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ECONOMICS OF MIXED RICE-FISH FARMING IN SOUTH-WEST REGION OF BANGLADESH

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ABSTRACT

The present research aims at investigating the economic performance of mixed rice-fish farming in south-west region of Bangladesh. In order to carry out the research objective descriptive statistics, profit function, Cobb-Douglas form of multiple linear regression model and t-test approaches have been applied. The study area has been selected using multi-stage sampling technique and convenient sampling method has been utilized to select the sample. In-depth interview technique has been employed to collect primary data by using pretested questionnaire from the samples. Results from descriptive statistics show that the average annual return on mixed rice-fish farming is BDT 56326.45 more than mono rice farming as well as production efficiency of mixed rice-fish farming is also found higher than mono rice farming. Besides, mixed rice-fish farming experiences increasing return to scale, whereas, mono rice farming undergoes decreasing return to scale. Moreover, test of hypothesis provides statistical evidence that mixed rice-fish farming is more profitable than mono rice farming in the study area.

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INTRODUCTION

Bangladesh is a country of agriculture situated in south-east Asia. It is one of the highly populated least developed countries in the world with an area of 144000 square kilometers (Ahmed et al., 2011). Agriculture sector is the driving forces of economic growth of Bangladesh contributing 19.41 percent to the gross domestic product (GDP) in fiscal year 2011-2012 and providing a space of occupation for 47.5 percent of the total labor force in the same year (BBS, 2013). Rice and fish are two important products of agriculture becoming the part and parcel of the people of the country. As the main crop of Bangladesh, rice is grown around 29 million tons per year as annual production, whereas, the annual production of fish is around 2.70 million tons (Ahmed and Garnett, 2011). With a population of 16.4 crore, the demand of both rice and fish is increasing continuously in the country every year (Ahmed et al., 2011). The average size of cultivable land holding is decreasing in Bangladesh forcing the farmers to bear high risk and cost to maximize crop production within a shortest possible time due to high pressure from increasing population**.** In this backdrop, practice of mixed rice-fish farming can be a way to tackle the growing demand for food by utilizing farm resources with least time and cost of production. The exercise of rice-fish cultivation can also be source of decent supply of carbohydrate and animal protein (Ahmed and Garnett, 2011; Mamun et al., 2012; Roy et al., 2013).

The total amount of rice cultivated area in Bangladesh is near about 10 million hectare which covers about 75 percent of the total cropped areas (Ahmed and Garnett, 2011; Roy et al., 2013). The country's total production of rice is 344.30 lakh metric tons and in case of fish, it remains 32.22 lakh metric tons in fiscal year 2011-2012**.** The available capacities for producing rice and fish are not being utilized fully although there exists potential to use them. Each year, a lot of food stuffs are imported to meet up the excess demand. In fiscal year 2011-2012, around 22.36 lakh metric tons food stuffs have been imported by both government and non-government sector (BBS, 2013). In this situation, producing rice-fish simultaneously in the same field paves the way for optimum resource utilization for maximum food production. In terms of cost and benefit, mixed rice-fish farming is also being preferred by farmers than mono rice farming in the recent times. One of the reasons may be that integration of fish and rice leads to lower production costs, where sails, insects, pests, and other harmful flies are caught and eaten by the fish.

Justification of the research

Extensive literature on mixed farming is still very few. In addition, studies on economic analysis on mixed rice-fish farming over mono rice production practice is also scarce. A little number of studies have been found on mixed farming, specifically on rice-fish mixed farming in Bangladesh perspective. Among them, a study conducted by Hasanuzzaman and the others investigate practice and economics of freshwater prawn farming in seasonally saline rice field at Shyamnagore Upazilla in Satkhira District of Bangladesh indicating that the culture of prawn in seasonally saline paddy field is economically viable (Hasanuzzaman et al., 2011). Another study explores the fish-paddy crop rotation practice at the farmer's pond at Sadar Upazilla of Bagerhat District, in south-west coastal region of Bangladesh describing that fish-paddy crop rotation system enhances the fertility of the ponds (Roy et al., 2013). However, another study conducted in Mymensingh District of northcentral Bangladesh provides evidence that integrated rice-fish farming can help Bangladesh keep pace with the current demand for food through rice and fish production (Ahmed and Garnett, 2011). On the other hand, Integrated Farming System (IFS) can eradicate high degree of risk and uncertainty because of seasonal, irregular and uncertain income and employment to the farmers by not only solving most of the existing economic and even ecological problems, but also provide other household needs like fuel, fertilizer and feed, along with increasing productivity of the farm manifold (Mamun et al., 2012). The objective of the research is to assess the economic performance of mixed rice-fish farming over mono rice farming at Dighalia Upazila in Khulna District of Bangladesh. Besides, the study also intends to estimate the production function of the two group of farmers to measure the production efficiency and returns to scale.

