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PROFITABILITY AND RESOURCE USE EFFICIENCY OF *BORO* RICE PRODUCTION IN FAVORABLE AND SUBMERGENCE ECOSYSTEMS OF TANGAIL DISTRICT: A COMPARATIVE STUDY

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Abstract

The present study was conducted to estimate the profitability and resource use efficiency of *Boro* rice production in two ecosystems of Tangail district. A total of 80 farmers were interviewed randomly for data collection through a structured questionnaire. Data were analyzed with a combination of descriptive statistics, mathematical and statistical techniques. Profitability analysis revealed that producing *Boro* rice resulted in the maximum profit for the farmers at submergence ecosystem compared to favorable ecosystem. The Cobb-Douglas production function analysis indicated that output of *Boro* rice was positively and significantly correlated with labor, seed, TSP and irrigation at favorable ecosystem. The study also found that inputs like labor, seed, power tiller, irrigation, urea and pesticide have significant influence on increasing *Boro* rice production at submergence ecosystem. Resource use efficiency analysis showed that farmers inefficiently used their inputs for *Boro* rice production. Following problem facing index (PFI), low price of paddy and lengthy water logging condition were the main problems faced by the farmers. The study recommended that proper training and extension support should be made available by the government and non-government organizations to enhance the profitability and to ensure the optimum use of resources in *Boro* rice production.

Keywords: Favorable ecosystem, Submergence ecosystem, Profitability, Resource use efficiency.

1. Introduction

Bangladesh economy has been growing over the last three decades. Among the different sectors of economy, agriculture plays an important role to generate employment for its population by increasing productivity and growth. At present, agriculture contributes about 12.92% to the gross domestic product (GDP) (BBS, 2020). Although the contribution of agriculture sector to GDP has gradually been declining in recent years but still it is playing a major role in the economy of Bangladesh. About 40% of the total national labor forces are employed by the agriculture sector (BBS, 2020). Rice is not just the staple food, it is at the center of the overall life of the people of Bangladesh, whether it is culture, politics, or the

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economy. Rice alone constitutes 80% of the total food grains produced annually (BER, 2017). It is the principal source of agriculture GDP and livelihood to majority of the rural population which supplies 69.8% of the total caloric intake and more than 58% of the protein intake (FAO, 2015).

Bangladesh has a subtropical monsoon climate which may be described as unstable and unpredictable. There are six seasons in a year of which three namely winter, summer, and monsoon are prominent. Rice is grown in three seasons i.e.,*Aus*, *Aman* and *Boro* in Bangladesh. Among these, *Boro* is dominant for its higher production capability and its important role in gaining self-sufficiency in food grain. In terms of area under cultivation, rice comes first among the cereals contributing about 42% of the land during *Boro* season and it accounts for the production of 19.56 million tons of clean rice, which is around 54% of the total production of the country (BBS, 2020). On the other hand, by 2050 this country's population is estimated to exceed 215 million and the nation would have to grow additional 10.8 million tons of rice (Hussain, 2010). It is, therefore, a major challenge to provide sufficient food through diminishing land and many other scared supplies to feed the future with the ever-growing population of the country (Rahaman*et al.*, 2018). Rice production has been intensified through the introduction of high-yielding and hybrid *Boro* rice varieties, cultivated in the dry season using irrigation, as well as the increased application of fertilizer, pesticides, and better crop management. HYV *Boro* was found more efficient among all other main rice varieties (Local *Aman,* HYV *Aman*and HYV *Boro*) in Bangladesh (Regmi*et al.*, 2016).

