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Profitability and Resource Use Efficiency of Maize Production in Changing Farming System and Its Implication in Household Food Security

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Abstract *The study was undertaken to investigate the profitability and resource use efficiency of maize production and implication of maize in household food security under changing farming system in Lalmonirhat district of Bangladesh. Sixty farms of different sizes constituted the sample of the study and both descriptive and econometric techniques were used to analyze the collected primary data. The existing farming system experienced major changes though they were not the same for all the sub-systems. Maize is a highly profitable crop irrespective of farm categories and profitability was the highest for small farms followed by large and medium farms. Maize is also a labor intensive technology. Irrigation, manure and credit were the most important variables influencing maize production positively and significantly while seed cost was the negatively influencing variable in this direction. Irrigation, manure and insecticide were found to be the efficiently used resources in production of maize where seed was an overused resource irrespective of farm categories. The respondents also used some resources more than their required amount in order to derive higher profit. Food security was found positively related with farm size while a negative relationship was found between farm size and contribution of maize in household food security. Maize farming brought a positive contribution to household food security in the study area, particularly for smaller farm households who are generally vulnerable in the case of food security.*

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1. Introduction

Farming system is a unique arrangement of enterprises that the households manage to achieve a pre-determined goal in accordance with well defined practices (Shaner *et al.,* 1982). Farming system is a dynamic concept and it depends on the ability of farmers, availability of input, market potential of output, etc. Profitability indicates the ability of an enterprise to generate income in excess of cost while the resource use efficiency generally means generating optimum output avoiding both over and under use of scarce resources. Profitability and efficiency are two important things to be considered in a farming system. Maize is the third most important grain crop in the world. It is introduced as relatively a new crop in the cropping patterns of Bangladesh especially in the northern region. It is a versatile crop with genetic variability enabling it to grow successfully throughout the world covering low and tropical, subtropical and temperate agro climatic conditions. Most countries of the Asia pacific region grow maize.

Though maize is relatively a new crop in Bangladesh, it has an enormous market potential. It has multiple uses as every part of the plant is used in one form or the other. Grain can be used for human consumption in various ways, such as, corn meal, fried grain and roasted cob or popped and corn flour; stem and foliage of maize plant can be used as green crop, hay, silage and pasture to feed livestock; stalk and dry leaves covering of cobs and shelled cobs can be used as fuel; etc. (Chowdhury and Islam, 1993). Maize meal provides more calories and vitamin.

Food security is availability of sufficient food of choices of all people at all times along with necessary purchasing power (Ahammed, 2009). To attain food security in Bangladesh, diversification side by side increasing yield and production is essential. As comparatively a new enterprise, maize certainly can play an important role in this diversification. Cultivation of maize has also been contributing significantly to the poverty reduction and achieving economic self-reliance by the poor in recent years in the region, including the vast char areas where large-scale maize farming has become possible. Maize has a great prospect for being established as a popular crop. After rice and wheat, it is a major cereal crop to reduce shortage of food, poultry feed and malnutrition. In terms of protein, carotene and oil content, maize is much better than rice. It is obvious that if rice is partially replaced by maize in the diet, protein intake will be increased. Maize is highly acceptable due to low cost and higher yield than rice and wheat (Huda, 2013).

Northern Bangladesh is a risk prone region of the country and Lalmonirhat district is one of the riskiest areas of this region. But in recent years maize has become one of the popular crops of this area though it is a new crop in the existing farming system. A good number of people, including producers, laborers, traders, etc., are involved directly and indirectly with maize production, processing and marketing. So, maize has certainly an implication for food security of Bangladeshi people in grass roots level. Thus issues like cost, return, profitability, resource use, etc. of maize production need be addressed properly. But studies regarding these are very few. Therefore, this study is expected to provide valuable information that might be useful for formulating appropriate policy for widespread cultivation of maize in the study area and the country as a whole. The maize producers, development organizations and policy are expected to benefit from the study. The present study seeks to achieve the following specific objectives:

a) to identify the major changes in existing farming system in the study area
b) to determine profitability and returns to scale of maize production and contributions of key variables in the production process
c) to study resource use efficiency in maize farming
d) to investigate the implication of maize in household food security of the respondents.

