Cost-benefit (Productivity) Analysis of Rice Production: A Study in Trishal Upazila, Mymensingh, Bangladesh

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Abstract: This descriptive as well as analytical study is aimed to examine the costs and benefits of rice production of agriculture limited to rice production in 2020 in Trishal upazila of Mymensingh district in Bangladesh. Besides descriptive statistics, this study employs a multiple regression model to analyze primary data collected from the 100 farmers from the study area. Descriptive statistics reveal an average of 1.16-degree productivity with no variation in rice-type-wise productivity and a significant difference in farmer size-wise productivity statistics. The findings indicate that big farmers have more productivity of 1.19 while medium farmers have an average productivity of 1.16 and the small ones have the lowest productivity of 1.11. Analysis of the regression model finds a significant association between specific cost heads and total benefits and suggests that ploughing, transplanting, irrigation, and labor costs are significantly and positively able to explain the total benefits. Cost heads like fertilizers, seeding, harvesting and processing are positively but not significantly related to total benefit. Only the cost of pesticides is negatively associated with benefits meaning that an increase in pesticide cost negatively influences the benefits. This study will be helpful for farmers in using the costs associated with production and policymakers in formulating the necessary supervision and training model while future researchers will be beneficial to understand the cost-benefit trends in the studied area and carry the further research works.

Keywords: Agriculture, Rice cultivation, Cost, Benefit, Productivity

1. Introduction

Bangladesh is predominantly an agricultural country. The agriculture sector plays a vital role in accelerating the economic growth here. It is therefore

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important to have a profitable, sustainable and environment-friendly agricultural system in order to ensure food security and long-term nutrition capacity for people. Rice is an important cereal crop in the world and one-third food requirement of the world population is fulfilled by it (Ahmed et al., 2015). In total, 90% of the production and consumption of world rice accounts in Asia (Said et al., 2000) and the general conclusion is that Asia will continue to dominate the world rice economy (Chauhan et al., 2017). Rice is the primary food item for about 156 million people in Bangladesh (Shelley et al., 2016). Rice provides almost one-half of agricultural GDP, about one-sixth of rural household income, approximately half of rural employment, two-thirds of per capita daily calorie intake, and half of per capita daily protein intake (Bangladesh Rice Knowledge Bank BRKB, 2020). Studies done by Rahman et al. (2015) and Islam et al. (2017) have proven rice production as a profitable farming practice in Bangladesh. The topmost priority has been given to Bangladesh's broad agricultural sector in an attempt to make the country self-sufficient in food production.

But there are also realities of losing hope and profit by the farmers exploited in the hands of market mechanisms and syndicates. The proportion of agriculture to total Gross Domestic Product (GDP) has been decreasing over time. The causes of this decrease cannot be imposed on only population growth. There must have been a number of concerns that incidents of demotivation to cultivation are happening. In this study, this concern for profitability against the associated cost will be examined.

In recent times, farmers in Bangladesh from different locations signaled the below profitability reality. There have been shouts at times that farmers are not getting the appropriate price for the produced rice. Even, some farmers protested against the marketing syndicate that they thought was liable for this less selling price. Events got deteriorated when farmers from Kalihati and Basail upazila, Tangail set fire to their rice land due to low market prices and higher labor charges. The price per 40 Kg rice (1 mon) was only 500 to 550 taka. (Deutsche Welle; retrieved on 14-05-2019). The event of this fire setting got attention throughout the country. On 11th May 2019, the headline of news by Vhaluka.com revealed that, the farmers are rudderless and even one labor isn't available for a price of forty kg (one mon) paddy (www.valuka.com, retrieved on 20 May 2019). Why rice producers are getting demotivated that they even think to destruct the paddy in the field? The trend of this reality and the cost-benefit analysis of rice productivity in agriculture, thus, became significant both from academic and practical perspectives. This paper is undertaken to evaluate that aspect of rice productivity in 2020 in Trishal, a upazila in Mymensingh to have an understanding of whether the producers (farmers) have prospects to continue the production or lose thereof. Thus, the researchers aim to:

a) Measure the productivity of land, capital and labor inputs.

b) Analyze total and per acre, rice variety-wise and farmer size-wise productivity (cost-benefit) of rice production.

c) Measure the individual and combined effect of different cost heads on total rice productivity or sales.

Research questions:

To examine the productivity and cost-benefit of rice production researcher investigates the following questions:

- What is the productivity of intermediate inputs (land, labor and capital inputs) of rice production?
- What is the scenario of rice productivity and the impact of different cost heads on rice productivity or sales?