Rice is cultivated in four different rice growing environments or ecosystems (IRRI, 1993). An ecosystem is a chain of interaction between organisms and their environment. In favorable ecosystem, the average temperature is required throughout the life period of the crop ranges from 21 to 37^o C and having minimum rainfall is 115 cm. Favorable condition is also defined by the depth of water varying over 25 mm at the time of transplanting to as much as 150 mm for 10 weeks of the growing period. Submergence ecosystemis defined on the basis of duration, depth, and frequency. Flood causes submergence and damage to rice crops. Two types of environment cause submergence: flash flood and deep water. Flash flood submergence is defined by water levels rising rapidly and plants remaining submerged for 1-2 weeks. Deep water submergence is defined by water depths greater than 100 cm persisting for months (Kannan *et al.*, 2017). *B. Aman* and *B. Aus* are grown in deepwater and upland rice ecosystems, respectively. *Boro* and *T. Aus* are grown under the irrigated ecosystem. *T. Aman* is grown primarily under rainfed lowland conditions. However, *T. Aman* is also grown under deepwater environment where flood water exceeds 50 cm (Shelley *et al.*, 2016).

Although rice is considered as the main crop in Bangladesh and the country is ranked as the fourth largest rice producer in the world (FAO, 2021), it is not produced with full efficiency.The increase in production is possible mainly through improvement in crop productivity which could be achieved by efficient utilization of available resources. Optimum use of resources could also increase the profit margin if the farmers are using inputs indiscriminately. The government of Bangladesh has given priority to the agriculture sector to increase the production of rice by giving subsidy to the farmers on different inputs such as fertilizer, irrigation, etc. The future of rice production in Bangladesh depends very much on the awareness of its profitability and how efficiently the farmers are using their resources.

The study can be supported by a modest number of literatures which are:Kamruzzaman and Uddin (2020) conducted a study on economic viability of *Boro* rice production in *haor* ecosystem of Kishoreganj district and found that *Boro* rice production was profitable and productivity index was very high; Subedi *et al.* (2020) carried out a study on profitability and resource use efficiency of rice production in Jhapa district of Nepal and revealed that optimum allocation of resources, cost on seed, chemical fertilizers, irrigation and pesticides/herbicides need to be increased and cost on human labor and tractor power should be decreased. Rasha *et al.* (2018) examined financial profitability and resource use efficiency of *Boro* rice production in some selected areas of Mymensingh district in Bangladesh and identified that seed, animal labor and power tiller, human labor, fertilizer and irrigation cost had a positive and significant effect on the gross yield of *Boro* rice production; and Sujon *et al.* (2017) evaluated financial profitability and resource use efficiency of *Boro* rice cultivation in some selected area of Bangladesh and found that human labor, irrigation, insecticide, seed and fertilizer had statistically significant effect on yield and growers allocated most of their resources in the rational stage of production. The existing literature indicates that plenty of research has been done on rice production including cost, return, profitability and resource use efficiency analysis in different areas of Bangladesh, but no systematic work has been done on *Boro* rice cultivation in different ecosystems. Therefore, the study was carried out to compare profitability and resource use efficiency of *Boro* rice cultivation between two ecosystems of Tangail district. The specific objectives of the study were: i) to estimate the comparative profitability in favorable and submergence ecosystems, ii) to analyze the factors affecting resource use efficiency of the production of *Boro* rice in two ecosystems.

2. Materials and Methods

2.1 Study areas and sample size

The study was conducted at four villages namely Singuria and Pachtikori from Ghatail upazilla; Betuajani and Ghugra from Nagorpur upazilla of Tangail district. Based on the rice ecosystem, upazillas were selected as favorable and submergence ecosystems, respectively. A total of 80 farmers (i.e., 40 from favorable ecosystem and 40 from submergence ecosystem) were selected following random sampling technique for primary data collection. Primary data were collected from the respondents by using a questionnaire during June 2019 to August 2019. Focus group discussions (FGD) and key informant interviews (KII) were also performed for data collection. Secondary data sources like reports, publications, handouts, etc. relevant with this study were also examined.

2.2 Analytical techniques

Descriptive statistics: Descriptive statistics like sum, averages and percentages were calculated to identify the farmers' socioeconomic status for producing *Boro* rice in different ecosystems.