2. Methodology of the Study

Five villages with similar physiographic characteristics of two unions, i.e., Tongvanga and Singimari, of Hatibanda upazila of Lalmonirhat district were the area of the study where maize is an emerging and popular crop. Depending upon farm size, 60 maize producers were randomly selected from the prepared list among which 35 were small, 15 were medium and the rest 10 were large farmers. Primary data were collected following survey method during August to October 2012 and the period of the study was 2011. Both descriptive statistics and econometric method were employed to analyze the collected data as mentioned below.

a. Gross margin was calculated by deducting total variable cost from gross return while net return was the difference between total return and total cost. Again, returns to scale was determined by summing up the regression coefficients, and undiscounted benefit cost-ratio (BCR) was calculated by dividing gross benefit by gross cost.

b. Interest on operating capital (IOC) was calculated by using the following formula (Main and AL-Imran, 2005):
IOC= AI×i×t
Where, AI= average investment = (total investment)/2, i= rate of interest and t=length of crop period (months).

c. The standard way to examine efficiency of resource allocation is to compare marginal value product (MVP) with the marginal factor cost (MFC) of each variable input. The optimum use of a particular input would be indicated by the condition of equality of MVP and MFC, i.e., MVP/MFC = 1 (Dhawan and Bansal, 1977).

If (MVP/MFC) is greater than 1, the resource is sub-optimally used and the gross return could be increased by using more of the resource. If it is less than 1 the resource is over used and the excess use of resource should be decreased to minimize the loss. The MVPs were computed from the estimated production elasticity by using the following method:

where, b_i= regression coefficient (i=1,2,3,.....,n), X_i=geometric mean of X_i variable and Y=geometric mean of gross return.

The above equation can be written as:
$dY/dX_i=b_i. Y/X_i$
where, dY/dX_i= slope of the production function.

Hence the MVPs indicate the value product in taka, per taka input cost expresses the ratio of MVP and MFC.

(d) In order to estimate the effects of key variables in the maize production, Cobb-Douglas form of production function (Gujarati, 2003) was used in modified form. The specification of the function was as follows:
$Y_i= aX_1^{b1} X_2^{b2}X_3^{b3}X_4^{b4} X_5^{b5}X_6^{b6}X_7^{b7} X_8^{b8}X_9^{b9} e^{ui}$
In the log linear form it can be written as:
$InY= lna+b_1lnX_1+b_2lnX_2+b_3lnX_3+b_4lnX_4+b_5lnX_5+ b_6lnX_6+ b_7lnX_7+b_8lnX_8+ b_9 lnX_9+u_i$

where, ln= natural logarithm, Y= return per hectare (Tk), X_1= seed cost (Tk/ha), X_2= human labor cost (Tk/ha), X_3= power tiller cost (Tk/ha), X_4= irrigation cost (Tk/ha), X_5= manure cost (Tk/ha), X_6= fertilizer cost (Tk/ha), X_7= insecticide cost (Tk/ha), X_8= seed rate (Kg/ha), X_9= amount of credit used (Tk/ha), a= intercept, b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8, b_9= production coefficient of the respective input and u_i error term.

e) Food security (FS) was calculated as
FS= (TAF/TRF) × 100
where, TAF= total availability of food and TRF = total requirement of food. Again the contribution of maize in food security was calculated as CFS= (FS×AFM)/TAF
where, CFS= contribution in food security and AFM = availability of food from maize.

