irrigation Project. It is located 225 kms. away from the capital city of Palembang, 85 kms. from the capital city of OKU Timur district and 26 kms. from the capital city of Buay Madang sub-district. During the time of survey, there were 3 hamlets and 6 neighborhoods. The total land area was 600 has., in which the irrigated rice fields occupied 353.5 has. The total population was 2,692 people or around 659 households, who mostly transmigrated from Java. There were 16 farmers groups, one KUD, and one P3A. However, the KUD and the P3A did not work well.

The Farmer Respondents

The profile of interviewed farmers is presented in Table 1. The average family size was rather small, 3.79 and 3.73 persons in Karang Sari and Tambak Boyo, respectively, indicating the success of the country's family planning program. The average age of household heads was 45.79 and 46.63 years in Karang Sari and Tambak Boyo, respectively, indicating a general trend of aging farmers in the country.

Table 1. Profile of farmer respondents in Karang Sari and Tambak Boyo, Sumatra, Indonesia in 2005.

Items	Karang Sari	Tambak Boyo
N	72	49
Age (years)	45.79	46.63
Education (years)	7.10	7.65
Rice farming experience (years)	24.08	21.54
Non-farming experience (years)	2.13	2.64
Family member (persons)	3.79	3.73
Family member above 16 years old	2.79	2.69
Average land area (ha)	0.62	0.51

Source: Survey June-October 2005

Although some farmers graduated from college, the

majority of farmers completed elementary school, which was the basic formal education until 1994. The average number of years of rice farming experience were 24.08 and 21.54 years in Karang Sari and Tambak Boyo, respectively, reflecting engagement in rice farming since their twenties. The average non-farming experience was 2.13 and 2.64 years in Karang Sari and Tambak Boyo, respectively. Non-farming experience refers to trading or business, tailor, carpenter, driver, etc. Lastly, the average operated land area which on the average was 0.62 ha and 0.51 ha per household in Karang Sari and Tambak Boyo, respectively was relatively small.

CROPPING PATTERNS

There are 3 common patterns of rice-fish production, namely: (1) fish production in between two paddy cultivations, at land preparation until the seedlings are ready for the transplanting, usually around 20-30 days; (2) fish production in the third season, usually around 80-90 days; and (3) combination of fish and rice production, usually called "Mina Padi" (Sudirman and Iwan, 2000). The recommended rice varieties to be planted for the Mina Padi pattern are IR64, Citanduy, Dodokan, Cisadane and Ciliwung which most farmers cultivated.

Rice-fish cropping patterns in Karang Sari Village

Some farmers in Karang Sari raised carp (Ikan Mas) in their rice fields because it has the ability to adapt to the rice field environment. It grows relatively fast and has high economic value leading to higher profitability (Sudirman and Iwan, 2000). The patterns of rice-fish production in Karang Sari are shown in Figure 1. There were 13 farmers who raised fish after double rice cropping (rice-rice-fish), 6 farmers with rice-fish-rice-fish pattern, 3 farmers with rice-fish-rice pattern, and the majority of farmers practiced double rice cropping. For double rice cropping, depending on the rice field location and timing of the water distribution which was decided by the water users' organization, farmers planted the first rice crop from June to September, July to October, and August to November. The second rice crop was cultivated from early November to February, end of November to early March, or December to March.

Source: Survey June-October 2005
Notes: R = Rice; F = Fish

Cropping Pattern	No. of Farmers	2004					2005						
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
R-R-F	13	R					R					F	
R-F-R-F	6	R					F	R					F
R-F-R	3	R					F	R					
R-R	50	R					R						

Fig. 1. Rice-fish production patterns in Karang Sari, Sumatra, Indonesia in 2004-2005.

