Farm size and productivity in rice farming: recent empirical evidence from Bangladesh

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Abstract:

Productivity in rice farming is increasing since modern inputs and techniques are being adopted in the production systems. In developing countries, farm sizes are also a concern for estimating productivity. In this study, primary data were collected from 958 households situated at 96 villages of 48 upazilas under 31 districts of Bangladesh in boro season, 2013. Upazilas, unions, villages and households were randomly selected from five rice growing divisions with mainly shallow tubewell (STW) irrigation. The study has covered landless farmers (18.68 percent), marginal farmers (36.53 percent), small farmers (37.27 percent), medium farmers (7.20 percent) and large farmers (0.32 percent). In terms of farm productivity, medium farmers have the highest yield of 6818 kg/ha followed by the small farmers with 6359 kg/ha, marginal with 6258 kg/ha, landless farmers with 6127 kg/ha, and large farmers with 5495 kg/ha. Net return from rice farming is minimal and medium farmers have the highest net earnings of 27033 Tk./ha where as small, marginal, landless and large farmers' net earnings are 20716 Tk. /ha, 15601, 1278 Tk./ha and -1094 Tk./ha, respectively. Farm-specific technical efficiency was calculated using translog stochastic production frontier function and estimated by the maximum likelihood estimation model. It is found that medium and small farmers have the higher level of efficiency and marginal farmers are the least among the farm types. And it is due to marginal farmers are resource poor and they have cash capital constraints as well. It is Cheaper price of rice during harvesting season is one of the main reasons of fewer net returns in rice farming as perceived by most of the famers. In addition, government policy in paddy procurement and increasing trend of farm input prices are also reasons for fewer margin. It is suggested that well ahead declaration of procurement price of rice and lower farm input prices policy can be good incentive for farmers to be in rice farming in the long run.

Key words: Rice farming, productivity, farm size, technical inefficiency, Bangladesh

Introduction:

The supply of rice, a staple food for half of the world's population and the primary source of income and employment of one-fifth of the global population, is therefore strongly determined by small farmers' incentives for rice production. More than 200 million small farmers with an average of less than 1 hectare of land produce 90% of the total rice in the world (Tonini & Cabrera, 2011). Small farm households are believed to face a lower opportunity cost of labour than large farm households (Carter & Wiebe, 1990; Hunt, 1979; Sen, 1966). In Bangladesh, rice is the staple food of 149.8 million people and supplies 76% of the total calorie intake and more than 65% of the protein intake of the people (Dey, Miah, Mustafi, & Hossain, 1996). The agricultural sector is also

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characterized by the traditional subsistence small-scale farming. This country has shortage of all factors of production except labour, obviously cannot afford to make an inefficient use of resources. It is therefore important to estimate the level of technical efficiency at the farm-level, and to identify the sources of such efficiency and inefficiency. Such information is important for formulating appropriate policies for reducing the level of technical inefficiency. Measurement of technical efficiency could also help decide whether to improve efficiency first or develop a new technology in the short run. Technical efficiency is used as a measure of a farm's ability to produce maximum output from a given set of inputs under certain production technology.

Farm efficiency is examined by comparing the economic efficiencies of various types of farm holders (landless, marginal, small, medium and large). The majority of studies of agricultural productivity in developing countries support the view that there is an inverse relationship between productivity and farm size (Berry and Cline, 1979; Barrett, 1996). The relationship between farm size and efficiency is found to be non-linear, with efficiency first falling and then rising with size (Helfan et.al., 2004). High technical efficiency will not only enable farmers to increase the employment of productive resources, but it will also give a direction of adjustments required in the long run to increase food production. This present paper examines technical efficiency with emphasis on farm size in Bangladesh in order to suggest the ways to increase the levels of rice production in Bangladesh. Previous studies in Asia have tested for relative efficiency differences by farm size, with conflicting results. Lau and Yotopoulos, 1971 and Yotopoulos and Lau, 1973 found that small wheat farms in the Indian Punjab were more technically efficient than large farms. In Pakistan, Khan and Maki (1979) found that large farms are more technically efficient than small farms. In Cote d’Ivoire, Adesina and Djato, 1996 found no differences in the technical efficiency of small and large farms. Onyenweaku, 1997 examined the technical efficiencies of two groups of farms in Kaduna state, Nigeria. The results showed higher level of technical efficiency for large scale farms. The above results on relative technical efficiency suggest the need to avoid generalizations in this regard as what obtains in one country may not follow in another country due to differences in agricultural and institutional settings. The definition of farm size has been variable in the efficiency literature, as what is considered “large” or “small” is relative depending on the agricultural system settings. In Pakistan agriculture, Khan and Maki, 1979 classified large farms as those having 12.5 acres or over 5 hectares. Using Indian data, Yotopoulos and Lau, 1973, and Sidhu, 1974 classified "large" farms as those with at least 10 acres (i.e., 4 ha). In Nigeria, Olayide et al., 1980 described small farms as those farm holdings less than 10 hectares. In a similar study in Cote d'Ivoire, Adesina and Djato, 1996 defined large farms as farms of at least 4 hectares. Ohajianya and Onyenweaku, 2002, in a similar study, defined large farms as farms of at least 4 hectares. In this study, large scale farmers were defined as farmers that have more than 3.04 ha (i.e.,7.50 acres) of land. This study investigates the productivity, technical efficiency and their determinants among different rice farmers based on farm size in Bangladesh. Necessary policies are suggested based on the findings of this study.