METHODS AND MATERIALS

Study area

Present study has been conducted in the south-east region of Bangladesh. Multistage sampling technique has used to select the study area. In the first stage, Khulna District has been chosen for purpose of the study from total of 64 districts in Bangladesh; because, this district is situated in the south-west region of Bangladesh. In the second stage, Dighalia Upazila, shown in Figure 1, has been selected from Khulna Districts because most of the farmers in Dighalia Upazila are engaged in rice cultivation and fish cultivation. At the third step, Gazirhat Union has been selected purposively as the farmers in this area are engaged in both rice-fish farming and mono rice production under double cropping system all the year round. At the last stage, a total of 8 villages of the union have been selected randomly.

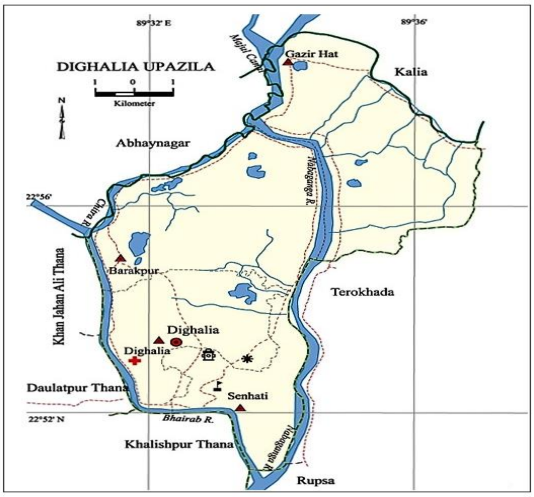

Figure 1. The study area

Source: Asiatic Society of Bangladesh (2006)

Sampling and data collection

For study purpose, farmers who produce only rice and farmers who produce rice-fish have been considered as population. Existing literature survey and a pilot field survey confirm that double cropping system is in operational for rice cultivation in the study area. Generally, cropping season for Boro rice ranges from November to April and duration of Aman rice is June to September (Ahmed and Garnett, 2011; Ahmed et al., 2011; Hasanuzzaman et al., 2011). On the other hand, two widely practiced rice-fish cultivation systems are concurrent culture (integrated) – growing the fish together with the rice in the same area – and rotational culture (alternate) – where the rice and fish are grown at different times (Ahmed et al., 2011; Hasanuzzaman et al., 2011; Roy et al., 2013). Time frame for integrated rice-fish farming is July to November and December to April for Boro rice production. On the other hand, alternate rice-fish farming involves producing of fish in the monsoon from June to December and cultivation of Boro rice from November to April.

In case of study area, quick field survey reveals that mono rice farmers produce Boro and Aman in two cropping season, on the other hand, most of the rice-fish farmers are practicing alternate culture due to the lack of enough water and fish prawn in the dry season. So, the samples of the present study include 30 mono rice farmers and 30 alternate rice-fish producing farmers from the time period of June 2015 to April 2016. The sample has been selected purposively for the study.

For accomplishing the study, data have been collected from both primary and secondary sources. In order to collect primary data, well-structured questionnaire, pretested and revised on the basis of findings and experiences originated at the time of pilot survey has been used. Primary cross-section data have been collected through questionnaire survey at the time of final field survey. Besides, necessary secondary data have been collected from published book, journals, working papers, internet etc.