Rice in the rice-rice-fish (R-R-F) pattern, is usually planted first between June and November, with a second cropping between November and March, and fish was raised between April and May. Second, in rice-fish-rice-fish (R-F-R-F) pattern, the first rice crop was planted from June to November, first fish raised from November to December, second rice planting from December to March, and second fish introduction from April to May. Finally, in rice-fish-rice (R-F-R), farmers cultivated first rice crop from June to September, raised fish from October to November, and planted the second rice crop from November to March. By adjusting the timing of the rice farming activities, farmers were able to avoid the shortage during transplanting and harvesting which is labor intensive.

Farmers also tried to raise fish at different periods to get better market prices that also consequently led to a more stable supply of fish.

Rice-fish-vegetables cropping patterns in Tambak Boyo Village

In Tambak Boyo village, 22 out of 49 farmers practiced double rice cropping (Figure 2). There were two farmers who practiced rice-(rice+fish) and (rice+vegetables)-(rice+fish) systems in which farmers raised fish (carp) together with rice (Mina Padi) in the rainy season. The dry season rice in the village was planted from May to August, June to September, and July to October, while the rainy season rice was cultivated from October to January, November to February, and December to March, depending on the location of the rice fields. Vegetables were commonly planted in the rice fields during the dry season from May to August following the patterns of (rice+vegetables)-(rice+fish) and (rice+vegetables)-rice. There were some farmers who cultivated vegetables during the rainy season from December to March in the pattern of rice-(rice+vegetables). Some farmers who planted longer growing vegetables such as string beans (kacang panjang) and tomato, cultivated vegetables from May to November under a cropping pattern of (rice+vegetables)-vegetables-rice. One farmer planted vegetables between the dry and rainy season from September to November under cropping pattern of rice-vegetables-rice while another farmer planted vegetables between the rainy and dry season from March to June, in the pattern of rice-rice-vegetables.

Fig. 2. Rice, vegetable and fish production patterns in Tambak Boyo, Sumatra, Indonesia in 2004-2005

Cropping Pattern	No. of Farmers	2004 May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2005 Jan	Feb	Mar	Apr	May
R-(R+F)	1	R						R+F						
(R+V)-(R+F)	1	R+V						R+F						
(R+V)-R	15	R+V						R						
R-V-R	1	R				V			R					
R-(R+V)	5	R							R+V					
(R+V)-V-R	3	R+V				V			R					
R-R-V	1		R					R				V		
R-R	22	R						R						

Source: Survey June-October 2005
Notes: R = Rice, V = Vegetables, F = Fish

Farmers in the village have been cultivating vegetables since the 1970s. Although there is a market near the village where some farmers sell their vegetables, most farmers would sell their products to middlemen or the village collectors.

DIVERSIFICATION

Variables and Empirical Models

Logit function analysis was used to examine the factors affecting farmers' decision to diversify to rice-fish production and rice-vegetables production. Two logit functions were estimated. First is the diversification to fish function in Karang Sari. Second is the diversification to vegetables function in Tambak Boyo. The dependent variable is the natural logarithm of the odds ratio, $L_i = Ln (P_i/(1-P_i))$. The P_i is the probability that each farmer will diversify his rice land to fish in Karang Sari and to vegetables in Tambak Boy.

The empirical model is specified as follows.

$$\text{Ln}\ (\ P / (1\text{-}P)\ ) = \alpha\ +\ \beta_1 X_1\ +\ \beta_2 X_2\ +\ \beta_3 X_3\ +\ \beta_4 X_4\ +\ \beta_5 X_5\ +\ \beta_6 X_6$$

Where: X_1 = irrigation condition score, ranging from 2 to 6
X_2 = educational attainment of farmer in years
X_3 = no. of family members above 16 years old (available family labor)
X_4 = distance of the rice field from the road in meters
X_5 = dummy variable, 1for having other jobs, 0 for otherwise
X_6 = dummy variable, 1 for raising cows, 0 for otherwise

In addition, marginal effects were also computed in order to determine the quantitative effects of the independents variables on each diversification (Banerjee and Martin, 2009). Marginal effects (Anderson and Newell (2003); Greene (2003)) measure the changes in probability of adopting each diversification due to given changes in the relevant independent variables. Marginal effects of continuous variables were calculated at the mean of the data and for the dummy variables, a value of 0 was used if the mean less than 0.5 and a value of 1 was used if the mean was greater than or equal to 0.5 (Banerjee and Martin, 2009).