Profitability analysis: Profitability of *Boro* rice production per hectare from the view point of individual farmer was measured in terms of gross return, gross margin, net return and benefit cost ratio (Dilon and Hardaker, 1993). The formulas needed for the calculation of profitability is as below:

GR = P × Q; GM = GR – TVC; NR = GR – (TFC + TVC); BCR = GR ÷ (TFC + TVC)

Where,

> GR = Gross return (Tk); P = Sales price of the product (Tk.); Q = Yield per hectare (metric ton); GM = Gross margin (Tk.); TVC = Total variable cost (Tk.); NR = Net return (Tk.); TFC = Total fixed cost (Tk.); and BCR = Benefit cost ratio.

A paired t-test was conducted to check whether the profitability of favorable and submergence ecosystems was significantly different or not. The hypotheses were as follows:

Null hypothesis (H_0): The net return from favorable and submergence ecosystems is indifferent

Alternative hypothesis (H_1): The net return from favorable and submergence ecosystems is different

Functional analysis: The input-output relationship in *Boro* rice production was analyzed with the help of Cobb-Douglas production function approach (Gujarati and Porter, 2008). To determine the contribution of the most important variables in the production process of *Boro* rice, the following specification of the model was used.

$$Y=ax_1^{b1}x_2^{b2}x_3^{b3}x_4^{b4}x_5^{b5}x_6^{b6}x_7^{b7}x_8^{b8}e^{ui}$$

The Cobb-Douglas production function was transformed into following logarithmic form so that it could be solved by ordinary least squares (OLS) method.

$\text{Ln } Y_i = B_0 + B_1 \text{ In}X_1 + B_2 \text{ In}X_2 + B_3 \text{ In}X_3 + B_4 \text{ In}X_4 + B_5 \text{ In}X_5 + B_6 \text{ In}X6 + B_7 \text{ In}X_7 + B_8 \text{ In}X_8$

Where,

Y=Profit (Tk./ha); B_0= Constant or intercept value; X_1= Cost of labor (Tk./ha); X_2= Cost of seed (Tk./ha); X_3= Cost of mechanical power (Tk./ha); X_4= Cost of urea (Tk./ha); X_5 = Cost of TSP (Tk./ha); X_6 = Cost of MoP (Tk./ha); X_7= Cost of irrigation (Tk./ha); X_8= Cost of insecticide(Tk./ha); Ln=Natural logarithm; and B_1……B_8 = Coefficient of the respective explanatory variables estimated.

Resource use efficiency: In order to investigate the resource use efficiency, the ratio of marginal value product (MVP) to the marginal factor cost (MFC) for each input was computed and tested for its equality to 1, That is,

$$\frac{MVP}{MFC} = r$$

Where,

r = Efficiency ratio;

MVP=Marginal Value Product; and MFC= Marginal Factor Cost.

Under this method, the decision rules are that, when:

r >1, the level of resource use is below the optimum level implying under-utilization of resources. Increasing the rate of use of that resource will help increase productivity.

r <1, the level of resources use is above the optimum level implying over utilization of resources. Reducing the rate of use of that resource will help improve productivity.

r =1, the level of resource use is at optimum implying efficient resource utilization.

The most reliable perhaps the most useful estimate of MVP is obtained by taking all input resources (X_i) and gross return (Y) at their geometric means (Dhawan and Bansal, 1977). All the variables of the fitted model were calculated in monetary value. As a result, the slope co-efficient of those independent variables in the model represent the MVPs, which were estimated by multiplying the production co-efficient of given resources with the ratio of geometric mean (GM) of gross return to the geometric mean (GM) of the given resources, that is,

$$MVP(X_i) = \beta_i \frac{\bar{Y}(GM)}{\bar{X}\ (GM)}$$

Where,

$\bar{Y}(GM)$ = Geometric mean of gross return (BDT);

$\bar{X}\ (GM)$ = Geometric mean of different independent variables (BDT);

β_i = Co-efficient of parameter; andi = 1, 2,………………..n.