3. Results and Discussion

3.1 Changes in the Existing Farming System

This study was an effort to identify the major changes that took place in the recent past in the existing farming system of the study area. The responses of the maize producers in this direction are summarized in Table 1. Farming system is not a simple collection of plant and animal, rather it is a complicated interwoven mesh of soil, crop, livestock, workers and so on (CGIAR, 1986). It can be divided into several sub-systems like crop, forest, animal, fish, etc. It is evident from Table 1 that the major change in the crop sub-system was occupying acreage by maize and

Table 1 : Major Changes in Existing Farming System

Major sub-system	Major changes
Crop	Maize and cassava are two newly introduced crops with existing major crops rice, jute and wheat. Maize is an emerging crop occupying acreage of other crops. Besides, maize is popular in almost all types of farmers while cassava is popular in marginal and landless farmers only.
Livestock	Number of livestock reduced dramatically due to contraction of grazing land. Some hybrids have been introduced with traditional breeds and beef fattening and milch cow rearing are widely practiced. Lack of pasture is the major constraint for expansion of this sub-system.
Poultry	Several commercial poultry farms have been established near market areas and number of scavenging birds reduced drastically in all categories of households.
Fisheries	Scope of capture fishery reduced to minimum and culture fishery is practiced widely. Traditional breeds are almost in extinction and hybrids and exotics are cultured extensively.
Homestead	Traditional varieties are almost in extinction because of lower productivity and HYVs occupied all households. Number of fruit trees reduced remarkably while the number of forest trees increased.

cassava. Moreover, increase of forest trees in lieu of fruit ones in recent years is worth mentioning in the case of homestead farming. So, it can be said that major changes occurred in all segments of the farming system though they were not the same for all sub-systems in the study area.

3.2 Cost of Maize Farming

Variable and fixed costs of maize production per hectare were estimated and are summarized in Table 2. The table shows that human labor was the largest cost item of maize production irrespective of farm categories in the study area. It was used for land preparation, shelling, harvesting and application of other inputs. Human labor alone constituted 32.64, 45.83 and 45.98 percent of total cost of small, medium and large farms, respectively. The second largest cost item was land use where the respective contributions in total cost are 18.33, 14.37 and 14.58 percent. The third important cost item of maize production in the study area was fertilizer, which contributed 14.23, 11.31 and 10.85 percent of total cost of the farms, respectively. Other cost items were seed, irrigation, power tiller and manure in order of their contribution to total cost. Besides, farmers had to spend some money for purchasing insecticide. They also incurred a commencement cost, i.e., holding some money in hand before starting maize cultivation. The objective of this cost was to have a good and uninterrupted start for smooth operation. Considering all cost items together, variable cost was 78.06, 82.44, and 82.04 percent of total cost for small, medium and large farms, respectively, while the percentage for fixed cost was 21.94, 17.56 and l8.45. Thus, among physical inputs, maize is a labor intensive technology in changing the arming system and it was also mentioned by the respondents during survey. All the cost items bear more or less the same importance to the maize producers. Moreover, the cost of producing maize maintained a positive relationship with farm size in the study area.

3.3 Return and Profitability of Maize Farming

Per hectare gross return of maize production was determined by multiplying yield per hectare by the prevailing price in the local market. Table 3 shows that per hectare gross margin was estimated at Tk 52579.35, 50150.45 and 63611.30 for small, medium and large farms, respectively. The corresponding net return was found to be Tk 43436.35, 40112.65 and 52828.30. Net return as percentage of total cost was the highest for small farm (104.25 percent) followed by large (88.01 percent) and medium (70.16 percent) farms. The undiscounted BCR also showed the same order where the figures are 2.04, 1.88 and 1.70, respectively. In terms of