Lowland vegetables were evaluated since the study villages are located in the lowland areas. Linear programming was used to determine the optimum rice-fish combination in Karang Sari and rice-vegetables combination in Tambak Boyo that would maximize net income of farmers with land area and family labor serving as constraints.

The Study Model

In this study, linear programming was used to maximize a linear objective function subject to the constraints (Vajda, 1958) where the objective function to be maximized was net income of farmers and the constraints were the land area and family labor (Pitipunya, 1995). The mathematical representation of the linear programming (LP) problem is:

Objective function: Maximize $Z = \Sigma\ C_j X_j$

Subject to

$$A_{ij}X_{ij} \leqq b_i$$
$$X_j \geqq 0$$

Where: Z is total net income (Rp)
C_j is net income of j^{th} crop or activity (Rp/0.1ha)
X_j is size of j^{th} crop or activity (0.1ha)
A_{ij} is technical coefficient of i^{th} input for j^{th} activity (unit/0.1ha)
b_i is available amount of i^{th} input (constraints)

RESULTS AND DISCUSSION

The results of logit analysis of factors affecting the probability of rice field diversification to fish production in Karang Sari are shown in Table 2. The deviance statistic is frequently used to determine whether or not the current model provides a good fit to the data under consideration (Berenson et al, 2002). The model has a good fit given a chi-square coefficient of 19.470 which is significant at 1% level. Three factors namely education, distance from the road and other jobs are significant at 5% level. The remaining two factors, irrigation condition and family members above 16 years old or available family labor, are significant only at 15% level.

The regression coefficient of education is equal to 0.250, implying it has a positive correlation with fish diversification. It indicates that with higher level of education, reflecting the level of knowledge, farmers will be more open to diversify their rice fields to fish production. The estimated marginal effect of 0.039 implies that an increase of one year formal education will increase the probability of fish production by 0.039 percent. Second, the regression coefficient of distance of

rice field from the road is equal to -0.003, reflects a negative correlation to fish diversification. It suggests that the nearer the rice field's location to the road, the higher the probability of farmers to diversify into fish production. Having an estimated marginal effect of -0.001, it indicates that one meter increase in the distance of the rice fields to the road will decrease the probability of farmers to choose fish diversification by 0.001 percent. The buyers usually purchase the fish at farmers' fields, thus the proximity of the rice fields to the road will attract buyers to come. Third, the regression coefficient of other jobs is equal to -1.290, implies a negative correlation to fish diversification. The estimated marginal effect is -0.228, indicates fish diversification is estimated to decrease by 0.228 percent for a farmer who has another job compared to a farmer without one. Since raising fish is a source of income, farmers without other jobs have a higher probability to choose fish diversification than farmers with other jobs. It must be noted that irrigation condition and available family labor had a positive correlation to fish diversification and were significant at 15% level. This implies that in fish diversification, water and labor supply are also factors to be taken into consideration.

Logit analysis of factors affecting the probability of diversification to vegetables in Tambak Boyo village are shown in Table 2. There are three important factors affecting farmers to diversify their rice farming to fish production in Karang Sari, namely education, proximity of the rice field to the road, and other jobs or source of income. Meanwhile, in Tambak Boyo the important factors include irrigation conditions, available family labor and cow raising for manure in vegetable cultivation.

Table 2. Logit analysis and estimated marginal effects of factors affecting the probability of rice fields diversification in Karang Sari and Tambak Boyo, Sumatra, Indonesia in 2004-2005.