Problem facing index (PFI): To address the problems in producing *Boro* rice, problem facing index (PFI) was calculated using the following formula (Goswami, 2016):

$$PFI = (P_s \times 3) + (P_m \times 2) + (P_l \times 1) + (P_n \times 0)$$

Where,

P_s = Number of respondents facing the problems severely (weight assigned as 3);

P_m = Number of respondents facing the problems moderately (weight assigned as 2);

P_l = Number of respondents facing the problems at low level (weight assigned as 1); and

P_n = Number of respondents facing no problems (weight assigned as 0)

The problem facing score was computed for each respondent. The possible range of total score could be 0 (zero) to 120, while ‘0’ indicating no problem and ‘120’ indicating severe problem in *Boro* rice production.

3. Results and Discussion

3.1 Socioeconomic status of the respondents

As socioeconomic status of the *Boro* rice farmers, it is found that average household size of farmers was 5.0 in favorable as well as in submergence ecosystem, which was almost 1.2 times higher compared to the country's average of 4.1 (HIES, 2016). It is seen that most of the farmers (50.6 percent for favorable and 56.4 percent for submergence ecosystem) are middle aged belonging to the age group of 26-50 which pre-supposed that many of them are in their active age. Though 54.1 percent favorable farmers had crossed primary level education, majority of the submergence farmers (60.4 percent) were illiterate in the study areas. The results also show that most of the respondents (92.9 percent for favorable and 87.1 percent for submergence ecosystem) were engaged in agricultural activities in the study areas (Table 1).

Table 1. Demographic information of the farmers

Particulars	Favorable ecosystem	Submergence ecosystem	Particulars	Favorable ecosystem	Submergence ecosystem
Ave. household size (no.)	5.0	5.0	Literacy rate (% of farmers)		
Average age(% of farmers)			Illiterate	45.9	60.4
Below 25 years	1.2	6.9	Primary	21.2	14.8
26-50 years	50.6	56.4	Secondary	24.7	13.9
Above 50 years	48.2	36.7	Above secondary	8.2	10.9
Experience status (% of farmers)			Occupational status (% of farmers)		
Below 20 years	36.5	44.6	Agriculture	92.9	87.1
21-40 years	51.8	41.6	Others	7.1	12.9
Above 40 years	11.7	13.8			

Source: Field survey, 2019.

3.2 Land tenancy arrangements of the farmers

Most of the farmers (91.8 percent for favorable and 90 percent for submergence ecosystem) were small in the study areas which was higher than the national mean value of 76.7% (HIES, 2016). Average farm size of small and medium farmers was 0.37 ha and 1.71 ha, respectively in favorable ecosystem whereas it was 0.39 ha, 1.35 ha and 3.56 ha for small, medium and large farmers, respectively in submergenceecosystem (Table 2).

Table 2. Farmers land tenancy arrangements

Farmers' categories	% of farmers	Average farm size (ha)	Land tenancy arrangement (ha)		
			Own	Rented/ Leased-in	Rented/ Leased-out
Favorable ecosystem					
Small (<1.00 ha)	91.8	0.37	0.26(70.3)	0.01 (2.7)	0.10 (27.0)
Medium (1.01-3.00 ha)	8.2	1.71	1.08 (63.2)	0.40 (23.4)	0.24 (13.4)
Submergence ecosystem					
Small (<1.00 ha)	90.1	0.39	0.32 (82.0)	0.01 (2.6)	0.06 (15.4)
Medium (1.01-3.00 ha)	8.9	1.35	0.80 (59.2)	0.28 (20.7)	0.27 (20.0)
Large (above 3.00 ha)	1.0	3.56	3.56 (100)	-	-

Source: Field survey, 2019.