Methodology:

A multi-staged sampling technique was employed to select a representative sample in this study. Five divisions were selected since they are the major rice growing divisions in Bangladesh. Forty eight upazilas were selected proportionately from the total rice areas of those five divisions. Unions and villages were selected randomly from the list of those. Ten irrigated rice growing households were selected randomly. Based on the category of farm size, there were five categories of farmers identified. They were landless (<0.20 ha), marginal (0.20 – 0.40 ha), small (0.40 – 1.01 ha), medium (1.01 - 3.03 ha) and large (>3.04) and their sample size were 17, 350, 357, 69 and 3 respectively. Data were collected using structured and validated questionnaire administered on the farm families using Surveybe CAPI software during the 2013 boro rice season by trained enumerators under the supervision of the researcher. Data were collected on the socioeconomic characteristics of the farmers, production activities in terms of inputs, outputs and their prices.

The methods to estimate farm household technical efficiency include parametric and nonparametric methods, i.e. stochastic frontier analysis (SFA) introduced by Farrell, 1957 and data envelopment analysis (DEA) introduced by Charnes et. al., 1978. There are debates on which one is more appropriate approach for the technical efficiency estimation. DEA, the non-parametric approach, does not impose the restrictions the production function and distribution assumption of error terms and is suitable to deal with the multiple outputs (Chavas et. Al., 2005). However, the measurement errors can influence on the shape and positioning of the estimated frontier largely (Coelli and Battese, 1996). Instead, in SFA, the two error terms, i.e. technical inefficiency and random error term are specified explicitly (Coeli and Battese, 1996; Battese and Coelli, 1995). In this study, focus will be on only one single specific crop and SFA would be applied which is suitable for this research.

To apply SFA approach, it actually includes two regressions. The first one is to estimate the technical efficiency coefficient based on the input-output data at farm level by using production function and the second one is to evaluate the effects of determinants for inefficiency in different payment systems. It is proposed that one-stage regression is more appropriate than the two separate stage regression because the assumption of technical inefficiency coefficient is not hypothesized to be independent and affected by the covariates in the efficiency model (Battese and Coelli, 1995). One-stage approach is thus applied in the study, i.e. a stochastic production frontier based on the factors of production was estimated simultaneously with the determinants of inefficiency using maximum likelihood estimate following the methodology of Battese and Coelli, 1995).

Technical efficiency and the determinants of technical inefficiency are calculated by first estimating a score for technical efficiency and then that score is used to determine influencing factors. The output or yield of the stochastic production frontier is considered to be a function of input variables (Aigner et. al., 1977). Following Coelli et al., 1998, a stochastic production function is specified as:

$$Y_i = f(X_i) \exp(\epsilon_i) \quad \ldots \quad (1)$$

Where Y_i is the yield for farmer i, X_i are the input variables used by the farmer i, ϵ_i is the error term, and f is the functional form to be specified. The error term is assumed to be composed of two separate errors, such that:

$$\epsilon_i = v_i - u_i \quad \ldots \quad (2)$$

Where v_i is the stochastic error term with a two-sided noise component and u_i is the one-sided error component. Within the error term, v_i, accounts for random noise that is outside of the farmers' control as well as measurement errors. The second component, u_i, captures the absolute distance between farmers' yield and production possibility frontier. The first component, v_i is assumed to be normally distributed ($v \sim N(0, \sigma^2_v)$ with a mean of zero and variance of σ^2_v. The second component, u_i is representing technical inefficiency (TI). If u=0, production lies on the stochastic frontier and production is technically efficient; if u>0, production lies below the frontier and is inefficient. Lastly, the two components of the error term are assumed to be independent of each other.