Data analysis and model specification

In order to analysis data, some mathematical tools have been applied in the study. Profit function has been used to identify the net profit of the farmers from mono rice and rice-fish cultivation, and a Cobb-Douglas production function has been applied to estimate the production efficiency of rice-fish farming and mono rice farming in association with measuring the returns to scale from both production function. In the Table 1, description of the variables used has been mentioned with measurement unit.

Table 1. Description of the variables

SL.	Variable name	Symbol	Measurement unit
i.	Total rice production	Y_r	Kg per acre per cropping season
ii.	Rice seed	X_{r1}	Kg per acre per cropping season
iii.	Fertilizer	X_{r2}	Kg per acre per cropping season (rice production)
iv.	Labor	X_{r3}	No. of labor man-day per acre per cropping season (rice production)
v.	Farm size	X_{r4}	In acre (rice production)
vi.	Total fish production	Y_f	Kg per acre per cropping season
vii.	Fish stocking	X_{f1}	Kg per acre per cropping season
viii.	Fish feed	X_{f2}	Kg per acre per cropping season
ix.	Fertilizer	X_{f3}	Kg per acre per cropping season (fish production)
x.	Labor	X_{f4}	No. of labor man-day per acre per cropping season (fish production)
xi.	Farm size	X_{f5}	In acre (fish production)

Source: Author's compilation, 2016

Estimation of profit function

For calculating profit level of the farmers, the following general profit functions have been used.

$\Pi = TR - TC$ --(1)

Where,

Π = Net profit

TR = Total revenue earned or, [TR = P*Q, where, P = price level and Q = quantity produced]

TC = Total cost incurred or, [TC = TFC + TVC, where, TFC = Total fixed cost and TVC = Total variable cost]

i. Profit function for mono rice production and mixed rice-fish production measured in (BDT/acre/year)

$\Pi_{ij} = TR_{ij} - TC_{ij}$ --(2)

Where,

Π = Net profit, TR = Total revenue, TC = Total cost, i = Profit function for mono rice production, j = Profit function for mixed rice-fish production

Estimation of production efficiency model

Production efficiency of rice-fish production and mono rice production process has been estimated to observe the efficiency level of the farmers. Econometric model of Cobb-Douglas production function is widely used to estimate production efficiency in agriculture. Since, alternative mixed rice-fish technique is prevalent in the study area, separate equation has been applied to estimate the efficiency level of alternate mixed rice-fish and mono rice production.

i. Production efficiency of rice production under alternate mixed farming

$\ln Y_{ri} = \beta_0 + \beta_1 \ln X_{r1i} + \beta_2 \ln X_{r2i} + \beta_3 \ln X_{r3i} + \beta_4 \ln X_{r4i} + \ln U_i$---------------------------------(3)

Where, Y_r = Total rice production, X_{r1} = Rice seed, X_{r2} = Fertilizer, X_{r3} = Labor, X_{r4} = Farm size, U_i = Error term, β_0 = Constant parameter in the equation, mathematically interpreted as the intercept, β's = Coefficient of the relevant variables, i = observation on i^{th} farmer (1, 2, 3 …………. 30)

ii. Production efficiency of fish production under alternate mixed farming

$\ln Y_{fi} = \beta_0 + \beta_1 \ln X_{f1i} + \beta_2 \ln X_{f2i} + \beta_3 \ln X_{f3i} + \beta_4 \ln X_{f4i} + \beta_5 \ln X_{f5i} + \ln U_i$--------------------(4)

Where, Y_f = Total fish production, X_{f1} = Fish stocking, X_{f2} = Fish feed, X_{f3} = Fertilizer, X_{f4} = Labor, X_{f5} = Farm size, U_i = Error term, β_0 = Constant parameter in the equation, mathematically interpreted as the intercept, β's = Coefficient of the relevant variables, i = observation on i^{th} farmer (1, 2, 3 …………. 30)

iii. Production efficiency of mono rice production

For estimating mono rice production (Aman season and Boro season), two modified Cobb-Douglas production function has been used as presented in equation (5) and (6).