3.3 Varietal status of the rice producers

The varieties of rice cultivated by the farmers under different ecosystems were identified and presented in Table 3. It is found that most the farmers (68.67%) used BRRI dhan29 in *Boro* growing season at favorable ecosystem followed by BRRI dhan28 (74.0%) at submergence ecosystem. The results implied that farmers still cultivate older improved rice varieties. The findings are similar to ToritsejuBegho

(2021) where the author identified improved rice varieties, those with age of 20 years since release (e.g., BRRI dhan32, BRRI dhan30, BRRI dhan29, BRRI dhan28 and BRRI dhan27) recorded the highest proportion (65.9%) in the count of adopted improved rice varieties.

Table 3. Distribution of *Boro* rice varieties of the farmers

Variety	Percent of farmers responded	
	Favorable ecosystem	Submergence ecosystem
BRRI dhan29	68.67	26.00
BRRI dhan28	25.30	74.00
BRRI dhan81	4.82	-
Binadhan-7	1.20	-

Source: Field survey, 2019.

Table 4. Cost-return analysis of *Boro* rice production

Particulars	Favorable ecosystem		Submergence ecosystem	
	(Tk./ha)	% of total cost	(Tk./ha)	% of total cost
Variable costs				
Human labor	31292	40.86	30064	40.48
Power tiller	5261	6.87	6319	8.51
Seed/seedlings	5746	7.50	4951	6.67
Fertilizers	7158	9.35	7709	10.38
Irrigation	14563	19.02	12848	17.30
Insecticides and herbicides	3808	4.97	4012	5.40
i. Total variable cost (Tk./ha)	67828	88.58	65903	88.74
Fixed costs (Tk./ha)				
Land use cost	4872	6.36	5120	6.89
Interest on operating capital	3876	5.06	3245	4.37
ii. Total fixed costs (Tk./ha)	8748	11.42	8365	11.26
iii. Total costs (Tk./ha)	76576	100.00	74268	100.00
Return (Tk./ha)				
iv. Gross return (Tk./ha)	93466		105966	
v. Gross margin (Tk./ha)	25638		40063	
vi. Net return (Tk./ha)	16890		31698	
vii. Benefit cost ratio (BCR)	1.22		1.43	
t-test: Paired two sample for mean net return				
P(T<=t) two-tail	0.003			
t Critical two-tail	2.022			
Remark	Null hypothesis rejected at 1% level of significance			

Source: Authors' estimation based on field survey, 2019-2021.

3.4 Profitability of Boro rice production

The profitability of *Boro* rice production was estimated in terms of gross return, gross margin, net return and benefit-cost ratio. For calculating total production cost, variable and fixed costs were taken into consideration. It is apparent from

Table 4 that the highest total cost was incurred by the farmers at favorable ecosystem (Tk.76576/ha) compared to submergence ecosystem (Tk.74268/ha).Though total cost was higher at favorable ecosystem, apart from this it is seen that farmers obtained higher gross return (Tk. 105966) per hectare at submergence ecosystem due to better production of *Boro* rice compared to favorable ecosystem.The p-value of the paired t-test for mean net return was found 0.003, which confirmed the decision to reject the null hypothesis (at 1% level of significance) and to accept the alternative hypothesis that there was a significant difference in the profitability of *Boro* rice production between favorable and submergence ecosystems. The estimated BCR was higher at submergence ecosystem (1.43) compared to favorable ecosystem (1.22). Thus, the profitability analysis revealed that producing *Boro* rice resulted in the maximum profit for the farmers at submergence ecosystem compared to favorable ecosystem.This finding is supported by Uddin and Dhar (2020) where the authors found profitability and productivity of *Boro* rice, as well as water productivity, were comparatively high for focal farmers compared to control farmers.