Farmers' individual technical efficiency scores are estimated to show the difference in the actual production to the potential production for each farm (Greene, 1980). The measurement of the technical efficiency is constructed using the observed deviation of output from individual farmers and the production frontier, the most efficient point obtainable by the farmers. Farmers with observed technical efficiency that lies on the production frontier are considered to be perfectly efficient. Conversely, any farmers with technical efficiency scores that are lying below the production frontier are considered to be technically inefficient. The index of technical efficiency is specified as:

$$\frac{Y_i}{f(X_i)e^{vi}} = \exp(-\mu_i) \quad \ldots (3)$$

Model specification:

Both descriptive and inferential statistics were used to analyze the pattern of inputs of production and the socioeconomic characteristics of the farm households. The Cobb-Douglas and Translog functional form will be used for this study. The empirical model of the Cobb-Douglas functional form (Gujarati, 1995) is as follows:

$$\ln Y_i = \beta_0 + \sum_{j=1}^{n} \beta_j \ln X_{ij} + v_i - \mu_i \quad \ldots (4)$$

where:

ln = natural logarithmic form

Y_i = rice production (yield) in tons ha^{-1}

k = number of input variables

β_0 = intercept or constant term

β_j = unknown parameters to be estimated

X_{ij} = vector of production inputs (j) of the farmer i

v_i = random error term

u_i = inefficiency component

Translog productional function:

$$\ln Y_i = \beta_0 + \sum_{i=1}^{k} \beta_i \ln X_i + \frac{1}{2} \sum_{i=1}^{k} \sum_{j=1}^{k} \beta_{ij} \ln X_i \ln X_j + v_i - \mu_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (.5)$$

We can generalized it in the following form like as,

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_2 i + 0.5\ \beta_{11}(\ln X_{1i})^2 + 0.5\ \beta_{22}(\ln X_{2i})^2 + \beta_{12} \ln X_{1i} \ln X_{2i} + v_i - \mu_i \ldots\ldots.(6)$$

While the technical inefficiency model is given as:

$$\mu_i = \delta_0 + \sum_{i=1}^{k} \delta_{ij} Z_{ij} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .(7)$$

Where,

μ_i = technical inefficiency

δ_0 = intercept or constant term

δ_j = parameters to be estimated

Z_j = determinants of inefficiency

To determine the appropriate functional form for the model specification, a likelihood ratio test (LR test) is conducted. This test compares the translog function and the Cobb-Douglas. The null hypothesis is H_0: Cobb-Douglas functional form and H1: Translog functional form. We run both the model and LR test as well. The test rejects the null hypothesis, H_0. This LR test proves that the translog functional form for estimating inefficiency with the current data set is the appropriate form of model.

Table 1. Model selection test results

Hypothesis and decision	Criteria	LR value and probability
H_0: Cobb-Douglas	Likelihood-ratio test	LR chi2(58) = 92.95
H1: Translog	(Assumption: Cobb_Douglas nested in Translog)	Prob > chi2 = 0.0024
Decision: Null hypothesis is rejected with ≤ 1 percent level of significance	Translog is the appropriate form for this data set.	

Given a flexible and interactive production frontier for which the translog production frontier is specified, the farmer specific technical efficiency (TE) of the ith farmer is estimated by using the expectation of ui conditional on the random variable ei as shown by Battese (1992). That is,

$$TE = \exp(-u_i) = e^{u_i} \ldots \ldots \ldots \ldots \ldots \ldots \ldots (8)$$

So that 0≤TE≤1. Farm specific technical inefficiency index (TI) is computed by using the following expression:

$$TI = [1 - \exp(-u_i)] \ldots \ldots \ldots \ldots \ldots \ldots \ldots (9)$$

In the production function, zero values were also observed in cases where farmers did not apply other fertilizer. As proposed by Battese, 1997, the following methodology was applied to account for the zero values.

$$\ln Y_j = \beta_0 + (\alpha_0 - \beta_0)D_{2j} + \beta_1 \ln X_{1j} + \beta_2 \ln X_{2j}* + V_j, i = 1, 2, ..., n \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (10)$$

where,

$D_{2j} = 1$ if $X_{2j} = 0$ and $D_{2j} = 0$ if $X_{2j} > 0$; and $X_{2j}* = \text{Max}(X_{2j}, D_{2j})$

The model in equation 3 implies that $X_{2j}* = X_{2j}$ is true for $X_{2j} > 0$ but if $X_{2j} = 0$ then $X_{2j}* = 1$.

Empirical models specification: Translog

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_2 i + 0.5\, \beta_{11}(\ln X_{1i})^2 + 0.5\, \beta_{22}(\ln X_{2i})^2 + \beta_{12} \ln X_{1i} \ln X_{2i} + \ldots + v_i - \mu_i \ldots (11)$$

Table 2. List of variables and interaction factors are as follows:

Input variables	Interaction factor variables
1. Seed	12. 0.5*Seed^2, 13. Seed*Human labour, 14. Seed*Tillage, 15. Seed*Irrigation, 16. Seed*Chemical fertilizer, 17. Seed* Insecticide & herbicides, 18. Seed* Other fertilizer dummy, 19. Seed* Other cost dummy, 20. Seed* marginal farm dummy, 21. Seed* small farm dummy, 22. Seed* medium farm dummy
2. Human labour	23. 0.5*Human labour^2, 24. Human labour*Tillage, 25. Human labour*Irrigation, 26. Human labour*Chemical fertilizer, 27. Human labour*Insecticide & herbicides, 28. Human labour*Other fertilizer dummy, 29. Human labour*Other cost dummy, 30. Human labour*marginal farm dummy, 31. Human labour* small farm dummy, 32. Human labour*medium farm dummy
3 . Tillage	33. 0.5*Tillage^2, 34. Tillage*Irrigation, 35. Tillage*Chemical fertilizer, 36. Tillage*Insecticide & herbicides, 37. Tillage*Other fertilizer dummy, 38. Tillage*Other cost dummy, 39. Tillage*marginal farm dummy, 40. Tillge*small farm dummy, 41. Tillage* medium farm dummy
4. Irrigation	42. 0.5*Irrigation^2, 43. Irrigation* Chemical fertilizer, 44. Irrigation* Insecticide & herbicides, 45. Irrigation*Other fertilizer dummy 46. Irrigation*Other cost dummy, 47. Irrigation*marginal farm dummy, 48. Irrigation*small farm dummy, 49. Irrigation*medium farm dummy
5. Chemical fertilizer	50. 0.5*Chemical fertilizer^2, 56. Chemical fertilizer*Insecticide & herbicides, 51. Chemical fertilizer*Other fertilizer dummy, 52. Chemical fertilizer*Other cost dummy, 53. Chemical fertilizer*marginal farm dummy, 54. Chemical fertilizer*small farm dummy, 55. Chemical fertilizer*medium farm dummy,
6. Insecticide & herbicides	56. 0.5*Insecticide & herbicides^2, 57. Insecticide & herbicides* Other fertilizer dummy, 58. Insecticide & herbicides*Other cost dummy, 59. Insecticide & herbicides*marginal farm dummy, 60. Insecticide & herbicides*small farm dummy, 61. Insecticide & herbicides*medium farm dummy
7. Other fertilizer dummy	62. Other fertilizer dummy*Other cost dummy, 63. Other fertilizer dummy*marginal farm dummy, 64. Other fertilizer dummy*small farm dummy, 65. Other fertilizer dummy*medium farm dummy
8. Other cost dummy	66. Other cost dummy*marginal farm dummy, 67. Other cost dummy* small farm dummy, 68. Other cost dummy*medium farm dummy
9. Marginal farm dummy	-
10. Small farm charge dummy	-
11. Medium farm dummy	-

Results and discussion:

Some descriptive statistics which ensure the selected farm specific socioeconomic variables used to see the variations among the farm size groups.

Table 1: Distribution of households by farm size

Category of farm holdings	Frequency	Percent
Landless	179	18.68
Marginal	350	36.53
Small	357	37.27
Medium	69	7.20
Large	3	0.32
All	958	100.00

The table reveals the category of farmers' according to their farm holdings. Most of the farmers are small and marginal farmer. The small and medium farmers are 37.27 % and 36.53 % respectively. The study shows that only 3 farmers are large farmer, which is about 0.32 percent of the total farmers.

Table 2. Well category and frequencies of the irrigation service provider

S.L. No.	Types of well	Frequencies	Percent
1.	Shallow Tube well (STW)	255	95.15
2.	Deep Tube well (DTW)	13	4.85

The study shows the extensive use of STW in the study area along with few DTW, because majority of the farmers (95 percent) have STW and remaining 5 percent have DTW.

Table 3. Well Ownership and frequencies by the well types

Types of Well	Pattern of Ownership	Frequencies	Percent
1. STW	Single ownership	237	92.94
	Joint ownership	18	7.06
	Total	255	100
2. DTW	Single ownership	6	46.15
	Joint ownership	7	53.85
	Total	13	100

Two types of well ownership are found in the study area namely single ownership and joint ownership in both cases of STW and DTW. Single ownership is preferable in case of STW. About 92.94 percent farmers' have single ownership on STW, whereas only 7.06 percent farmers have joint ownership. The phenomena indicate that in case of STW, majority of the farmers have their own STW for irrigation. Joint ownership is preferable in case of DTW since it is capital intensive irrigation technology. Single ownership also has the similar trend. About 54 percent farmers have joint ownership and about 46 percent farmers' have single ownership.

Table 4. Ownership patterns on the basis of farm category

Farm category	Single ownership (Frequency)	Percent	Joint ownership (Frequency)	Percent
Landless	8	3.29	2	8
Marginal	44	18.12	5	20
Small	138	56.79	13	52
Medium	49	20.16	5	20
Large	4	1.64	-	-
Total	243	100	25	100

The study shows that the ownership of well (i.e., both single and joint) is highly concentrated by the small farmers. More than one-half of the small farmers captured the ownership market. Similar to the small farmers the medium farmers are in the second best position. The contribution of large farmers is insignificant and they have no contribution in joint ownership. The landless farmers are contributing more in joint ownership than single ownership. They are trying their level best which is ensured by their contribution in joint ownership. Due to the lack of capital they can hardly cope with the ownership market in irrigation technology. On the other hand marginal farmers are in significant range in the both cases. The table also shows that both small and medium farmers are in highly significant range in this regards and their ownership is as like as duopoly.