2. Literature Review and Hypothesis Development

Theoretically, cost-benefit analysis implies the detailing and appraisal of all the relevant costs and benefits (Prest & Turvey, 1965). It is the methodical and analytical process of comparing benefits and costs in assessing the desirability of a project or program and attempts to answer questions on the worth, scale and constraints of an undertaking (Mishan & Quah, 2020). Chanda et al. (2019) studied the variety-wise cost-benefit comparison in rice production in the Sirajganj district in 2017. Analyzing the benefit-cost ratio formula, the study revealed a positive relationship between cost and return on both gross and per kilogram basis for Aus and Aman rice. It was found that a 1.21 time increase in cost resulted in a 0.71 time increase in returns in total while it is 0.56 time increase per kg. production cost for Aus rice. Similarly, 0.36 time increase in cost resulted in a 0.26 time increase in returns in total while it is 0.43 time increase per kg. the production cost of Aman (Local) rice. For Aman (HYV), 0.86 time increase in cost resulted in a 1.09 time increase in returns in total while it is 0.46 time increase per kg. the production cost of Aman (Local) rice. In the current study, no variety-wise cost-benefit analysis has been done as the responses by farmers showed no significant differences.

Akter et al. (2019) analyzed the profitableness of rice production in major rice-cultivating regions of Bangladesh in 2016. They executed cost-benefit and component investigation of rice profitability. Utilizing three inputs of production namely power tiller cost, fertilizer cost and labor costs as constituents of the total cost, and found that the total benefits were higher than the total projected production cost causing rice cultivation as a cost-effective undertaking in our country.

Khushi & Tabassum (2018) examined farmers' attitudes and influencing factors towards rice production. 98 percent of farmers' perceptions were found favorable and socio-economic factors like level of education, occupation and farm size etc. were identified as the most influencing factors on the farmers' attitudes towards rice production.

Hussain (2013) analyzed seven rice varieties viz. JP-5, Basmati-385, Sara Saila, Swat-1, Swat-2, Dil Rosh-97 and Fakhr-e-Malakand by using benefit-cost ratios. The most beneficial variety was found to be Fakhr-e-Malakand, and then Basmati-385. The variables used for output ratio were selected in area, fertilizer, seed, labour, tractor hours, and pesticides and the ratios were found to be 31.12%, 0.120%, 59.24%, 62.12%, 51.24% and 0.13% respectively. The input-output affiliation embraced cumulative returns to scale.

Ingabire, et al. (2013) analyzed the distinct impact of the factors of production namely labor, land, and capital on rice production using the Cobb-Douglas production function. Besides, an analysis of costs and benefits popularly known as the CBA approach was used to estimate the profitable viability of rice farming. Results found the substantial effect of land and labor for a 5% profitability. On the other hand, seeds and fertilizers assumed as capital was found not to be significant. It was also found that only one category of farmers (big farms), among the three categories, had a positive Net Present Value (NPV).

Sarker & Hasan (2010) investigated the variations in expenses and revenues for the borrower farmers and non-borrower farmers. Results exposed that farmers borrowing from financial institutions used different variables along with common factors and acquired higher yields than the farmers who didn't borrow. The output for borrowers of rice per hectare was also found to be more than that of non-borrower farmers. The total margin and net margin were also 24% and 97% more than that of the non-borrowing farmers.

Banerjee (2009) measured per acre profit for rice and compare the result with that of jute. Linear trend equation and least square with dummy variable

(LSDV) method for estimation were used for the analysis. Time series data from 1979 to 2000 were analyzed and the result found a positive trend for both crops revealing a positive productivity trend in agriculture in Bangladesh.

Taufique (2005) investigated the association between farm size and output by studying the operation costs for laborers in a high-land area in Madhupur and a low-land area in Chandina. It was seen in Madhupur that farmers hired laborers on a task basis whereas, in Chandina, laborers were hired on a daily basis. Thus, in Madhupur transaction costs for labor were found lower in big farms resulting in greater output than in small farms. In Chandina, the excellence of monitoring by household workers fell when farm size increased. As a result, per acre production for big farms was lesser than small size farms. Mandal (1980) also conducted a similar study in the Mymensingh district and observed the opposite connection between cultivable land and output in the agricultural sector of Bangladesh. The study found that up to a range of 4 acres, the productivity increases and then, as the land size increases above that level, productivity falls down. However, the study suggested medium farms as more productive than small or large farms.

The earliest study evaluating the effect of individual inputs creating variances among large, medium and small farms was perhaps Abedin & Bose (1988) who tested this issue by using breakdown analysis and found a positive association between farm size and productivity. Farm or land size seems to be a factor for determining benefit from the production in those areas but whether this finding fits in the current study area of Trishal or not, the land size-wise comparative analysis has been tried.

Lakho et al. (2004) conducted a study in a student experimental farm taking urea as inorganic nitrogen fertilizer while as the organic compost, buffalo manure was applied. The results showed the mixture of 25:1 buffalo manure and urea was found to give better production output, gross revenue, net benefit and Benefit Cost Ratio (BCR) compared to other blends of fertilizers. This result was suggested to be the best blend of fertilizers for getting a higher yield. In this paper on cost-benefit analysis, no blend or mix of such manure has been tried. No organic or inorganic fertilizer comparison has been used in the current analysis.

Hossain (1990) studied major crops with respect to sustaining progress and analyzed the differences in productivity among crops in various areas of Bangladesh based on the data for a period of 37 years. Poor productivity of individual crops was found indicating disappointing growth in gross output.