3.5 Factors affecting production of Boro rice

In order to assess the individual effects of different inputs of *Boro* rice production, Cobb-Douglas production function model was used. The results as shown in Table 5 indicated that labor cost, seed cost and irrigation cost had positive impacts on producing *Boro* rice at favorable ecosystem as well as submergence ecosystem. It is seen that power tiller cost and urea cost had negative impacts at favorable ecosystem, while these two variables had positive impacts on profitability of *Boro* rice at submergence ecosystem.The values of standardized regression coefficients as presented in Table 5 demonstrate that TSP had the largest impact on *Boro* rice production at favorable ecosystem while insecticide had the largest impact at submergence ecosystem. This finding is relevant to Sujon *et al*. (2017) where the authors observed that human labor, irrigation, insecticide, seed and fertilizer had statistically significant effect on *Boro* rice yield. The co-efficient of determination (R^2) was found as 0.809 for favorable ecosystem and 0.795 for submergence ecosystem which implied that 80.9 and 79.5 percent variation of dependent variable has been explained jointly by the independent variables, i.e., the model is well fitted. The F-value of the equation was 23.37 and 21.74 for favorable and submergence ecosystems, respectively meant that all of the explanatory variables included in the model were important to explain the variation of the dependent variable. The model shows a decreasing return to scale (0.27 for favorable and 0.58 for submergence) which means that the outputs will increase in a lower rate compared to the rate of increase in all the production inputs.

Table 5. Estimated values of co-efficient and related statistics of the Cobb-Douglas Production function

Variables	Favorable ecosystem			Submergence ecosystem		
	Co-efficient (S.E.)	t-value	SRC	Co-efficient (S.E.)	t-value	SRC
Intercept	9.204*** (2.637)	3.49		7.189*** (1.179)	6.10	
Labor (X_1)	0.057* (0.031)	1.84	.087	0.049* (0.025)	1.96	.105
Seed (X_2)	0.018* (0.010)	1.80	.037	0.005* (0.003)	1.67	.009
Power tiller (X_3)	-0.122** (0.050)	-2.44	-.124	0.233** (0.097)	2.40	.297
Urea (X_4)	-0.042*** (0.012)	-3.50	-.057	0.136* (0.081)	1.67	.194
MoP (X_5)	-0.029 (0.054)	-0.54	-.227	-0.002(0.0027)	-0.74	-.025
TSP (X_6)	0.209* (0.115)	1.81	.342	0.009(0.009)	1.00	.020
Irrigation (X_7)	0.193* (0.109)	1.77	.251	0.067** (0.031)	2.16	.161
Insecticide (X_8)	-0.011(0.366)	0.03	-.078	0.081***(0.018)	4.50	.585
R^2	0.809			0.795		
F-value	23.37			21.74		
Return to scale	0.27			0.58		

Source: Authors' estimation based on field survey, 2019-2021.

Note: *, ** and *** indicate significant at 10%, 5%, 1% level, respectively.

Table 6. Resource use efficiency of *Boro* rice production

Variables	GM	MVP	MFC	MVP/MFC	Comments
Favorable ecosystem					
Return	79819.6				
Labor	28136.3	2.519	450	0.005	Over-utilized
Seed	2053.5	11.025	40	0.275	Over-utilized
Power tiller	4696.1	-32.062	4955	-0.006	Over-utilized
Urea	3156.8	-16.577	16	-1.036	Over-utilized
MoP	520.7	-68.193	16	-4.262	Over-utilized
TSP	2245.2	115.225	22	5.237	Under-utilized
Irrigation	12595.4	18.918	552	0.034	Over-utilized
Pesticide	1125.5	-11.432	163	-0.070	Over-utilized
Submergence ecosystem					
Return	91603.8				
Labor	23367.9	2.959	400	0.007	Over-utilized
Seed	2122.5	3.611	40	0.090	Over-utilized
Power tiller	5930.9	55.827	6230	0.008	Over-utilized
Urea	3298.3	58.588	16	3.661	Under-utilized
MoP	194.4	-13.141	16	-0.821	Over-utilized
TSP	2388.9	5.705	22	0.259	Over-utilized
Irrigation	11067.9	8.607	400	0.021	Over-utilized
Pesticide	2385.2	48.336	166	0.291	Over-utilized

Source: Authors' estimation based on field survey, 2019-2021.