Variables	Karang Sari				Tambak Boyo			
	b	Marginal Effects			b	Marginal Effects		
Constant	-4.614				-4.507			
Irrigation condition	0.422		0.066		0.486	*	0.112	*
Education	0.250	**	0.039	**	-0.003		-0.001	
Family members above 16 years old	0.409		0.064		0.907	*	0.209	*
Distance from the road	-0.003	**	-0.001	**	0.002		0.001	
Other Jobs (Yes=1, No=0)	-1.290	**	-0.228	**	-0.795		-0.174	
Raised cow (Yes=1, No=0)					1.597	**	0.372	**
N	72				45			
Chi-square	19.470	***			12.170	*		

Source: Survey June-October 2005

Notes: *** denotes significant at the 1% level.
** denotes significant at the 5% level.
* denotes significant at the 10% level.

OPTIMAL COMBINATION OF CROPS

Enterprise Budget of Fish

Farmers in Karang Sari usually raise fish for one to two months. Fish culture can be divided into two seasons, i.e. after the dry season rice between September and December and after the rainy season rice between March and May. Table 3 presents the average cost and returns of fish production per 0.1 ha in Karang Sari village. In the first season, the gross return was Rp 154,377/0.1 ha with a total cost that includes family labor of Rp 102,301/0.1 ha and net profit of Rp 52,076/0.1 ha. In the second season, the gross return was Rp 138,341/0.1 ha, with a total cost that includes family labor,

of Rp 116,700/0.1 ha, and net profit of Rp 21,640/0.1 ha.

The biggest percentage of production costs was due to family labor followed by fingerlings and fertilizers. Farmers bought the fingerlings at Rp 6,000/bowl on the average. Fertilizers were applied during land preparation to enhance the growth of microorganisms that serve as the natural feed for the fish. Farmers feed the fish with rice bran that they purchase from the rice mill or from their own production. During land preparation and harvesting, hired labor were paid in kind (e.g. fish).

Table 3. Average cost and returns of fish production per 0.1 ha in Karang Sari, Sumatra, Indonesia in 2004-2005.

	Dry season rice		**Rainy season rice**	
Items	**Rp/0.1 ha**	**%**	**Rp/0.1 ha**	**%**
N	5		14	
Gross Return (A)	154,377		138,341	
Production Costs				
Fingerlings	33,033	32.3	39,974	34.3
Fertilizers	2,494	2.4	2,588	2.2
Feed	15,041	14.7	20,018	17.2
Hired labor	560	0.5	5,599	4.8
Imputed family labor	51,173	50.0	48,521	41.6
Total Costs (B)	51,128		68,180	
Total Costs (C)	102,301	100.0	116,700	100.0
Net Return (A-B)	103,249		70,161	
Net Return (A-C)	52,076		21,640	

Source: Survey June-October 2005

Notes:

Total Costs (B) refers to cash cost of fingerlings, fertilizers, feed and hired labor.

Total Costs (C) includes the imputed cost of family labor.

Enterprise Budget of Crops

Based on market demand and profitability, lowland vegetables can be divided into three groups (Nazaruddin, 2000). The first group consists of chili, a main commodity which Indonesians eat almost daily. The second group consists of shallot and beans, such as string beans while the third group consists of eggplant, spinach, kangkung, and other vegetables that are not so profitable. In Tambak Boyo, farmers cultivate the third group of vegetables while some farmers plant string beans. The average costs and returns of vegetables per 0.01 ha in Tambak Boyo are shown in Table 4. The number of farmers who planted spinach, Indian mustard, string beans and tomato was 19, 11, 7, and 3 farmers, respectively. If the imputed or non-cash costs of manure and family labor were included in the computation, farmers were actually incurring losses from their production. However, if only cash costs were considered, the highest cash returns was from producing spinach (Rp 107,609/0.01 ha), followed by Indian mustard (Rp 97,563/0.01 ha), string beans (Rp 85,865/0.01 ha), and tomato (Rp 42,843/0.01 ha). It was observed that the vegetable cultivation was labor intensive in the study villages where all farmers used family labor. Therefore, vegetable cultivation is considered as an employment provider for farmers in the village. In Tambak Boyo, farmers initially cultivated vegetables in the 1970s for their own consumption but later on sold some of their vegetables to generate income.