The proper use of fertilizer and irrigation for boosting productivity was suggested. By considering the comparative influence of individual ingredients, it was found that expanded cultivable land area had the greatest impact on the positive change in Boro rice. In this paper also, it was applied to see if there exists any relation between cultivable land size and production.

Hossain (1988) examined the impact of land and labor work processed with technology using cross-sectional analysis of data and suggested that the acceptance of up-to-date technology might help farmers increase their net returns. In our study, the technological aspects were ignored as it was seen that farmers, more or less use the same technology and processes for production.

By taking a sample of 95 farms, Hossain (1973) conducted a study on 95 in Phulpur, Mymensingh. Both partial factor productivity (PFP) and total factor productivity (TFP) analysis were done and the results revealed that land and labor productivity was the highest for 2.5 to 5-acre land compared to the productivity of land and labor in large farms cultivating above 5 acres. It was also suggested that adding to a limited extent of land in small farms might be able to increase the productivity and growth of agriculture.

In the current study, the variables taken to capture the total cost of production and the benefits associated were chosen from various studies namely Akter et al. (2019) where power tiller cost, fertilizer, seeding, irrigation, pesticides, interest in operating capital and labor costs were used, from Ingabire, et al. (2013) where three cost heads namely land, labor and capital including the cost of fertilizers and seeds, from Ahmed et al. (2015) where ploughing, puddling, seeding, bedding, maintenance, pulling, fertilizers, transplanting, irrigation, insecticides, weedicides, harvesting, threshing and cleaning were used as the inputs and paddy and straw yield were used as output, from Chanda et al. (2019) where fertilizer, seeding, ploughing, transplanting, irrigation, weeding, pesticides, harvesting, processing, bank interest have been used for measuring cost and rice and straw sales have been used for measuring benefits. In this paper, Fertilizer cost, seeding cost, ploughing cost, transplanting cost, irrigation cost, pesticide cost, harvest and process cost, labour and other cost have been developed for measuring the total cost as these variables could cover all the costs associated with rice production and rice and straw sales have been taken to measure the benefits.

Existing research studies reviewed here on rice agriculture have not fully devoted to finding out the area-based trend of productivity and cost-benefit ratio with a specific point of view of land, labor, capital and intermediate inputs. In the zones of the Mymensingh division, the stated realities and incidents of continuous mistrust among farmers have raised the importance to analyze the cost-benefit scenario in this locality. Thus, this paper tries to have an actual picture of this phenomenon and bridge the studies done earlier.

To show the impacts of cost heads on total rice productivity we also formulate the following hypotheses:

H1: Cost of fertilizer is positively associated with benefits (Sales)

H2: Cost of seeding is positively associated with benefits (Sales)

H3: Cost of plowing is positively associated with benefits (Sales)

H4: Cost of transplanting is positively associated with benefits (Sales)

H5: Cost of Irrigation is positively associated with benefits (Sales)

H6: Cost of pesticide is positively associated with benefits (Sales)

H7: Harvest and Process Cost is positively associated with benefits (Sales)

H8: Labour and other cost is positively associated with benefits (Sales)

3. Methodology

3.1 Sample selection and data collection

Primary data collected during the year 2020 from Trishal upazila in Mymensingh district were mainly used in this study. Trishal Municipality is divided into 12 union parishads. 10 farmers from each union parishad were randomly selected totaling 120 farmers as respondents. Due to errors, we removed 20 data, and finally, 100 data were selected for analysis purposes. Primary data were collected through face-to-face interviews and questionnaire surveys from the sampled respondents of different villages of Trishal upazila. The questionnaire which is annexed with the appendix below involves two parts; the first part covers demographic information, and the second part includes information about the different costs and production of rice. Questionnaire was first prepared in English, and then it was translated into Bengali to make easily understandable to the respondents.

3.2 *Rice variety and land, labor and capital productivity*

We studied two types of rice; Aus and Boro, and the total land size was 73 Acres where the farmer size was categorized into three groups from the viewpoint of their cultivable land. It is due to see if there exist any significant difference among the profits produced from different size of cultivable land (Ingabire et al., 2013). Farmers producing in land size from 0.1 acre to 0.50 acre are categorized in category 1, from land size 0.51 to 1.00 acre are put in category 2 and from 1.00 to above acre belong to category 3. Ingabire et al. (2013) considered fertilizers and seeds as the capital employed for rice production. Besides these two variables, the cost of ploughing, transplanting, irrigation, pesticides, harvesting and processing are also used as the capital employed in this study. Labor productivity is measured by the number of persons worked for producing the rice. The total amount spent for labor for each farmer is divided by the average market price for labor and thus the number of laborers has been calculated for each piece of cultivated land.

3.3 Model and variables

Our main endeavor is to conduct a cost-benefit analysis. To achieve the objective, a research model represented in Figure 1 was proposed. Total benefits are measured by the sum total of straw sales and rice sales and hence, the total sales were taken as a dependent variable. Based on reviews of prior literature, eight independent variables were selected; fertilizer, seeding ploughing, transplanting, irrigation, pesticide, harvest and process, and labour and other costs and these are valued at their current market prices in total cost calculations.