Table 2 : Per Hectare Cost of Maize Production

Cost items	Small farm (Tk/ha)	Medium farm (Tk/ha)	Large farm (Tk/ha)
A. Variable cost			
labor	13600.00	26200.00	27600.00
	(32.64)	(45.83)	(45.98)
Power tiller	2869.00	3121.00	3326.00
	(6.89)	(5.46)	(5.54)
Seed	4630.00	5090.00	5455.00
	(11.11)	(8.90)	(9.09)
Manure	1830.85	1897.00	1977.50
	(4.39)	(3.32)	(3.29)
Fertilizer	5930.00	6463.00	6510.00
	(14.23)	(11.31)	(10.85)
Insecticide	460.00	558.00	573.0
	(1.11)	(0.98)	(0.95)
Irrigation	3200.00	3800.00	3800.00
	(7.68)	(6.65)	(6.33)
Total variable cost	**32520.65**	**47129.55**	**49241.70**
	(78.06)	**(82.44)**	**(82.04)**
B. Fixed cost			
Interest on operating capital	658.00	725.00	920.00
	(1.58)	(1.27)	(1.53)
Land use cost	7635.00	8213.00	8753.00
	(18.33)	(14.37)	(14.58)
Commencement cost	850.00	1100.00	1400.00
	(2.04)	(1.92)	(2.33)
Total fixed cost	**9143.00**	**10038.00**	**11073.00**
	(21.94)	**(17.56)**	**(18.45)**
Total cost (A+B)	**41663.65**	**57167.35**	**60024.70**
	(100)	**(100)**	**(100)**

Figures in parentheses indicate percentage of total cost

both net return (percentage term) and BCR, small farm was the most profitable followed by large and medium farms in the study area. It was found that maize is both labor and capital intensive compared to other crops in the study area. Small farms had the advantage of home supplied labor while the large farms had the advantage of capital to hire labor for timely use. Medium farms lacked these advantages in operation. So, it might be one of the reasons for making higher profit by small and large farms compared to medium ones. But one thing is worth mentioning that maize is a profitable crop irrespective of farm categories and it is a highly profitable crop in the changing farming system of the study area.

Table 3 : Per Hectare Return and Profitability of Maize Production

Particulars		Small farm	Medium farm	Large farm
Yield (kg)		4255.00	4864.00	5239.00
Gross return (Tk)		85100.00	97280.00	112853.00
Total variable cost (Tk)		32520.65	47129.55	49241.70
Total fixed cost (Tk)		9143.00	10038.00	11073.00
Gross/Total cost (Tk)		41663.65	57167.35	60024.70
Gross margin (Tk)		52579.35	50150.45	63611.30
Net return	Tk	43436.35	40112.65	52828.30
	% of total cost	104.25	70.16	88.01
BCR (undiscounted)		2.04	1.70	1.88

3.4 Contributions of Key Variables in Maize Production

The respondents were asked about the most important variables affecting maize production. According to their response, 9 variables were selected for Cobb-Douglas production function analysis and the results are summarized in Table 4. Among the selected variables, regression coefficients of irrigation, manure, insecticide and credit of small farm were positive and significant and in the case of manure and credit, they were highly significant. It means that other factors remaining constant a 1 percent increase in these variables would increase gross return by 0.065, 0.168, 0.137 and 0.348 percent, respectively. In the case of medium farm, significant variables were seed, irrigation, manure, insecticide, seed rate and credit. Again, except seed cost, others had positive coefficient, and coefficients of seed, irrigation and credit were highly significant. It means that a 1 percent increase in seed cost would decrease the gross return by 0.389 percent while the same increase in irrigation, manure, insecticide, seed rate and credit would be able to increase gross margin by 0.193, 0.113, 0.129, 0.306 and 0.427 percent, respectively. Except human labor and power tiller, other variables brought significant impact on gross return of large farms. The coefficients of seed cost, irrigation, manure and seed rate were highly significant and only seed cost had negative sign. It implies that, a 1 percent increase in seed cost would decrease gross return by 0.312 percent while the same increase in irrigation, manure, fertilizer, insecticide, seed rate and credit would increase gross return by 0.123, 0.153, 0.065, 0.044, 0.323 and 0.489 percent, respectively. Values of R^2 show

more or less satisfactory fit of the models and highly significant F-values indicate that all the selected variables were important to explain the total variation of maize production. Table 4 also reveals that irrigation, manure and credit were the most important inputs for maize production in the study area as they brought highly significant impact for two of the three farm categories. The summation of all regression coefficients was less than one for all farms. So, the production functions exhibit decreasing returns to scale implying that if all the variables were increased by 1 percent gross return would be increased by 0.541, 0.601 and 0.465 percent for small medium and large farms, respectively. Thus it can be said that farmers are