Spinach, *Amaranthus* sp. is the most common vegetable eaten not only in the study area but the entire country as well. Thus most farmers would grow them. Within a month of planting, these vegetables can be harvested and sold in the market. Indian mustard, *Brassica juncea* is the second most commonly planted vegetable in the village that can be harvested around two months after planting. string beans *(Vigna sinensis*) and tomato (*Solanum lycopersicum*) can be harvested for the first time two months after planting and then once a week until it reaches four months.

Table 4. Average cost and returns of vegetables per 0.01 ha in Tambak Boyo, Sumatra, Indonesia in 2004-2005.

Labor Requirement and Net Income

Items	Spinach Rp/0.01 ha	%	Indian mustard Rp/0.01 ha	%	String beans Rp/0.01 ha	%	Tomato Rp/0.01 ha	%
N	19		11		7		3	
Gross Return (A)	121,019		114,436		95,434		53,157	
Production Costs								
Seed	4,333	0.8	3,136	0.7	1,286	0.5	1,296	0.8
Fertilizer	6,636	1.3	8,340	1.7	5,790	2.1	8,237	4.9
Pesticides	2,441	0.5	5,396	1.1	2,493	0.9	781	0.5
Manure	18,830	3.7	39,606	8.3	9,542	3.5	11,157	6.6
Imputed Family Labor	478,978	93.7	420,895	88.2	250,573	92.9	146,829	87.2
Total Costs (B)	13,411		16,873		9,569		10,315	
Total Costs (C)	511,219	100.0	477,374	100.0	269,684	100.0	168,301	100.0
Net Return (A-B)	107,609		97,563		85,865		42,843	
Net Return (A-C)	(390,199)		(362,938)		(174,250)		(115,144)	

Source: Survey June-October 2005
Notes: Total Costs (B) refers to cash cost of seed, fertilizer and pesticide.

This section presents the family labor input and net income from fish and crops by month in the two study villages. In terms of rice cultivation in Karang Sari, most family labor was utilized in July, August and September in the rainy season and in January during the dry season. In terms of fish production, the average raising period was one and a half months. The highest family labor requirement was in October in the first season and in April in the second season (Table 5).

Farmers gained a net income of Rp 236,829/0.1 ha. and Rp 302,415/0.1 ha. on the average from rice during the dry and rainy seasons, respectively. In terms of fish production, farmers earned a net income of Rp 103,249/0.1 ha. and Rp 70,161/0.1 ha. on the average during the first and second seasons, respectively.

Table 5. Family labor requirement, gross return, cash expenses and net income per 0.1 ha of rice and fish in Karang Sari, Sumatra, Indonesia in 2004-2005.

	Dry Season		Rainy Season		Fish 1	Fish 2
	Rice 1	Rice 2	Rice 1	Rice 2		
Labor (hours)						
June	7.29	5.85	0	0	0	0
July	12.80	5.64	0	0	0	0
August	10.31	13.51	0	0	0	0
September	3.09	7.98	0	0	0	0
October	0	0	0	0	15.15	0
November	0	0	5.69	4.50	5.50	0
December	0	0	9.37	4.20	0	0
January	0	0	10.15	12.51	0	0
February	0	0	4.28	6.99	0	0
March	0	0	0	1.30	0	0
April	0	0	0	0	0	12.11
May	0	0	0	0	0	7.30
Gross Return (Rp)	580,191	580,191	656,438	656,438	154,377	138,341
Cash Expenses (Rp)	343,362	343,362	354,023	354,023	51,128	68,180
Net Income (Rp)	236,829	236,829	302,415	302,415	103,249	70,161