3.6 Efficiency of resource use of Boro rice production

Resource use efficiency implies how efficiently the farmer can use their resources in production process. For determining resource use efficiency, eight input factors namely human labor, seed, power tiller, Urea, MoP, TSP, irrigation and pesticide were considered. It is apparent from the Table 6 that farmers had chances of increasing per hectare output of *Boro* rice by utilizing more TSP and Urea at favorable and submergence ecosystems. The study also found that farmers had no scope for the enhancement of yield by utilizing more labor, seed and irrigation as favorable ecosystem as well as submergence ecosystems.The ratio for power tiller, urea, MoP and pesticide under favorable ecosystem was negative which means additional input of these two factors bring no benefit but incur losses. Excessive supply of inputs was the one explanation for the farmer's overutilization of inputs. Another reason was the absence of proper knowledge on efficient resource management. The result was similar to Osti *et al.* (2017) where the authors exposed that organic manures, potassium fertilizer and human labor were over utilized and land was under-utilized in monsoon rice production. For spring rice, land and seed were under-utilized and potassium fertilizer, human labor and irrigation were over utilized.

3.7 Problems faced by the farmers producing Boro rice production

A range of problems were faced by the farmers in producing *Boro* rice in the study areas. The extent and frequency of the problems professed by the farmers was measured according to their perceptions. From farmers' experience point of view, six major problems were identified. It is evident that low price of paddy and lengthy water logging condition were the major problems which were ranked as 1st in both favorable and submergence ecosystems (Table 7). The findings seem to be consistent with Kamruzzaman and Uddin (2020) where authors found that lower price of output, early flash flood inundation and lack of short-duration and high-yielding variety were found the major constraints faced by the farmers in *haor* ecosystem.

Table 7. Problem facing index for *Boro* rice farmers

Identified problems	Frequently (3)	Occasionally (2)	Rarely (1)	Not at all (0)	PCI	Rank order
	Favorable ecosystem					
Scarcity of labor	22	9	6	3	90	3
High price, low quality and non-availability of inputs	20	7	8	5	82	5
Lack of short-duration and high-yielding variety	20	8	7	5	83	4
Low price of paddy	25	8	6	1	97	1
Lack of storage and transportation facilities	20	10	7	3	81	6
Lack of training and extension support	24	7	6	3	92	2

Identified problems	Frequently (3)	Occasionally (2)	Rarely (1)	Not at all (0)	PCI	Rank order
Submergence ecosystem						
Scarcity of labor	22	10	6	2	92	3
High price, low quality and non-availability of inputs	20	10	6	4	86	5
Lack of short-duration and high-yielding variety	18	12	5	5	83	6
Lengthy water logging condition	26	8	4	2	98	1
Low price of paddy	24	9	4	3	94	2
Lack of training and extension support	20	12	5	3	89	4

Source: Authors' estimation based on field survey, 2019-2021.

Note: Calculation of PCI score for the problem of scarcity of labor

PCI score of favorable ecosystem farmers = (22×3) + (9×2) + (6×1) + (3×0)= 90

PCI score of submergence ecosystem farmers = (22×3)+(10×2)+ (6×1) + (2×0)= 92

PCI scores for rest of the problems were computed accordingly.

4. Conclusion

The study concludes that *Boro* rice production resulted in the maximum profit for the farmers at submergence ecosystem compared to favorable ecosystem in the study areas. Functional analysis implied that farmers could be augmented their net return with more investment on labor cost, seed cost and irrigation cost at both favorable as well as submergence ecosystems. Though farmers inefficiently used their maximum resources, *Boro* rice could be efficiently produced by increasing the use of TSP at favorable ecosystem and Urea at submergence ecosystem. The study exposed that low price of paddy and lengthy water logging condition were the major problem for the production of *Boro* rice. Considering the findings of the study, some essential policy recommendations have been arisen which are: short-duration and stress-tolerant rice varieties should be made available for enhancing profitability considering the submergence agricultural environment; effective training and extension services should also be extended for proper and optimum resource utilization.

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