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PRODUCTIVITY AND RESOURCE USE EFFICIENCY IN RICE FARMING IN SYLHET DISTRICT, BANGLADESH

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ABSTRACT

Sylhet is the Northeast part of Bangladesh and its geographical location is little bit different from other districts in Bangladesh. Due to heavy rainfall and extensive march area (*haor*), rice is the only mono crop in the study area. Therefore, in this study, an investigation has been made to find out the input productivity and resource use efficiency of rice farm in Sylhet District. In total 120 farmers were selected randomly from three thanas of Sylhet District named Gohainghat, Fenchugonj and Balagonj, where equal number of samples were collected from each thana. Data were collected through farm survey by using a suitable pre-tested questionnaire. Cobb-Douglas Production Function, Marginal Value Product (MVP) and Marginal Factor Cost (MFC) are used for analysis. To find out productivity and resource use efficiency Cobb Douglas production function are used. The use of fertilizers is statistically significant at 1%, 5%, and 10% level of significance for all categories of farms. The use of inputs like human labour, seed, irrigation, insecticides, power tiller/animal power are also statistically significant but not for all the crops. Findings of the study revealed that the farmers were inefficient of the use of resources, generally, inputs such as fertilizer, seed and insecticides were under-utilized in Boro Paddy under three categories of farms (animal, power and pooled farm). The ratios of the MVP to the MFC were less than unity for Boro and Aman Paddy of all categories of farms except Boro Paddy in animal operated farm. The results show that there is need for making inputs such as HYV seeds, fertilizer, insecticides and machinery affordable and accessible to the farmers so as to improve efficiency. Moreover, policies that encourage the creation of alternative employment opportunities to absorb the excess labour used in rice production should be formulated.

Keywords: productivity, resource use efficiency, rice farm and mechanization

INTRODUCTION

As agriculture is one of the broad sector in the economy of Bangladesh and it contributes about 19.68% of the gross domestic product (GDP) and 47.5% of overall employment (BBS, 2012). Though the direct contribution of the agriculture sector has decreased gradually, but the indirect contribution has increased to the overall growth of GDP. The growth of broad services sector, particularly the growth of wholesale and retail trade, hotel and restaurants, transport and communication sector, is strongly supported by agriculture sector. The dominant food crop of Bangladesh is rice. Rice accounts for 94% of the cereals consumed, supplies 68% of the carbohydrate in the national diet, accounts for approximately 78% of the value of agricultural output, and 30% of consumer spending (Ahmed *et al.* 2000). It also accounts for 93% of the total crops produced and 76.62% of the cropped area ((Bangladesh Economic Review 2012). In Bangladesh 88.44% of the total households are located in rural areas and they are more or less dependent on agriculture for a living (Bangladesh Agricultural Census, 2010). Agriculture provides the basic food for the survival of the subsistence farmers in Bangladesh.

Sylhet is a mono cropped area where almost all the farmers cultivate Aman crop due to frequent and heavy rainfall in monsoon. The second highest rice crop grown in Sylhet district is Boro paddy. Inspite of the high risk of early flood, farmers cultivate Boro crop in *haor* area, which is very fertile because of siltation. Due to soil type and weather, Sylhet district is not suitable for growing other crops like wheat, jute, pulses, sugarcane and vegetables. Large portions of farmers of this district cultivate rice to meet their family needs and they are not interested for surplus production. Sometimes, land owners lease their land on contract basis called fixed-rent contract, one in which the landlord charges a sum of money per year or per season as a rent of the land and, in turn, allows the tenant to carry out production. The other type of contract is commonly referred to as sharecropping, which means the sharing of the tenant's output in some pre assigned proportion between the landlord and the tenant. Farmers of the study area are not aware about their resource productivity and efficiency in rice production. People of this area have a higher tendency to migrate abroad and the remaining family members have no interest in farming. So, labour shortage is a common problem of Sylhet district and hiring labour with high wage increased production cost.