Source: Survey June-October 2005

The family labor requirement, gross return, cost and net income per 0.1 ha. of rice and per 0.01 ha of vegetables in Tambak Boyo are shown in Table 6. For rice cultivation, most family labor was utilized in July during the dry season and from November to January during the rainy season. The family labor requirement for spinach cultivation was 191.6 hours/0.01 ha/month; Indian mustard cultivation family labor requirement was 92.41 and 75.94 hours/0.01 ha. for the first and second months, respectively; string bean cultivation family labor requirement was 35.60, 20.91, 25.12, and 18.56 hours/0.01 ha. for the four consecutive months, respectively; and for tomato cultivation it was 20.60, 13.12, 9.63, and 15.33 hours/0.01 ha for the four consecutive months. For rice production, farmers earned a net income of Rp 136,132/0.1 ha. and Rp 231,595/0.1 ha. on the average during the dry and rainy seasons, respectively. From vegetables, farmers earned a net income of Rp 107,608/0.01 ha. from spinach, Rp 97,563/0.01 ha. from Indian mustard, Rp 85,865/0.01 ha. from string beans and Rp 42,842/0.01 ha. from tomato.

Constraints

In this study, land and family labor were taken as limited resources. The limitation of land and family labor were based on the average operated land area and the number of family members older than 16 years old. The average operated land area was 0.622 ha. in Karang Sari and 0.514 ha. in Tambak Boyo. In both study villages, the average number of family labor was 3. Given a 30-day working period with one day off a week or 4 days off a month, and 8-working hours a day, the total is 624 hours per month**.**

Optimal Combination of Fish and Crops

The results of the linear program to determine the optimal combination of rice-fish production in Karang Sari and rice-vegetables production in Tambak Boyo are presented in Table 7. The combination of rice-fish-rice-fish (R-F-R-F) gives the highest net income of 4.4 million rupiah with the largest operated land area of 2.488 has. and family labor of 637.8 hours. By diversifying their rice farming into rice-fish culture, farmers would be able to increase their net income by 13 % (R-F-R) to 32 % (R-F-R-F). Although fish diversification would increase family labor absorption, it was still much lower than the availability of family labor of 624 hours per month or 7,488 hours per year. It is clear that fish diversification would absorb family labor and also contributes to increased the net income of households.

Based on the crops combination results in Tambak Boyo, (rice+spinach)-rice pattern would occupy the largest planted area, followed by rice-Indian mustard-rice, and rice-spinach-rice (Table 7). In terms of family labor, (rice+spinach)-rice combination would utilize the most family labor, followed by (rice+Indian mustard)-rice and rice-spinach-rice. There are several interesting points that can be observed from these findings. Vegetable diversification would absorb a larger amount of family labor than double rice cropping although it would utilize only around 17% to 35% of the total available family hours per year. It is clear that vegetable cultivation is more labor-intensive than rice cultivation; therefore development of vegetable cultivation would provide more employment for the village. Lastly, vegetable diversification can increase the farm household economy by 24% (rice-(rice+Indian mustard) to 68% (rice+spinach)-rice) compared to double rice cropping only.

From the crops-fish combinations in Karang Sari and Tambak Boyo, it is clear that fish and vegetable diversification would provide more employment in the village. In addition, fish and vegetable diversification would contribute a higher net income to the household economy.

CONCLUSIONS

In line with the government program to increase farmers' income, fish and vegetables diversification can be one of the options for increasing income. Through fish diversification, farmers would be able to increase their net income by 13 to 32 % higher than the common rice double cropping in Karang Sari. In Tambak Boyo, farmers would be able to increase their income by 24 to 68 % through vegetable diversification than rice double cropping. Moreover, it would also provide more employment to farmers and villagers in these areas. More effort should be exerted to enhance the educational level of farmers. This is especially true in Karang Seri where the results show that higher educational attainment allows farmers to be more open and receptive to new technologies and improves the chances of deciding to diversify their rice farming into fish culture. Poor farmers especially in the rural areas should at least be given an opportunity to get nine years of basic formal education. Another is the improvement and maintenance of infrastructures like irrigation and road systems which will ensure a stable water supply for the crops while good farm-to-market roads will reduce transport costs for farm products and improve access to the market.