Table 5: Patterns of joint ownership by farm category

Farm category	Frequency (If No. of Owner =2)	Frequency (If No. of Owner =3)	Frequency (If No. of Owner =4)	Frequency (If No. of Owner =5)	Frequency (If No. of Owner >5)
Landless	2	-	-	-	-
Marginal	3	1	-	-	1
Small	6	1	1	2	3
Medium	1	-	2	2	-
Total	12	2	3	4	4

As the farm size increases ownership also increases when the number of owner is two except medium farmers. The small farmers' incentive to invest is higher when the number of owner is two or more than five. In other cases they only invest to keep themselves into the ownership market of irrigation. When the number of owner is four and five then the medium farmers' dominance is highly significant than others. In this situation marginal farmers have incentive to invest. The table shows that the joint ownership market is captured by the marginal and small farmers.

Table 6: Major inputs used by farm category (Kg/ha)

Farm category	Seed	Urea	TSP	MP	DAP	OF	Insect & herbicide

Landless	30.87	251.24	77.44	83.89	67.73	657.81	5.52
Marginal	32.21	249.55	80.65	83.75	69.24	185.08	5.42
Small	36.09	255.02	77.84	85.60	68.50	279.60	4.81
Medium	33.57	231.80	91.27	98.44	69.85	260.85	3.95
Large	46.53	260.72	124.12	124.12	24.95	37.42	1.13
All	33.55	250.66	79.91	85.65	68.59	313.63	5.09

There is a positive correlation between farm category and seed requirements, except medium farmers. The small farmers are the second highest user of seed. The fertilizer application varied due to lack of capital and proper knowledge about the fertilizer dose. The study finds the extensive use of Urea by the large and small farmers. The large farmers use the highest amount of Urea, TSP and MP because they have more financial solvency and easy access to fertilizer dealers. Landless farmers are in disadvantageous position in using fertilizer. Their financial inability is the main reason in this regard but they extensively use other fertilizers of which prices are lower. Di Ammonium Phosphate (DAP) is highly used by the medium farmers. As the farm size increases insecticides and herbicides application decreases meaning is the small farmers use more insecticide and herbicides to produce more crops in their field.

Table 7: Major input costs by farm category (Tk./ha)

Farm category	Seed cost	Urea cost	TSP cost	MP cost	DAP cost	OF cost	Insect & herbicide	Other cost	Total input cost

Landless	2350.96	5366.12	2198.63	1477.38	1967.80	1527.33	1724.41	1122.64	17735.27
Marginal	2177.37	5074.56	2227.41	1410.76	2092.81	790.63	1567.32	1539.27	16880.13
Small	2014.03	5016.65	2069.49	1426.55	2046.58	715.94	1418.24	1589.74	16297.22
Medium	1991.83	4651.39	2399.09	1500.66	2040.19	812.79	1292.35	2471.67	17159.97
Large	2644.65	5244.38	3228.47	2198.05	698.59	1122.73	1243.26	1202.11	17582.24
All	2137.04	5077.51	2178.68	1438.03	2044.07	903.08	1520.30	1546.33	16845.04

The seed cost and Urea cost decrease with the increase in the size of the farms except large farm size. Medium farmers incur more cost for TSP, MP and other fertilizers. As the farm size becoming larger the farmers use less insecticides and herbicides. Small farmers' miscellaneous costs are high compare to others except medium farmers. The study shows that the landless farmers incur more costs (i.e. Tk. 17,735.27/ha) and the small farmers incur less costs (i.e. Tk. 16297.22/ha) for their input use. The expenditure pattern reveals that small farmers are more rational in their expenditures on inputs as mentioned earlier small farmers are major share holder in all aspects. In order to maximize their output, the landless irrationally incur more cost for inputs.

Table 8: Operation-wise labour used by farm category (Man-day/ha)

Farm category	Land preparation	Transplanting	Cultivation	Harvesting	Irrigation	Tillage
Landless	19.32	28.17	36.57	41.23	47.26	1.26
Marginal	18.43	26.82	31.08	40.52	44.05	1.25
Small	15.22	25.61	24.76	37.98	42.13	1.18
Medium	10.41	25.91	26.11	42.50	41.66	0.85
Large	25.03	29.69	24.77	21.71	22.58	1.20
All	16.84	26.56	29.37	39.79	43.69	1.19

On an average the number of labour requirements for small and medium farmers is low, but during the harvesting times, medium farmer use more labour than others. So the per hectare labour requirements ensure that the small and medium farmers are more rational. But landless farmers use more labours for different activities of farm but the small and medium are in convenient situation in this regards.