Farm equipment are used in farming operations including immediate post harvest activities with a view to increase productivity of land and labour through timeliness of operations, for efficient use of inputs, improvement in quantity of production and safety and comfort of farmers, and reduction in loss of produce and drudgery of farmers. Power tiller mounted implements such as mould board ploughs, disc ploughs, cultivators and other crop-specific equipment are widely being used for seed bed preparation. Seed drills and planters, both animal drawn and Power tiller mounted, have became popular. Mechanization transplanters for rice and vegetables crops are catching up with farmers. Technological progress has helped Bangladesh to achieve self-sufficiency in rice production in 2001 from a heavy import-dependence, despite doubling of population and a reduction in arable land since its independence in 1971. As the adoption of modern varieties (MV) of rice is reaching a plateau, particularly for the irrigated ecosystem, and important issue is whether the research system will be able to sustain the growth of production (Mozumder *et.al.,* 2009; Pandey, 2004; Miah, 2002; Roshan, 1991).

Three types of farms like animal operated, power tiller operated and animal plus power tiller (pooled) operated farms were shown in the study area but it is very expensive to use animal power in ploughing deep wetland. Using machinery (power tiller, shallow machine and thresher) helps to increase the cropping intensity by providing temporal and partial adjustment in crop production activities so that least time is lost between the crops and the farmer is able to raise more number of crops in a given time and it also helps able to reduce his cost. The post-harvest operation like threshing is undertaken; using machines not only reduces the losses but also improves the quality of the product. It is known to all that the literacy rate of Sylhet district is very low compared to other districts and the education level of the farmers is not in satisfactory level. Due to the lack of education farmers of this area cannot use High Yield Variety (HYV) seeds, fertilizer and insecticides properly. But we know education has a positive impact on resource use efficiency. So, it is clear that there is a great chance to increase productivity and profitability of rice farm in Sylhet district. Thus, keeping in view the importance of the study of input productivity and profitability of rice farm, the objectives were to identify the input productivity of different categories of rice farm, to examine the resource use efficiency at different levels of farm mechanization, to identify the constraints in the use of resource efficiently and to forward policy suggestions in increasing resource use efficiency.

MATERIALS AND METHODS

A micro-level study based on primary cross-section data was designed to attain the objectives of this study. The methodology of the study is mainly about the sampling procedure, collection of data and analytical framework.

Sampling

This study was conducted in Sylhet District. It comprises of twelve thanas – Sylhet Sadar, Gowainghat, Fenchuganj, Bishwanath, Balagonj, Beanibazar, South Surma, Zakigonj, Golapgonj, Jaintapur, Companigonj and Kanaighat. For collecting data, a three-stage stratified random sampling design was used. In the first stage, three thanas were selected from the list of all thanas in Sylhet District. In the second stage, two unions were randomly selected from each selected thana. In the third stage, one village was selected from each selected union using random sampling technique. To collect data about land area, production of rice, and costs and returns of rice production, 40 farmers were selected randomly from each village. To select the village, priority has been given on those areas where large numbers of farmers were engaged in rice production.

Since the study focuses on input productivity in a predominantly rice grown area, attempt was made to choose the villages, which had an average level of agricultural performance in their respective sub-regions. Relevant information like total rice growing area, number of farmers, extension service etc. were collected from thana agricultural offices.

Data Collection

Following the conventional survey techniques, primary data on resource availability and their use, input-output levels, prices of farm production and inputs as well as some other relevant information were collected by interviewing the farmers personally using a designed and pre-tested questionnaire.

Analytical Framework

Cobb-Douglas production function has been used to estimate the effects of various inputs employed for the production of rice in three categories of farms (animal operated farms, power tiller operated farms, animal plus power tiller operated farms). Six independent variables, namely human labour cost, seed cost, fertilizer cost, irrigation cost and tilling cost were taken into consideration, which likely to have an impact on production of two seasonal rice (Aman and Boro). All variables were expressed in monetary terms. The land use cost as a variable has not been considered, because this per hectare cost was fixed for all farmers in producing rice. To determine the contribution of the most important variables in the production process, the following specification of the model was applied:

$$Y_{ij} = a \; X_{ij1}^{b1} \; X_{ij2}^{b2} \; X_{ij3}^{b3} \; X_{ij4}^{b5} \; X_{ij5}^{b5} \; X_{ij6}^{b6}$$

In log-linear form the above function can be written as:

$$lnY_{ij} = lna + b_1 \, lnX_{ij1} + b_2 \, lnX_{ij2} + b_3 \, lnX_{ij3} + b_4 \, X_{ij4} + b_5 \, X_{ij5} + b_6 \, X_{ij6}$$

Where,

Y_{ij} = per hectare output of ith crop on jth type of farm,

X_{ij1} = human labour used (work days) per hectare for ith crop on jth type of farm