Production efficiency of Aman rice:

$\ln Y_{rai} = \beta_0 + \beta_1 \ln X_{r1i} + \beta_2 \ln X_{r2i} + \beta_3 \ln X_{r3i} + \beta_4 \ln X_{r4i} + \ln U_i$--------------------------------(5)

Production efficiency of Boro rice:

$\ln Y_{rbi} = \beta_0 + \beta_1 \ln X_{r1i} + \beta_2 \ln X_{r2i} + \beta_3 \ln X_{r3i} + \beta_4 \ln X_{r4i} + \ln U_i$--------------------------(6)

Where, Y_{ra} = Total Aman rice production, Y_{rb} = Total Boro rice production, X_{r1} = Rice seed, X_{r2} = Fertilizer, X_{r3} = Labor, X_{r4} = Farm size, U_i = Error term, β_0 = Constant parameter in the equation, mathematically interpreted as the intercept, β's = Coefficient of the relevant variables, i = observation on i^{th} farmer (1, 2, 3 …………. 30),

iv. Measurement of returns to scale

Returns to scale have been estimated both for mono rice production and mixed rice-fish production by using following equation adopted from (Ahmed and Garnett, 2011).

$r = \sum \beta_i$ --(7)

Where, r = Returns to scale

$\sum \beta_i$ = Sum of all the production coefficients

r < 1 = Decreasing returns to scale

r = 1 = Constant returns to scale

r > 1 = Increasing returns to scale

Hypothesis testing

This study intends to find out the economic difference between mixed rice-fish and mono rice farming in the study area. For this reason, a research hypothesis has been articulated as given below:

Null Hypothesis:

H_0 = There is no difference between mixed rice-fish and mono rice farming in terms of economic returns.

Alternative Hypothesis:

H_1 = There is economic difference between mixed rice-fish and mono rice farming in terms of economic returns.

For data analysis, a number of computer software have been used. At first, collected primary data have been organized and stored by MS Excel 2016. In the second step, mathematical and statistical calculations have been compiled through using STATA 12 and IBM SPSS Statistics 20.

RESULTS AND DISCUSSION

Social profile of the respondents

Social profile of the respondents helps to get general idea of the samples in the study area. Descriptive analysis presented in the Table 2 shows that among the samples average ages of the mixed faming farmers and mono rice farmers are 40 and 42 respectively. Among the mixed farmers, mean education level is 7 years and it is 5 years for the mono rice produces. In addition, there is little difference between the two type of respondents in terms of household size. However, the average farming experience of the former group of farmers is 16 years, whereas, the latter group of farmers have on an average 20 years of farming experience.

Household farm production related information

Farm related information of the household provides significant insight of the production process of the respondents in the study area. To make it clear, cropping season-wise summary statistics of the respondents has been presented in the Table 3. It has been seen from the Table 3 that, Boro production under alternate mixed rice-fish farming system has an average rice production of 4184 kg per acre. In terms of using inputs per acre, on an average, 57 labor man day, 10 kg of rice seed and 308 kg of fertilizer are applied per acre of land. On the other hand, fish production under the same farming system yields on an average 1233 kg of white fish per acre of land in the same area. In order to produce that level of output, it takes on an average 15 labor man day, 195 kg of fish feed, 68 kg of fish prawn and 60 kg of fertilizer. There is variation in the output and inputs employed from respective farmer to farmer as indicated by standard deviation.

On the other hand, Aman production under mono rice production represents different results apart from mixed farming in the same area. It has been found that, average production of Aman per acre of land is 1836 kg. It takes on an average, 12 labor man day, 13 kg rice seed and 51 kg of fertilizer to produce that level of output. However, the production volume of Boro rice under mono rice farming shows different picture. Summary statistics presented in the Table 3 articulates that on an average 3733 kg of rice is produced per acre. To come up with this amount of output, it takes on average, 28 labor man day, 8 kg of rice seed, and 111 kg of fertilizer. There is variation in the output and input level from producer to producer which is shown by standard deviation in the Table 3.