Research Model

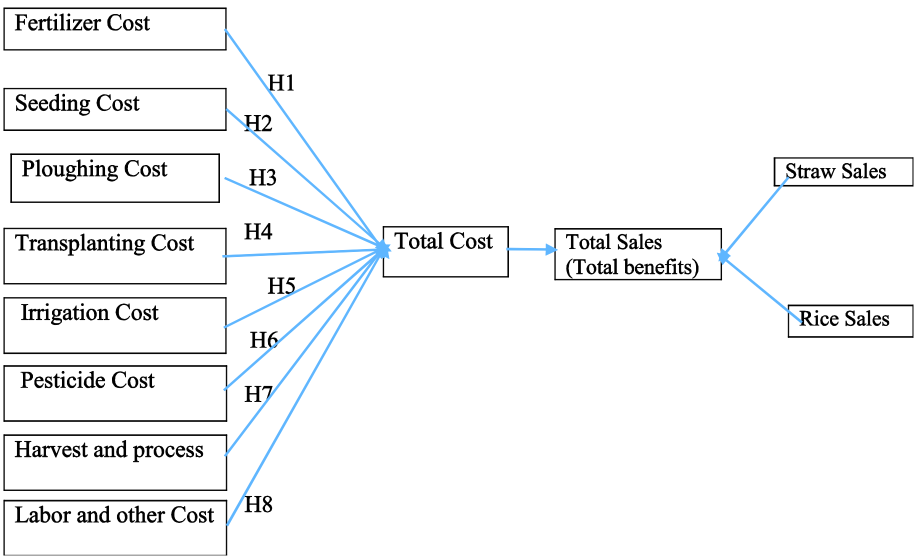

Figure 1: Research Model

We developed the following regression model to conduct the standard multiple regression analysis for testing the hypotheses (Agyei-Mensah, 2012):

$Y = a + \beta 1 X_1 + \beta 2 X_2 + \beta 3 X_3 + \beta 4 X_4 + \beta 5 X_5 + \beta 5 X_6 + \beta 5 X_7 + \beta 5 X_8 + e$

Y = Total benefits (Total Sales)

a = constant

X_1= Fertilizer cost

X_2 = Seeding cost

X_3 = Ploughing cost

X_4 = Transplanting cost

X_5= Irrigation cost

X_6= Pesticide cost

X_7= Harvest and process cost

X_8= Labour and other cost

e = error term.

3.4 Constructs Development

We followed quantitative approach in our study and used eight specific cost heads as constructs to measure total costs. All constructs such as fertilizer cost (Akter et al., 2019; Chanda et al., 2019), seeding cost (Akter et al., 2019; Chanda et al., 2019), plowing cost (Ahmed et al., 2015; Chanda et al., 2019), transplanting cost (Ahmed et al., 2015; Chanda et al., 2019), irrigation cost (Akter et al., 2019; Ahmed et al., 2015; Chanda et al., 2019), pesticide cost (Akter et al., 2019; Ahmed et al., 2015; Chanda et al., 2019), harvest and process cost (Ahmed et al., 2015; Chanda et al., 2019), and labour (Ingabire et al., 2013) and other costs (interest and other costs included) were taken from these studies and then adapted into the research model. The benefit heads straw sales and rice sales are constructed according to the studies by Ahmed et al. (2015) and Chanda et al. (2019). The constructs were measured on the basis of the specific cost heads and benefits for each farmer's cultivable land.

3.5 Data analysis tools

SPSS software and several sets of statistical analyses were employed to work over the collected data from the respondents. Descriptive statistics were applied to demonstrate cost structure, land productivity, labor productivity, capital productivity, and total and per unit, cost-benefit of rice production based on rice variety and land (farmer) size. To assess the per-acre cost-benefit of rice production the following equation was utilized.

$$\pi = PR + PS - \sum(PXi)$$

Where, π = net profit per acre of rice production, PR = per acre price of rice (BDT/ Kg), PS = per acre sales price of straw (BDT/), PXi = per acre cost of i-th input used, i = (1, 2, 3……. n); Moreover, to measure the impact of cost heads associated with production and process (independent variables/ predictors) on total production benefits from the sale of rice and straw (dependent variable/ residual), multiple regression model demonstrated above was performed using SPSS software.

3.5 Reliability and validity of data

The convergent and divergent validity was checked using Cronbach's alpha, tolerance, and variable inflation factor (VIF), Mahalanobis distance and Cook's distance. The convergent validity was ensured with Cronbach's alpha, tolerance, and variable inflation factor (VIF) techniques whereas the divergent validity of data was achieved with Mahalanobis distance and Cook's distance.