In Tambak Boyo, a good irrigation system is very important to encourage farmers to diversify to vegetable production. The water users' organization should be assisted in the operation and maintenance of the irrigation system. Farmers should be encouraged to raise cows to augment farm income and provide manure for vegetable production, which is in line with the governments integrated crop management program. Farm households with more available family labor will have a higher probability to decide to diversify to vegetable production.

Overall however, there is excess labor in these farm areas possibly because the farms are too small to absorb all of the farm labor and different options should therefore be explored to absorb surplus labor. The agrarian reform program, for example, can be explored as a means of increasing the farm holdings of farmers and absorbing more farm labor.

Table 6. Family labor requirement, gross return, cash expenses and net income per 0.1 ha of rice and 0.01 ha of vegetables in Tambak Boyo, Sumatra, Indonesia in 2004-2005.

	Dry Season		**Rainy Season**		**Spinach**	**Indian mustard**	**String beans**	**Tomato**
	Rice 1	**Rice 2**	**Rice 1**	**Rice 2**				
Labor (hrs)								
May	9.27	0	0	0	0	0	35.60	20.60
June	6.09	10.5	0	0	191.6	92.41	20.91	13.12
July	9.37	10.09	0	0	0	75.94	25.12	9.63
August	4.19	6.63	0	0	0	0	18.56	15.33
September	0	2.05	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0
November	0	0	11.20	0	0	0	0	0
December	0	0	5.50	11.30	0	0	0	0
January	0	0	12.12	10.69	0	0	0	0
February	0	0	3.56	7.93	0	0	0	0
March	0	0	0	2.47	0	0	0	0
April	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0
Gross Return (Rp)	442,214	442,214	556,063	556,063	121,019	114,436	95,434	53,157
Cash Expenses (Rp)	306,082	306,082	324,469	324,469	13,411	16,873	9,569	10,315
Net Income (Rp)	136,132	136,132	231,595	231,595	107,608	97,563	85,865	42,842

Source: Survey June-October 2005

Note: Labor requirement in this table is for one planting period only.

Table 7. Summary of optimal combination of rice-fish in Karang Sari and rice-vegetables in Tambak Boyo, Sumatra, Indonesia in 2004-2005.

Source: Survey June-October 2005
Notes: R = Rice; F = Fish; C = Indian mustard; SB = String Beans; S = Spinach; T = Tomato

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Items	Gross Income (Rp)	Cash Expenses (Rp)	Net Income (Rp)	Total Planted Area (ha)	Total Family Labor Input (hours)
Karang Sari					
R-F-R-F	9,512,538	5,079,830	4,432,708	2.488	637.8
R-R-F	8,652,057	4,655,751	3,996,306	1.866	517.1
R-F-R	8,552,313	4,761,814	3,790,499	1.866	512.5
R-R	7,691,832	4,337,735	3,354,097	1.244	391.7
Tambak Boyo					
(R+S)-R	6,476,805	3,307,783	3,169,022	1.119	2,621.0
(R+SB)-R	5,982,402	2,891,289	3,091,113	1.028	1,932.5
(R+C)-R	6,296,986	3,258,017	3,038,969	0.976	2,390.2
R-S-R	6,313,572	3,372,059	2,941,513	1.061	2,145.7
(R+T)-R	5,392,909	2,646,495	2,746,414	1.028	1,949.5
R-C-R	5,903,869	3,354,963	2,548,906	1.096	1,412.4
R-(R+C)	5,495,861	3,144,467	2,351,394	1.028	1,305.5
R-R	5,131,143	3,241,028	1,890,115	1.028	273.6

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