Table 2. Summary of social profile of the respondents

	Variable	Obs.	Mean	Std. Dev.	Min	Max
Alternate mixed rice-fish farmers	Age	30	40.93	10.05	23	61
	Education	30	7.97	2.41	5	12
	Household size	30	5.67	1.84	3	9
	Farming experience	30	16.73	10.66	3	45
Mono rice farmers	Age	30	42.43	10.77	25	65
	Education	30	5	4.28	0	12
	Household size	30	6.03	1.69	3	10
	Farming experience	30	20.87	10.54	5	42

[Note: Obs. = Observation, Std. Dev. = Standard Deviation, Min = Minimum, Max = Maximum]
Source: Author's compilation based on field survey, 2016

Table 3. Summary of farm production information of the respondents

	Variable	Obs.	Mean	Std. Dev.	Min	Max
Boro production [alternate mixed rice-fish farming]	Rice production	30	4184	1456.53	1260	6720
	Farm size	30	1.20	0.376	0.50	1.98
	Labor	30	57.88	25.73	18	150
	Rice seed	30	10.88	3.84	3	18
	Fertilizer	30	308.9	138.30	37	600
Fish production [alternate mixed rice-fish farming]	Fish production	30	1233	471.24	200	2500
	Farm size	30	1.20	0.37	0.50	1.98
	Labor	30	15.85	14.83	3	85
	Fish feed	30	195.23	69.06	22	300
	Fish stocking	30	68.83	39.71	20	150
	Fertilizer	30	60.17	28.05	10	120
Aman production [mono rice farming]	Rice production	30	1836.33	917.11	800	4200
	Farm size	30	1.14	0.41	0.33	1.65
	Labor	30	12.13	3.60	2	20
	Rice seed	30	13.03	3.38	5	18
	Fertilizer	30	51.2	11.90	40	80
Boro production [mono rice farming]	Rice production	30	3733.67	1456.23	950	5600
	Farm size	30	1.14	0.41	0.33	1.65
	Labor	30	28.1	12.19	12	58
	Rice seed	30	8.93	4.03	1	16
	Fertilizer	30	111.73	37.15	40	188

[Note: Obs. = Observation, Std. Dev. = Standard Deviation, Min = Minimum, Max = Maximum]
Source: Author's compilation based on field survey, 2016

Table 4. Profit level of mixed rice-fish and mono rice production

Type of farming	Cost per acre		Gross return per acre		Net return
	Input	BDT	Output	BDT	BDT
Boro production [alternate mixed rice-fish farming]	Labor	10883.33	Rice production	83680.00	
	Rice seed	2144.83	Rice straw	7746.67	
	Fertilizer	6228.67			
	Land preparation	981.33			
	Total	20238.16		91426.67	71188.51
Fish production [alternate mixed rice-fish farming]	Labor	1832.50	Fish production	147960.00	
	Fish stocking	10845.00			
	Fish feed	8013.67			
	Fertilizer	1547.17			
	Lime cost	766.5			
	Total	23004.84		147960.00	124955.2
Aman production [mono rice farming]	Labor	2263.33	Rice production	27545	
	Rice seed	394.07	Rice straw	2366.67	
	Fertilizer	1536			
	Land preparation	1032.5			
	Total	5225.9		29911.67	24685.77
Boro production [mono rice farming]	Labor	5780	Rice production	74673.33	
	Rice seed	1536.00	Rice straw	9802.9	
	Fertilizer	2234.67			
	Land preparation	800.00			
	Irrigation	2237.08			
	Total	12587.75		84476.23	71888.48
Alternated mixed rice-fish farming [rice + fish]/acre/year	**43243**		**196143.71**		**152900.7**
Mono rice farming [Aman + Boro]/acre/year	**17813.65**		**114387.9**		**96574.25**

Note: Inputs (average in kg/acre/cropping season) and costs (average in BDT/acre/cropping season)
Source: Author's compilation based on field survey, 2016