X_{ij2} = value of manures and fertilizers per hectare for ith crop on jth type of farm

X_{ij3} = value of seed per hectare for ith crop on jth type of farm,

X_{ij4} = cost of irrigation per hectare for ith crop on jth type of farm

X_{ij5} = cost of animal or power tiller or both per hectare for ith crop on *jth* type of farm,

$Xij6$ = cost of insecticide per hectare for ith crop on jth type of farm,

a = technical efficiency coefficient,

$b_1, b_2, ..$ = production elasticity of the corresponding inputs

The economic efficiencies of the farm can be measured by comparing the actual profits with the maximum possible profits on the basis of actual production functions of the farms. The production function was estimated for the sample farms and the marginal value productivities of the farms were then compared with the marginal factor costs to estimate the efficiency of the farm in question under the situation of unconstrained resources. The optimum use of a particular input would be indicated by the condition of equality of MVP and MFC.

$$\text{i.e. } \frac{MVP}{MFC} = 1$$

If the ratio of MVP and MFC equals one, the factor was said to be efficiently allocated on the farm; but if it was greater than (or less then) one, it can be concluded that profits can be increased (or decreased) by increasing (or decreasing) the use of factor. The marginal productivities of a particular resource represents the addition to gross returns in value term caused by an additional of unit of that resources, while other inputs are held constant. The most reliable, perhaps the most useful estimate of MVP is obtained by taking resources (Xi) as well as gross return (Y) at their geometric means. Since all the variables of the model were measured in monetary value, the slope co-efficient of the explanatory variables in the function represent the MVPs, which were computed by multiplying the production coefficient of given resources with the ratio of geometric mean (GM) of gross return to the geometric mean of the given resources.

$$\ln Y = \ln a + b_i \ln X_i$$

$$\frac{dy}{dx} = b_i \frac{y}{x_i}$$

$$\text{Therefore, } MVP(x_i) = bi \frac{\overline{Y}(GM)}{\overline{X}_i(GM)}$$

Where Y= Mean value (GM) of gross return in taka
Xi= Mean value (GM) of different variable inputs in Taka
(i= 1, 2,............)

RESULTS AND DISCUSSION

Resource Productivity

The input productivity for important crops grown on different categories of farms were examined with the help of production function analysis. Linear regression equation was estimated through ordinary least squares method, where the human labour, fertilizers, seed, insecticides, irrigation and land cultivation are regressed upon yield. Production functions on per hectare basis were estimated for Boro and Aman Paddy.

The estimated regression coefficients are presented in Table 1. It has been seen that, the inputs namely human labour, fertilizers, seed, insecticides, irrigation and land cultivation were jointly responsible for explaining about 31 to 95 percent variations in the yield of rice crops between the animal and power tiller operated farms. In the case of log linear Cobb-Douglas type of production function, the estimated parameters gave the production elasticity of factors included in the model. The elasticity of an input indicates the percentage increase / decrease of the quantity of that input keeping other inputs at a specified level.

Table 1. Estimated Production Functions for Rice Corps on Power tiller, Animal Operated Farms and Pooled Farms in Sylhet District

Category	Mechanical Power		Animal Power		Pooled	
Variables	Boro	Aman	Boro		Boro	Aman
Constant in log	2.0756	1.89	1.92	1.49	2.66	1.82
Human labour	0.104*** (0.055)	0.082** (0.032)	-0.044 (0.046)	0.010 (0.013)	0.052 (0.040)	0.023*** (0.013)
Fertilizers	0.060** (0.025)	0.168* (0.036)	0.078*** (0.041)	0.126** (0.050)	0.061* (0.020)	0.105* (0.030)
Seed	0.181* (0.053)	0.033 (0.031)	0.146** (0.061)	-0.003 (0.013)	0.206* (0.038)	0.015 (0.012)
Insecticides	0.033 (0.034)	0.007 (0.015)	0.043 (0.054)	0.008 (0.007)	0.042 (0.028)	0.023 (0.006)
Irrigation	0.024 (0.025)	-0.059 (0.009)	0.052 (0.098)	0.011 (0.072)	0.005 (0.021)	-0.036 (0.052)
Tillage	0.021 (0.033)	0.282* (0.053)	0.277** (0.110)	0.692* (0.060)	0.045 (0.029)	0.504* (0.046)
R^2	0.313	0.91	0.86	0.95	0.45	0.89
F Value	5.40	68.13	25.93	57.69	14.32	94.8
Returns to scale	0.423	0.513	0.552	0.844	0.41	0.634

* 1 % level of significance, ** 5% level of significance, *** 10% level of significance
Figure in the parenthesis show standard error of the respective co-efficient.