Table 4 : Estimated Coefficients and Related Statistics of Cobb-Douglas Production Function Model

Explanatory variable	Small farm	Medium farm	Large farm
Intercept	8.624	8.523	9.485
	(0.821)	(1.893)	(0.456)
Seed cost	-0.081	- 0.389***	-0.312***
(X_1)	(0.173)	(0.135)	(0.066)
Human labor cost	0.029	0.172	0.045
(X_2)	(0.081)	(0.165)	(0.062)
Power tiller cost	0.049	-0.048	0.024
(X_3)	(0.052)	(0.082)	(0.045)
Irrigation cost	0.065*	0.193***	0.123***
(X_4)	(0.035)	(0.059)	(0.026)
Manure cost	0.168***	0.113**	0.153***
(X_5)	(0.054)	(0.043)	(0.035)
Fertilizer cost	0.006	0.125	0.065*
(X_6)	(0.127)	(0.197)	(0.060)
Insecticide cost	0.137**	0.129*	0.044*
(X_7)	(0.062)	(0.071)	(0.052)
Seed rate	0.168	0.306*	0.323***
(X_8)	(0.164)	(0.231)	(0.080)
Credit	0.348***	0.427***	0.489**
(X_9)	(0.097)	(0.058)	(0.109)
R^2	0.752	0.538	0.741
F-value	8.669***	5.145***	12.295***
Returns to scale	0.541	0.601	0.465

Figures within parentheses indicate standard errors
***significant at 1% level
**significant at 5% level
*significant at 10% level

using more of some inputs than their required amount just to make higher profit. This unsound practice should be avoided from economic point of view.

3.5 Efficiency in Resource Use in Maize Production

Economic efficiency refers to the combination of inputs that maximize individual or social objectives (Doll and Orazem, 1984). To accomplish the objective of profit maximization i.e., for efficient allocation of resources, one should use more of the variable resource so long as the value of the added product is greater than the cost of the added amount of the resource used in producing it. The estimated

Table 5 : Ratio of MVPs and MFCs o Different Inputs in Maize Production Function

Resource	Small farm			Medium farm			Large farm		
	Geometric mean	Coefficient	MVP_{xi}/MFC_{xi}	Geometric mean	Coefficient	MVP_{xi}/MFC_{xi}	Geometric mean	Coefficient	MVP_{xi}/MFC_{xi}
Seed	3112.32	-0.081	-2.90	5027.98	-0.389	-8.57	3156.65	-0.312	-11.10
Human labor	12659.34	0.029	0.26	11215.36	0.172	1.70	18336.85	0.045	0.27
Power tiller	2536.22	0.049	2.16	3965.48	-0.048	-1.34	3201.36	0.024	0.84
Irrigation	4258.99	0.065	1.70	4236.09	0.193	5.10	4269.49	0.123	3.23
Manure	1236.67	0.168	15.20 1992.28		0.113	6.29	2781.95	0.153	6.17
Fertilizer	5241.69	0.006	0.13 6436.69		0.125	2.15	6025.69	0.065	1.21
Insecticide	527.29	0.137	28.99	684.36	0.129	20.90	729.64	0.044	6.76

MVP of different inputs for maize production is presented in Table 5. If MFC_{xi} divides the MVP_{xi} the product will be equal to the value of MVP_{xi} because MFC at all cases is equal to Tk one (X_i= i^{th} input).