Estimation of profit level of mixed rice-fish and mono rice production

Integrated rice-fish farming provides benefits such as economic, optimum and double utilization of paddy field, where it is possible to produce fish and rice simultaneously without supplying any excess fertilizer, food and water and rice yield also will increase (Noorhosseini-Niyaki and Bagherzadeh-Lakani, 2011). One of the prime motives of any production activity is to earn revenue. In this case, attempts have been taken to figure out the level of revenue earned by the farmers who practice rice-fish mixed farming and mono rice farming in the study area. Net return from both farming type has been calculated separately based on cropping season and combinedly as presented in the Table 4. It has been seen from the Table 4 that, farmers have to spend money on labor, seed, land preparation, fertilizer, fish stock, fish fee etc. On the other hand, they get return from rice production, rice straw etc. Estimated results shown in the Table 4 indicates that on an average, Boro rice production under alternate mixed rice-fish farming incurs a total of BDT 20238 as input cost. On the other hand, it gets return amounted to BDT 91426. In the end, the amount of net return reaches to near about BDT 71188 to the producer. In the same manner, on an average, a total of BDT 124955 is left as net return in fish farming under alternate mixed rice-fish farming in the same area. In that case, the total cost is BDT 23004 and gross return is equivalent to BDT 147960. However, the net return from mono rice farming is a bit different from the previous one. It is clear from the Table 4 that, on an average Aman production under mono rice farming gives net return of BDT 24685 and Boro production renders a sum of BDT 71888 as net return.

To sum up, it is found that on an average, mixed rice-fish producer get on an average BDT 152900 as annual net return. On the other hand, annual average net return is BDT 96574 for the farmers who practice mono rice farming system in the study area. The analyses presented in the Table 4 crystalize that mixed farming is more profitable than mono rice farming the study area. This result is consistent with the findings of (Dey et al., 2013) showing that alternating rice–fish systems provides substantial potential for increasing productivity and farm incomes in Bangladesh. Besides, Nahar (2010) finds that production level from rice-fish system is significantly higher than other farming system and suitable for poor people considering the yields and economics benefits from it.

Table 5. Results from regression analysis

Explanatory variables	Farming type			
	Boro production [alternate mixed rice-fish farming]	**Fish production [alternate mixed rice-fish farming]**	**Aman production [mono rice farming]**	**Boro production [mono rice farming]**
Rice seed	(-0.102) {0.065} [-1.57]	-	(0.671) {0.361} [1.86***]	(0.001) {0.099} [0.01]
Fertilizer	(0.211) {0.064} [3.30*]	(-0.147) {0.189} [-0.78]	(-0.601) {0.390} [-1.54]	(-0.129) {0.210} [-0.62]
Labor	(0.166) {0.099} [1.68]	(-0.140) {0.151} [-0.93]	(-0.195) {0.210} [-0.93]	(-0.009) {0.169} [-0.05]
Farm size	(0.775) {0.159} [4.87*]	(-0.140) {0.356} [-0.39]	(-0.029) {0.249} [-0.12]	(1.054) {0.151} [6.96*]
Fish stocking	-	(0.262) {0.211} [1.24]	-	-
Fish feed	-	(0.471) {0.207} [2.27**]	-	-
Constant	(6.559) {0.653} [10.03]	(4.472) {1.187} [3.76]	(7.707) {1.301} [5.92]	(8.529) {.617} [13.82]
Summary statistics				
R^2	0.91	0.32	0.21	0.78
Observation	30	30	30	30
Mean VIF	2.95	1.70	1.50	2.10
Return to scale Σb_i	1.05	0.31	-0.154	0.917

[Note: Figure in the first bracket indicates coefficient value, figure in the second bracket indicates standard error and figure in the third bracket refers to t-value, * = significant at 1 percent level, ** = significant at 5 percent level, *** = significant at 10 percent level]

Source: Author's compilation based on field survey, 2016

Table 6. Hypothesis testing

Variable	Obs.	Mean	Std. Err.	Std. Dev.
Gross return from mixed rice-fish farming	30	231640	12721.45	69678.22
Gross return from mono rice farming	30	102218.3	5775.811	31635.42
Difference		129421.7	13971.23	
		t = 9.2634 Degrees of freedom = 58		
H_o: mean(diff) = 0				
H_a: mean(diff) < 0	H_a: mean(diff)! = 0	H_a: mean(diff) > 0		
$P_r(T < t) = 1.0000$	$P_r(\|T\| > \|t\|) = 0.0000$	$P_r(T > t) = 0.0000$		
[Note: Obs. = Observation, Std. Err. = Standard Error, Std. Dev. = Standard Deviation]				