Table 9: Per hectare cost of production of boro rice by farm category

Farm category	Input cost	Labour cost	Service cost	Other cost	Total cost
Landless	16612.64	44530.33	25952.54	1122.64	79456.11
Marginal	15340.87	46570.60	27080.78	1539.27	80914.52
Small	14707.47	44523.32	24151.75	1589.74	74135.23
Medium	14688.29	45769.30	17482.14	2471.67	67252.65
Large	16380.11	48880.60	21560.45	1202.11	74700.24
All	15298.71	45375.98	25069.84	1546.33	77112.25

Per hectare production cost of boro rice is higher in case of marginal and landless farmers and the medium farmers incur low cost for production practices. The small farmers' production costs are higher than the medium farmers' but lower than others. Service cost (including irrigation cost and tillage cost) is lower for medium and small farmers but higher for marginal and landless farmers. Large farmers use more labour and the labour requirement is low for small farmers. Compost, diesel, electricity, and animal feed costs, wages, and tilling costs increased nearly twofold in 2010 for small households compared with large farm households (Mottaleb et. Al., 2014). For the higher wage rate small farmers use less labour. Finally it is clear from the expenditure pattern on cost that the medium and small farmers make wise use of scarce resources to maximize their farm production. Their rational cost allocation has positive effect on their overall farm production.

Table 10: Per hectare cost and return of boro rice by farm category

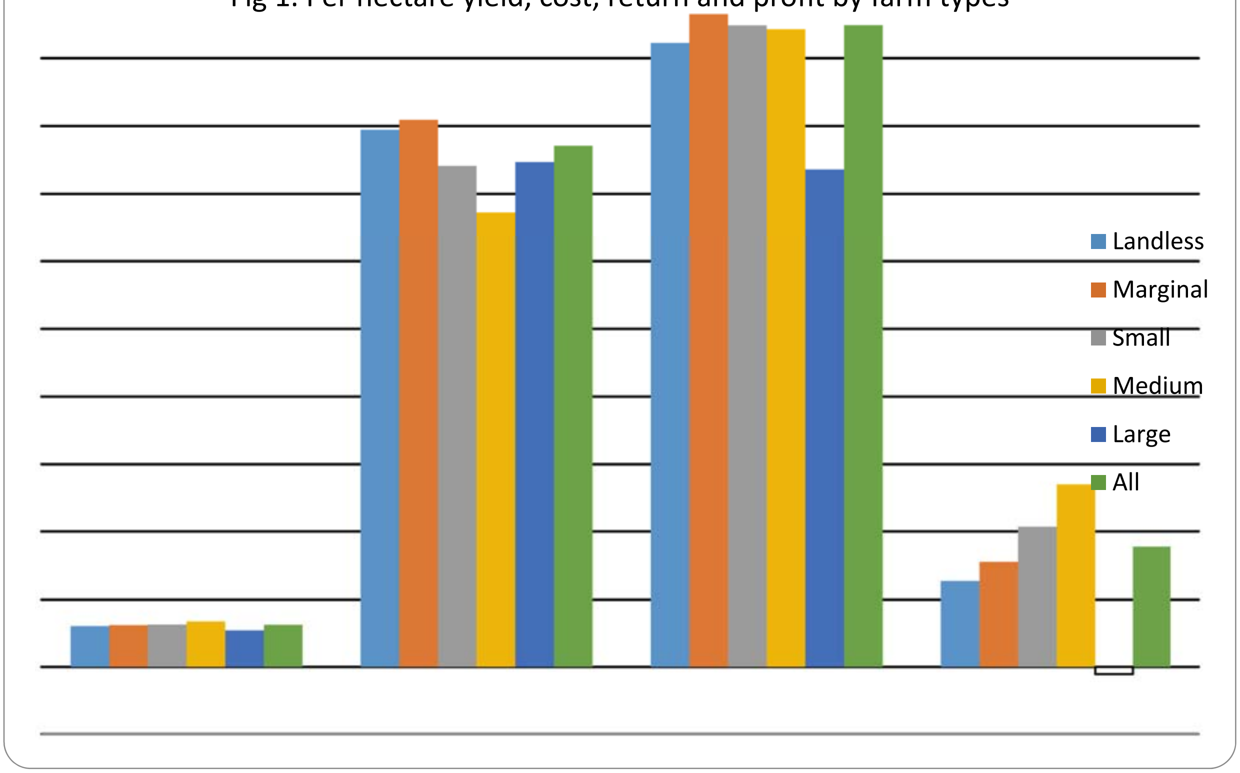
Farm category	Yield*** (kg)	Price (Tk./40 kg)	Total cost (Tk.)	Total return (Tk.)	Profit (Tk.)
Landless	6127	569	79456	92254	12798