4. Findings and Analysis

4.1 Descriptive statistics

Cost structure: To measure the cost structure of rice production in Trishal upazila, eight heads regarding costs associated with the production were used. The selection of these heads was finalized based on queries from the local farmers and other studies such as Chanda. et al. (2019), Akter et al. (2019) and others. The cost structure comprised fertilizer, seeding, ploughing transplanting, irrigation, pesticide, harvest and process, labor and others. It is seen from Table 1 that cost the of harvesting and processing, and the cost of labor and others comprise the major cost for rice production while the cost of seeding and pesticides cover the minimum costs. Costs for ploughing, transplanting and irrigation remain average for rice production.

Table 1: Total Cost for Specific Cost Heads

Fertilizer	Seeding	Ploughing	Transplanting	Irrigation	Pesticide	Harvest & Process	Labor & others
440854	167300	261727	304500	288054	89010	652350	818980

Source: Computed from the data collected from the questionnaire

Land productivity: Land productivity is measured revealing 2028 Kgs per acre. A total of 73 acres of land has been used in the study in which a total of 1,47,080 Kg of rice was found to be produced. However, per acre productivity with respect to the sales price in Tk. is found to be 48,571 Tk.

Table 2: Land Productivity (Per Acre and Tk.)

Cultivable Land	Total Production	Production Per Acre (Kg.)	Benefit Per Acre (Taka)
72.51 acre	147080 kg.	2028 kg.	48,571

Source: Computed from the data collected from the questionnaire

Capital Productivity: It is found that the quantity productivity is 0.641 Kg meaning that 1 Tk. can produce 64 grams of rice while with respect to the sales price of that output, 1 Tk. yields 1.508 Tk.

Table 3: Capital Productivity Kg. and Tk.

Total Production	Total Sales	Capital Employed	Capital Productivity (Kg.)	Capital Productivity (Tk.)
147080 Kg	32,21,950 Tk.	22,03,795 Tk.	0.066 Kg.	1.598 Tk.

Source: Computed from the data collected from questionnaire.

Labor productivity: It is found that each person contributed 90 Kgs of rice yielding a total of 2150 Tk.

Table 4: Labor Productivity Kg. and Tk.

Total Production	Labor Unit	Labor Productivity (Kg.)	Labor Productivity (Tk.)
147080 Kg.	1638 Person	90 Kg.	2150 Tk.

Source: Computed from the data collected from the questionnaire

Total and Per Acre Cost- Benefit: A total of 72.51-acre land area is used for the study. It is found from the data analysis shown in the table the total cost with respect to rice production is not profitable at all in Trishal upazila. But a handsome amount of the total process comes from the by-product straw. When added to the rice sales proceedings, straw provides a productive meaning and profitable amount.

Table- 5: Total and Per Acre Cost- Benefit

Particulars	Total Tk.	Tk. Per Acre
Cost of fertilizer	4,40,854	6,080
Cost of seeding	1,67,300	2,307
Cost of plowing	2,61,727	3,610
Cost of transplanting	3,04,500	4,200
Cost of Irrigation	2,88,054	3,973
Cost of pesticide	89,010	1,228
Cost of harvesting and processing	6,52,350	8,997
Cost of labor and others	8,18,980	11,295
Total cost of production (PXi)	**30,22,775**	**41,690**
Sales from rice (PR)	29,50,850	40,696
Sales from straw (PS)	5,71,100	7,876
Total benefit	**35,21,950**	**48,572**
Net benefit (π)	**4,99,175**	**6,882**
Rice productivity (R)	0.98	0.98
Straw productivity (S)	0.18	0.18
Productivity (R+S)	**1.16**	**1.16**

Rice Variety-wise Total and Per Acre Cost- Benefit: It is evident from Table 6 that there has been seen no significant difference in benefit and productivity for producing Boro or Aman rice in Trishal. The productivity is almost the same with respect to both types of production. Since Aman rice is produced in the rainy season, the cost of irrigation decreases to an important extent.

Table 6: Rice Variety-wise Total and Per Acre Cost- Benefit

Particulars	Boro (56.76 acres)		Aman (15.75 acre)	
	Total Tk.	Tk. Per Acre	Total Tk.	Tk. Per Acre
Cost of fertilizer	3,74,254	6,594	66,600	4,229
Cost of seeding	1,25,200	2,206	42,100	2,673
Cost of ploughing	2,03,727	3,589	58,000	3,683
Cost of transplanting	2,51,500	4,431	53,000	3,365
Cost of Irrigation	2,78,054	4,899	10,000	635
Cost of pesticide	73,660	1,298	15,350	975
Cost of harvesting and processing	5,52,650	9,737	99,700	6,330
Cost of labor and others	6,92,880	12,207	1,26,100	8,006
Total cost of production (PXi)	**25,51,925**	**44,961**	**4,70,850**	**29,898**
Sales from rice (PR)	25,32,550	44,960	4,18,300	26,559
Sales from straw (PS)	4,41,400	7,777	1,29,700	8,235
Total benefit	**29,73,950**	**52,737**	**5,48,000**	**34,794**
Net profit (π)	**4,22,025**	**7,776**	**77,150**	**4,896**
Rice productivity (R)	1.0	1.0	0.89	.89
Straw productivity (S)	0.17	0.17	0.27	0.27
Productivity (R+S)	**1.17**	**1.17**	**1.16**	**1.16**

Farmer Size-wise Total and Per Acre Cost- Benefit: It is seen from the result that large farmers belonging to category 3 have the greatest net profit and productivity amounting to 1.19 which is higher than the average productivity rate (1.16) of the study. Medium farmers fulfil the average productivity rate of 1.16 while small farmers experience less productivity (1.11) than the average productivity (01.16). This means that big farmers have more profitability or benefit than smaller ones. Therefore, it can be summed up that big farmers tend to have more profit in rice production than medium and small ones.