Source: Author's compilation based on field survey, 2016

Production efficiency and reruns to scale of mixed rice-fish and mono rice farming

Production efficiency of the respective farming system has been estimated using econometric regression model of Cobb-Douglas production function. Results from alternative mixed rice-fish farming show that coefficient of multiple determination (R^2) ranges from 0.91 to 0.32. It implies that 32 to 91 percent of total variation in the production of mixed rice-fish farms can be explained by the explanatory variables used in the models. In addition, it omits variables that can explain 9 to 68 percent of the model. The estimated coefficients of farm size and fertilizer are 0.77 and 0.06 respectively. This indicates that 1 percent increase in farm size and fertilizer, keeping other thing constant, would increase the production by 0.77 percent and 0.06 percent respectively and it is statistically significant at 1 percent. In case of fish production under the same farming system, estimated coefficient value of fish feed is 0.47 which is significant at 5 percent level. It states that 1 percent increase in input fish feed results in 0.47 percent increase in the fish production. The other variables are found statistically insignificant. On the other hand, the estimated coefficients of R^2 of Aman and Boro rice production under mono rice farming system are 0.21 and 0.78. It refers that 21 to 78 percent of total variation in the production of mono rice farms can be explained by the explanatory variables used in the models, the other thing remaining constant. In addition, it excludes explanatory variables that could explain 22 to 79 percent of the model. However, estimated coefficient of input rice seed is 0.67 indicating 1 percent increase in rice seed would increase Aman rice production by 0.67 percent and it is statistically significant at 10 percent level. Besides, estimated coefficient of farm size of Boro rice production is 1.05 meaning 1 percent increase in farm size would increase Boro rice production by 1.05 percent, which is statistically significant at 1 percent level. The other variables are found statistically insignificant.

The summation of all the production coefficients (Σb_i) in the alternate rice-fish mixed farming system is 1.36. This result is closer to the findings of (Ahmed and Garnett, 2011), who have revealed that return to scale of alternate rice-fish mixed farming is equivalent to 1.41. Since it is greater than 1, the returns are supposed to increase with the increase in inputs. For instance, if all the inputs mentioned in the model are increased by 1 percent, farm production will increase by 1.36 percent in the alternate rice-fish mixed farming system. This results suggests that there is still scope to increase production under the alternate mixed farming system in the study area by increasing the amount of inputs. On the other hand, the summation of all the production coefficients (Σb_i) in the mono rice farming system is 0.763. Since it is smaller than 1, the returns are supposed to decease with the increase in inputs in the study area.

Hypothesis testing

The result of hypothesis testing has been mentioned in the Table 6. It is seen from Table 6 that, there is statistically significant difference between return of mixed rice-fish farming and mono rice farming in the study area. The mean difference of gross return between the two-farming system is found equivalent to BDT 129421.70. The probability of mean difference to be equal to zero or greater than zero is significant at 1 percent level. So, the null hypothesis implying there is no difference of economic return from mixed rice-fish farming and mono rice farming is rejected at 1 percent level of significance. This estimate provides significant insight and proof that mixed rice-fish farming is more profitable and economically beneficial than mono rice farming in the study area.

CONCLUSION

The study intends to analyze the economic performance of mixed rice-fish farming and mono rice farming in the study area. Results from the descriptive statistics show that average ages of the mixed faming farmers and mono rice farmers are over 40. However, the average farming experience of the two group of farmers' ranges from 16-20 years. Farm related information of the farmer indicates that average Boro rice and fish production under alternate mixed rice-fish farming system are 4184 kg and 1233 kg per acre respectively. In term of return on production, mixed rice-fish producer gets on an average BDT 152900.7 and mono rice producer obtains BDT 96574.25 per annum. Results from regression models provide statistical evidence that mixed rice-fish farming is more efficient than mono rice farming in the area. Estimated coefficients of the model also show that mixed farming enjoys increasing returns to scale, whereas, mono rice farming system is being operated under decreasing returns to scale. Test of hypothesis also supports the notion that mixed rice-fish farming system is more profitable than mono rice farming. It is important for the concerned policy maker to take steps for promoting mixed farming to remove poverty and ensure sustainable rural development in Bangladesh.

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