Marginal	6258	574	80915	96515	15601
Small	6359	565	74135	94851	20716
Medium	6818	522	67253	94286	27033
Large	5495	533	74700	73606	-1094
All	6309	566	77112	94867	17754

***Significant at 1% level of significance

The study shows that medium and small farmers enjoy higher yield (i.e., 6818 kg and 6359 kg respectively) and their profit is comparatively higher than other farm holders. On the other hand the large farmers have negative return in their farm practices. Small farmers tend to be more productive and profitable than large farmers (Barrett, 1996; Berry and Cline, 1979; Sen, 1975). In the similar fashion the study also reveals that medium and small farmers tend to be more productive and profitable than large farmers. The findings of this study indicate positive relationship between farm size and profitability except landless and large farmers.

Fig 1. Per hectare yield, cost, return and profit by farm types



The loss in profitability is generally larger for small farms than for large farms, as small farms use more labour and other inputs than large households to earn higher rice income and profit (Mottaleb et al. 2014). But the findings of this study represent the loss in profitability is generally larger for large and landless farm holders than medium and small farmer holders. And finally their production costs are low compared to large and landless farm holders.

The study shows that the medium and small farmers are in advantageous position, because they enjoy higher yields. On the contrary, large farmers are in disadvantageous position. Their returns from production are low compare to other farm holders. The number of large farmers in the study area is not satisfactory, which is only 0.32 percent, as mentioned earlier. The phenomena indicate that large farmers are not intensively involved in agriculture. It is found that agriculture is their secondary occupation and they have some other non–farm businesses. The large farm holders always searching for new innovative non-farm businesses and finally migrate themselves to the urban and peri-urban areas (Al-Hassan, 2012).

Yield influencing factors:

The following table shows the results of the stochastic frontier analysis. The model fits well with the variables here. The variables those have significant influences on yield are irrigation, seed-tillage, seed-irrigation, seed-insecticides and herbicides, labour-irrigation, irrigation-other fertilizer, irrigation-small farm dummy, chemical fertilizer-other fertilizer, other fertilizer-marginal farm dummy. Most of the coefficients of those variables or interactive factors are significant at 1 & 5 percent level of significance. Different cross product or interaction factors have robust influence on yield which means the interaction factors need to be taken care intensively to explain the yield variation of the farmers.

Table 11. List of significant variables in the translog model

	Number of observation =955 Wald chi-square =3.48e+11 Probability > chi-square = 0.0000 Log likelihood = -223.48184	
Input variables and integration variables	Coefficient.	Std. Err.
Irrigation	-0.48^{**}	0.20

Seed-tillage	-0.09***	0.03
Seed-irrigation	0.03**	0.02
Seed-insecticides and herbicides	0.02*	0.01
Labour-irrigation	0.11***	0.03
Irrigation-other fertilizer	-0.05**	0.02
Irrigation-small farm dummy	0.05*	0.03
Chemical fertilizer-other fertilizer	0.11**	0.15
Other fertilizer-marginal farm dummy	0.11*	0.06
Constant term	13.29	1.58
/lnsig2v	-4.33	0.15
/lnsig2u	-1.89	0.07
sigma_v	0.15	0.01
sigma_u	0.39	0.01
sigma2	0.16	0.01
lambda	3.39	0.02
Likelihood-ratio test of sigma_u=0: chibar2(01) = 2.2e+02Prob>=chibar2 = 0.000		