Table-7: Farmer Size-wise Total and Per Acre Cost- Benefit

Particulars	Small Farmers (0.1-0.50 acre) Total 10.53 acre		Medium Farmers (0.51-1.00 acre) Total 30.66 acre		Large Farmers (1 acre and above) Total 31.32 acre	
	Total Tk.	Tk. Per Acre	Total Tk.	Tk. Per Acre	Total Tk.	Tk. Per Acre
Cost of fertilizer	58,954	5,599	1,99,200	6,497	1,82,700	5,833
Cost of seeding	29,150	2,768	70,150	2,288	68,000	2,171
Cost of plowing	40,327	3,830	1,00,700	3,284	1,20,700	3,854
Cost of transplanting	38,900	3,694	1,50,500	4,909	1,15,100	3,675
Cost of Irrigation	35,154	3,338	1,21,900	3,976	1,31,000	4,183
Cost of pesticide	13,600	1,292	34,910	1,139	40,500	1,293
Harvesting and processing	98,100	9,316	3,11,800	10,170	2,42,450	7,741
Cost of labor and others	1,34,400	12,764	3,73,980	12,198	3,10,600	9,917
Total cost of production (PXi)	**4,48,585**	**42,601**	**13,63,140**	**44,461**	**12,11,050**	**38,667**
Sales from rice (PR)	4,05,600	38,519	13,13,700	42,847	12,31,550	39,322
Sales from straw (PS)	90,400	8,585	2,67,100	8,712	2,13,600	6,820
Total benefit	**4,96,000**	**47,104**	**15,80,800**	**51,559**	**14,45,150**	**46,142**
Net profit (π)	**47,415**	**4,503**	**2,17,660**	**7,098**	**2,34,100**	**7,475**
Rice productivity (R)	0.904	0.904	0.964	0.964	1.017	1.017
Straw productivity (S)	0.202	0.202	0.196	0.196	0.176	0.176
Productivity (R+S)	**1.11**	**1.11**	**1.16**	**1.16**	**1.193**	**1.193**

4.2 Regression analysis

We performed a regression analysis on the dependent and independent variables to examine whether multicollinearity existed in the model. Multicollinearity happens in a regression model when the independent variables are highly co-related to each other meaning that variables are homogeneous in nature.

Table 8: Results of Multicollinearity Statistics

Multicollinearity Statistics		
Variable	Tolerance	VIF
Fertilizer Cost	.249	4.011
Seeding Cost		
Ploughing Cost	.135	7.404
Transplanting Cost	.241	4.145
Irrigation Cost	.262	3.810
Pesticide Cost	.319	3.132
Harvest and P		
Labor and other Cost	.265	3.770

According to Neter & Ben-Shakhar (1989) when the tolerance is less than 0.1 and the variable inflation factor (VIF) score is above 10, the data violates the collinearity assumption. Table-5 above reveals that the tolerance score of independent variables ranges from 0.135 to .345 and the VIF score ranges from 2.896 to 7.404 which confirms that the model is free from multicollinearity problems and is valid for the data analysis.

Table 9: Measurement of cook's distance

Residuals Statistics					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	9079.2715	140255.2656	34359.5000	24756.34233	100
Std. Predicted Value	-1.021	4.278	.000	1.000	100
Standard Error of Predicted Value	1434.765	9654.872	2684.970	1499.821	100
Adjusted Predicted Value	9233.9912	160553.2031	34765.7625	26804.50047	100
Residual	-41078.51562	36760.04688	.00000	9816.94907	100
Std. Residual	-4.012	3.590	.000	.959	100
Stud. Residual	-4.488	3.814	-.011	1.065	100
Deleted Residual	-51408.20312	41490.65625	-406.26253	12560.24195	100
Stud. Deleted Residual	-5.058	4.138	-.013	1.116	100
Mahal. Distance	.954	87.030	7.920	12.575	100
Cook's Distance	**.000**	**.937**	.041	.141	100
Centered Leverage Value	.010	.879	.080	.127	100
Dependent Variable: Total Sales					

Mahalanobis distance was used to measure divergence in the data groups in terms of multiple characteristics (McLachlan, 999). The recommended value for eight independent variables is 26.13 (Statistical value table), while in this analysis, four samples from the dataset were found as outliers to exceed the critical value. The Cook's distance which measures extreme or undue effects of one or more observations in a regression model (Kim et al., 2001) was used to examine the effects of such outliers where the maximum Cook's distance proves the outlier samples to be not significantly effective as the cook's value is found less than the recommended value of 1.00