It is evident from Table 5 that irrigation, manure and insecticide are the efficiently used resources for maize production by all farms because they have positive and greater than MVP/MFC ratio irrespective of farm categories. Similarly seed is an inefficiently used resource as it has negative and greater than one MVP/MFC ratio in all farm categories.

3.6 Implication of Maize in Household Food Security

Generally rice and wheat come first to meet the food requirement of Bangladeshi people and the farmers of Bangladesh usually choose cropping pattern emphasizing these two cereals. But in the study area maize is getting popularity

in this traditional cropping system. So, it is assumed that maize certainly bears some importance in the food situation of the study area. Therefore, an attempt was made to investigate the implication of maize in food security status of the respondents' households under study.

Respondents consumed several food items in a year and units of these items were also different. Again there are several methods to calculate food security- ranging from easy algebraic to highly mathematical using strict scientific data. In the study area scientific information were not possible to collect from the respondents. So, food security of respondent households was examined by using easily available data like total requirement of food, total availability of food, etc.

Table 6 : Contribution o Maize in Household Food Security

Farm category	TRF (Tk)	TAF (Tk)	FS (%)	Contribution of maize	
				TAM (Tk)	CFS (%)
Small	63875.00	22812.50	35.71	18251.27	28.57
Medium	131400.00	78840.00	60.00	24637.50	18.75
Large	236520.00	223380.00	94.45	35475.90	15.00
All	143931.67	108344.16	63.38	26121.55	15.28

and analysis was done accordingly. As there were differences in food items and in their measurements, all the data were converted into money terms for calculation.

It is evident from Table 6 that yearly average total requirement of food (TRF) for small, medium and large farm households was Tk 63875.00, 131400.00 and 236520.009, respectively. Against this requirement the respective total availability of food (TAF) was Tk 22812.50, 78840.00 and 223380.00. Thus food security (FS) for small, medium and large farm households stood at 35.71, 60.00 and 94.45 percent, respectively. So all of TRF, TAF and FS were positively related with farm size and overall household FS was found to be 63.38 percent. Moreover, larger farm households were more food secured than smaller ones in the study area. In TAF, total availability from maize (TAM) in small farm was Taka 18251.27 while it was Tk 24637.50 for medium farm and Tk 35475.90 for large farm. Thus contribution in food security (CFS) by maize farming stood at 28.57, 18.75 and 15.00 percent for small, medium and large farm, respectively. The overall CFS stood at 15.28 percent and CFS maintained a negative relationship with farm size.

Thus it proves that maize is an important crop enhancing food security status of the respondents irrespective of farm categories in the study area. Moreover, its role is worth mentioning in the case of small farms that are generally vulnerable in the status of food security. So, maize certainly bears a good and favorable implication for enhancing the household food security status of the producers in the study area.

4. Conclusion

Major changes took place in all sub-systems of farming in the study area. Maize is relatively a new crop in the changing farming system. But it is getting popularity because it is comparatively a highly profitable crop irrespective of farm categories in the study area. Small farm realized the largest profit while it was the lowest for medium farm. Maize is also a labor intensive technology and labor cost constituted a remarkable share in total cost of production. Irrigation, manure and credit were the most important factors as they affected maize production positively and significantly in almost all the farms under study. In the case of resource use efficiency irrigation, manure and insecticide are the efficiently used resources while seed is an overused one. Being ambitious of higher profit, respondents were found to use some inputs more than their required quantity. Household food security status was positively related with farm size, i.e., larger farms were found to be more food secured than the smaller ones. But contribution of maize in food security was negatively related with farm size. It means that maize contributed more in enhancing food security of the smaller farms compared to the larger ones in the study area. So, maize bore positive implication for improving household food security status of the respondents and its implication was worth mentioning in food vulnerable small farm households. As maize is a new but profitable and food security enhancing enterprise in the changing farming system, proper measures should be taken for its rapid and rational expansion in the study area as well as in other parts of the country.

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