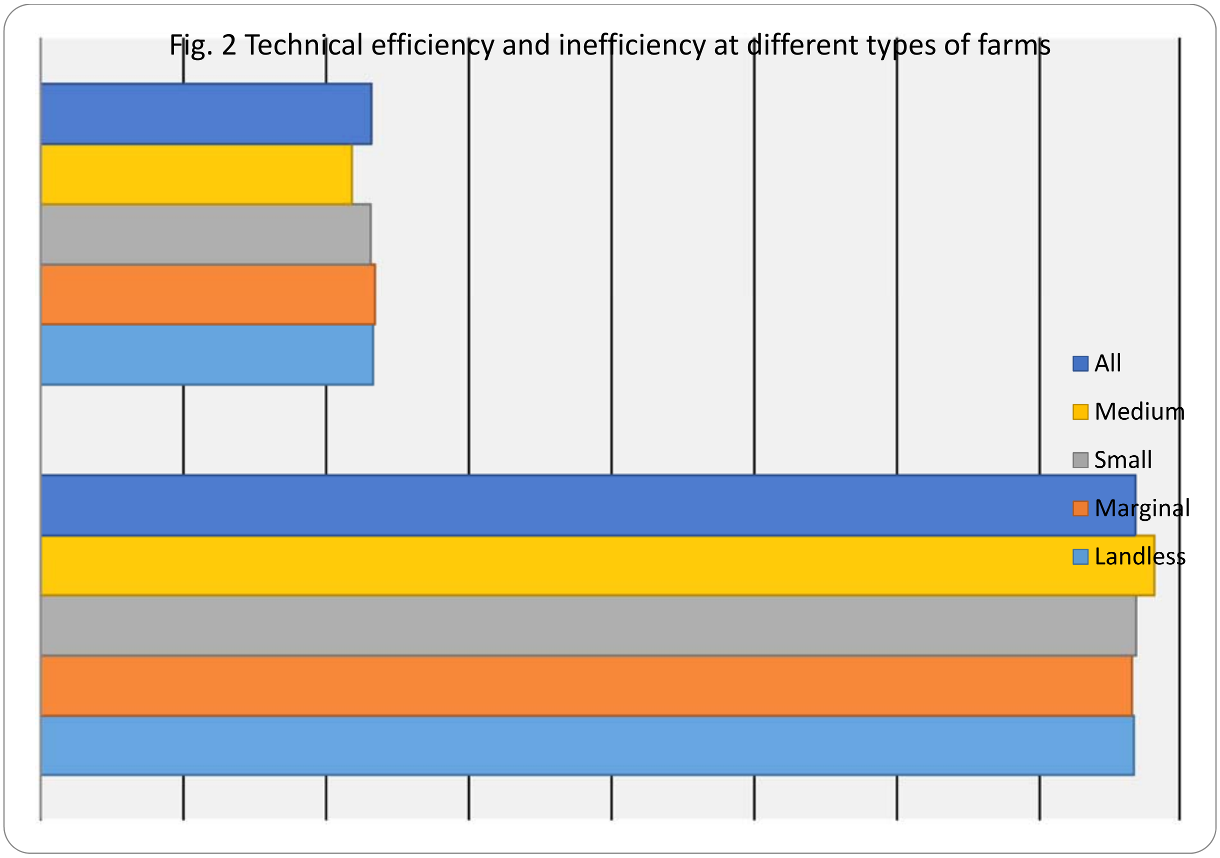
*, **, *** significant at 10%, 5% and 1% level of significance

Table 12: Efficiency level of the households by farm category

S.L. No.	Category of Farm holdings	Technical Efficiency*	Technical Inefficiency*	Ranking by TE	Ranking by TI
1.	Landless	0.767	0.233	III	II
2.	Marginal	0.766	0.234	IV	I
3.	Small	0.769	0.231	II	III
4.	Medium	0.782	0.218	I	IV
5.	All	0.768	0.233	-	-

*Significant at 10% level of significance

Differences in technical efficiency in the study area imply that some farmers are more successful compare to others in using technology efficiently. The table shows that medium farmers are technically efficient (i.e., 0.782), whereas small, landless and marginal farmers achieved 0.769, 0.767 and 0.766 levels of technical efficiency.



The study shows that there is a positive relationship between farm size and technical efficiency except marginal farm. On the other hand, there exists inverse relationship between farm size and technical inefficiency again except marginal farm meaning is farm size is a key determining factor for productivity. Higher technical efficiency of the medium farmers will not only enable them to increase the employment of productive resources, but also give them a direction of adjustments required in the long run to increase food production. On the other side, the low levels of technical efficiency of the marginal farmers suggest that the presence of random shocks (production risks) is negatively affecting the use of the technologies available to them due to the resource and cash capital problems of marginal farmers.

Conclusions and policy implications:

In terms of farm productivity, medium farmers have the highest yield of 6818 kg/ha followed by the small farmers with 6359 kg/ha, marginal with 6258 kg/ha, landless farmers with 6127 kg/ha, and large farmers with 5495 kg/ha. Net return from rice farming is minimal and medium farmers have the highest net earnings of 27033 Tk./ha where as small, marginal, landless and large farmers' net earnings are 20716 Tk. /ha, 15601, 1278 Tk./ha and -1094 Tk./ha, respectively. Farm-specific technical efficiency was calculated using translog stochastic production frontier function and estimated by the maximum likelihood estimation model. It is found that medium and small farmers have the higher level of efficiency and marginal farmers are the least among the farm types. It is seen that medium farmers have more options in choosing technologies and cash capital availability than any other categories of farm. On the other hand, marginal farmers are resource poor and they have cash capital constraints as well and due to that they are technical inefficiency is higher. Medium farm owners deserve more attention from the government side and they should get priority to receive new technologies in agricultural production particularly rice production. Cheaper price of rice during harvesting season is one of the main reasons of fewer net returns in rice farming as perceived by most of the famers. In addition, the farmers perceptions from FGD at village level is that the government policy in paddy procurement and increasing trend of farm input prices are also reasons for fewer margin. It is suggested that well ahead declaration of procurement price of rice and lower farm input prices policy can be good incentive for farmers to be in rice farming in the long run.

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