Table 10: Regression results and hypothesis testing

Hypothesis	Variable	Beta	t-value	Sig.	Test Results
H1	Fertilizer Cost	-.107	1.409	.171	Not Supported
H2	Seeding Cost	-.060	-1.380	.366	Not Supported
H3	Plowing Cost	.556	-.909	<.001	Supported
H4	Transplanting Cost	.449	5.292	<.001	Supported
H5	Irrigation Cost	.310	5.704	<.001	Supported
H6	Pesticide Cost	-.326	4.114	<.001	Supported
H7	Harvest and Process Cost	-.090	-4.761	.315	Not Supported
H8	Labor and other Cost	.264	-1.010	<.001	Supported

Results of the multiple regression along with the hypothesis test result in Table 10 above support H3, H4, H5, and H8. That is, the cost of ploughing, transplanting, irrigation, pesticide and labor, and others have a significant individual impact of 0.55, 0.44, 0.31, 0.32, and 0.26 percent respectively on total benefit, whereas fertilizers, seeding and harvest and processing cost have no significant impact on benefits.

Table 11: Regression model result summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.930[a]	.864	.852	10239.37478
Predictors: (Constant), Fertilizer, Seeding, Ploughing, Transplanting, Irrigation, Harvest and Process, Pesticide Labour and others				
Dependent Variable: Total Sales				

Table 12: Significance summary of the model

ANOVA					
Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	60674772051.934	8	7584346506.492	72.339	<.001
Residual	9540876423.066	91	104844795.858		
Total	70215648475.000	99			
Dependent Variable: Total Sales					
Predictors: (Constant), Fertilizer, Seeding, Ploughing, Transplanting, Irrigation, Harvest and Process, Pesticide Labour and others.					

It is seen from the model summary that; the independent cost variables significantly assume the total benefit from sales. It reveals that cost heads have a combined 85 percent impact on total benefit. The ANOVA table value of <0.001 also shows the significance of the model showing a less than 0.05 level of significance.

5. Major Findings

The analysis finds a significant productivity trend in rice cultivation in the study area. Rice cultivation in Trishal upazila is productive at least to the extent of 1.16 tk. The major costs in rice cultivation occur for harvesting and processing, and labor costs, while the minimum cost for rice cultivation occurs pesticides. 83% of the total benefit comes from rice sales and the rest is from straw sales and the cost per kg. of rice is tk. 20.55 whereas the benefit per kg. is tk. 24 including straw sale. The average benefit-cost ratio (BCR) is 1.16 meaning for 1 taka of cost there yields a 1.16-taka benefit from rice cultivation. Land productivity is 1.51 and land production per acre is 2028 kg and benefit per acre is 48571 tk. whereas Capital productivity is 1.60 and labor productivity per labor is 90 kg. and 2150 tk. Boro rice and Aman rice productivity is almost the same revealing 1.17 and 1.16 respectively meaning there is no significant difference in the type of rice cultivation. Big farms having more than one acre of land have more productivity than that medium (0.51-1.00 acre) and small farms (0.1-0.50 acre). Small farms have the lowest level of productivity (1.11) whereas medium ones have the average level of productivity (1.16). The cost of ploughing, transplanting, irrigation, and labour have a significant impact on total benefit and thus can be used to explain the trend of profitability. (Akter et al., 2019). The cost of fertilizers, seeding, harvesting and processing doesn't have a significant impact on total benefit and cannot explain variations in returns. The cost of pesticides negatively affects benefit function and will not be able to assume in considering the benefit variations. (Akter et al., 2019)

6. Discussion

The soil in Bangladesh is fertile and diverse enough to produce different varieties of agricultural crops among which rice is the most prominent and provides the major source of food demand for the population. But in recent times there has seen a difficult scenario of the farmers who were claiming repeatedly in times to suffer losses in rice production in different areas in the country among which the districts namely Tangail and Mymensingh got attention. This study attempts to look into this reality closely and tries to analyze the costs and benefits associated with rice production in Trishal upazila located in Mymensingh district and examines the various cost heads that are influential to explain the output and benefits. The findings also reveal the reality that productivity is positive although to a little extent. In descriptive statistics, the big farmers' productivity found in Trishal is 1.19 which is consistent with other studies like Akter et al. (2019) and Ingabire et al. (2013). This implies that big farmers tend to have more profit than smaller ones. Findings also showed that there is no significant difference in rice variety-wise productivity which is somewhat inconsistent with another study like Chanda et al. (2017) meaning that the variety of rice will not produce any significantly different profit. Akter et al. (2019) found fertilizer as a concerning factor, however, in this study, fertilizers, seeding, harvesting and processing are found with no impact on the benefits. Besides some cost heads like ploughing, transplanting, irrigation, and labor are found to be positively significant which is consistent with the findings on labor and land by Ingabire et al. (2013), meaning that these costs if utilized will positively influence the benefits. Costs like fertilizers, seeding, harvesting and processing cannot explain the trend of productivity meaning that these costs will ultimately not influence benefits. No study is consistent with the result of the cost of pesticide that negatively impacts benefits so this variable should also be taken as an important factor for production and be used attentively.

7. Practical and Managerial Implications

Overall, this study shall be helpful for the farmers to understand the trend of productivity of rice and in practice, this understanding shall help to implement the total production process more efficiently. Policymakers may also take the findings as important and formulate the agricultural policy to ensure effective use of the cost heads. Hope, this study be useful for the stakeholders associated with agriculture and that the trend of carrying the knowledge will go on. Future researchers can conduct the study and expand on other parts in greater detail to investigate the benefits and drawbacks of particular heads, tools, and procedures.

8. Conclusion and Recommendations

This study suggests several significant recommendations. Firstly, it should be tried to reduce the cost of harvesting and processing, and labor. Secondly, the by-product straw has a prospect to contribute to profit suggesting the initialization of newer markets and uses of straw. Thirdly, it is also recommended to try to cultivate in big land areas as big farms are more productive than smaller ones. Joint farming covering large areas can be more profitable. Special attention should be given to using pesticides as it significantly reduces the benefit. Finally, importance should be given to the cost of ploughing, transplanting, irrigation, pesticide and labor, and farmers should be trained to become more skilful in using ploughing, transplanting and irrigation.

Note: Following Akter et al. (2019), we regarded farmers cultivating land sizes of 0.01–0.50 acres as small farms, 0.51–1.00 acres as medium farms, and 1.00 and above acres as big farms.

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Appendix 1

Serial No ক্রমিক নম্বর:	Particulars বিষয়বস্তু	Details বিস্তারিত
1	Name (নাম):	
2	Total cultivable land (উৎপাদনে ব্যবহৃত জমির পরিমাণ)	
3	Total Production (মোট উৎপাতিদ ধানের পরিমাণ):	
4	Do you have your own land? (নিজের জমিতে উৎপাদন করেন কি না):	
5	What kind of rice do you produce (কোন জাতের ধান উৎপাদন করেন):	
6	How many times in a year do you produce (এক বছরে কত বার উৎপাদন করেন):	
7	How much you spend for fertilizer (সার বাবদ মোট ব্যয়):	
8	How much you spend for seeding (বীজ বাবদ মোট ব্যয়):	
9	How much you spend for plowing (হাল চাষ বাবদ মোট ব্যয়):	
10	How much you spend for transplanting (ধান গাছ বাবদ মোট ব্যয়):	
11	How much you spend for irrigation (সেচ বাবদ মোট ব্যয়):	
12	How much you spend for pesticide (কীটনাশক বাবদ মোট ব্যয়):	
13	How much you spend for weeding harvesting and processing, (আগাছা পরিষ্কার এবং ফসল তোলা/সংগ্রহ এবং প্রক্রিয়াকরণ বাবদ মোট ব্যয়):	
14	How many and how much you spend for labor (লেবার বাবদ আপনি কত খরচ করেন):	
15	Total Sales amount of rice/Sales per Kg (মোট ধান বিক্রি/ প্রতি কেজি):	
16	Total straw sales amount (মোট খড় বিক্রি):	

Questionnaire for productivity analysis (cost-benefit) in Trishal Upazila, Mymensingh.

Appendix 2

Table: Collinearity Statistics check

Coefficients												
Model	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta	T	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
(Constant)	-24.93	96.959		-.257	.798	-217.3	167.50					
Land quantity	465.88	187.66	**.186**	2.483	**.015**	93.421	838.34	.777	.244	.112	**.363**	**2.75**
Total cost	.038	.004	**.740**	9.885	**<.001**	.031	.046	.889	.708	.446	**.363**	**2.75**

Dependent Variable: Total production (kg)

Appendix 3

Collinearity Statistics check

Coefficients													
Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
2	(Constant)	3128.112	2219.567		1.409	.162	-1280.786	7537.010					
	Fertilizer	-.668	.484	-.107	-1.380	.171	-1.630	.294	.746	-.143	-.053	**.249**	**4.011**
	Seeding	-1.256	1.382	-.060	-.909	.366	-4.000	1.489	.455	-.095	-.035	**.345**	**2.896**
	Plowing	5.952	1.125	**.556**	5.292	**<.001**	3.718	8.186	.812	.485	.204	**.135**	**7.404**
	Transplanting	4.957	.869	**.449**	5.704	**<.001**	3.230	6.683	.788	.513	.220	**.241**	**4.145**
	Irrigation	2.526	.614	**.310**	4.114	**<.001**	1.306	3.746	.711	.396	.159	**.262**	**3.810**
	Pesticide	-6.408	1.346	**-.326**	-4.761	**<.001**	-9.082	-3.735	.579	-.447	-.184	**.319**	**3.132**
	Harvest and Process	-.581	.575	-.090	-1.010	.315	-1.724	.562	.695	-.105	-.039	**.187**	**5.338**
	Labor and other	.955	.271	**.264**	3.525	**<.001**	.417	1.494	.742	.347	.136	**.265**	**3.770**

Dependent Variable: Total Sale