The coefficients of partial elasticity of production of all the six inputs (human labour, fertilizers, seed, insecticides, irrigation and land cultivation) are less than unity with positive signs at all the levels of mechanization implying diminishing marginal productivity of factor inputs. In other words, by holding other inputs constant at their geometric mean levels, and increasing any of them, the yield would increase at a diminishing rate. The coefficients of partial elasticity of production of inputs are greater or less than unity with negative sign indicates that any increase in these inputs will have negative impacts on total production of crops. The intercepts of the estimated equations are positive in the case of Boro and Aman Paddy on power tiller and animal operated farms.

Human Labour

It has been seen from Table 1 that the human labour use in the crop production process is statistically significant for Boro and Aman Paddy under Mechanized farm. The effect is significant at 10% and 5% level, respectively for Boro and Aman paddy in power tiller operated farms. The elasticity coefficients of human labour for Aman and Boro paddy indicate that the higher the use of human labour would surely increase the yields and returns of Boro and Aman paddy in all categories of farms, especially power tiller operated farm.

The insignificant effects of human labour use on output are found in the case of Aman paddy in animal power operated farms. The regression coefficient -0.044 indicates that for a unit increase of human labour in Boro paddy under animal operated farm the output will result in a 0.044 unit decrease. In the case of pooled farm the effect is statistically significant at 10% level for Aman paddy and the effect is statistically insignificant for Boro paddy under pooled farms. The comparison of elasticity coefficients of human labour among the different categories of farms in different crops shows that in the case of Boro, the elasticity coefficient is maximized in power tiller operated farms. This indicates the output is maximized in the power tiller operated farms by increasing one unit of human labour on such farms compared to other categories of farms.

Fertilizers

The production elasticity coefficients of fertilizers is statistically significant at 1% level in the case of Aman on power tiller operated farms. The coefficients are statistically significant at 5% level for Boro and Aman paddy on power tiller and animal operated farms, respectively. The coefficients are significant at 10% level for Boro paddy on animal operated farms. In the case of pooled farm the production elasticity coefficients are statistically significant at 1% level for both Boro and Aman paddy.

The comparison of elasticity coefficients indicates that in the case of both animal operated farms and power tiller operated farms, it is highest in Aman paddy production. Thus, the use of fertilizers would significantly increase the output of the Aman crop among various categories of farms.

Seeds

It is seen from Table 1 that the seed used in the production process is statistically significant for the Boro Paddy under power tiller operated and pooled farms. The effect is statistically significant at 1% level for Boro Paddy on power tiller operated and pooled farms and 5% level for Boro Paddy on animal operated farms. The insignificant effects of seed on output are found to be in the case of Aman Paddy on the power tiller operated farms. The production elasticity coefficient of -0.003 indicates that for a unit increase of the seed cost will result in a 0.003 unit decrease in the output of Aman paddy under animal operated farm. In pooled farm, 1% level of significance is found for Boro Paddy where as the effect was insignificant in the case of Aman paddy.

The comparison of elasticity coefficients of seed use among the different categories of farms for different crops has shown that for the Boro crops, the elasticity coefficient is maximized in power tiller operated farms. This indicates that the increase in the output would be maximized in the power tiller operated farms by the one unit increase seed use on such farms, than on the other category farms.

Insecticides and Irrigation

The production elasticity coefficients of insecticides and irrigation are statistically insignificant for Boro paddy on power tiller and animal operated farms. In the pooled farm the production elasticity coefficients of insecticides are statistically insignificant for both Boro and Aman paddy where as the irrigation has negative impact on production of Aman under pooled farm.

Tillage

The production elasticity coefficients of power tiller and animal power are statistically significant at 1% level in the case of Aman Paddy. The coefficient is statistically significant at 5% level for Boro Paddy on animal operated farms. The insignificant effects of power tiller use on output are found to be in the case of Boro Paddy on the power tiller operated farms. The production elasticity coefficient of Aman Paddy is statistically significant at 1% level under pooled farm where the coefficient is insignificant for Boro paddy in the case of pooled farm.

Returns to Scale

The returns to scale explain the behavior of change of yield when all inputs are changed simultaneously in the same proportion. This is indicated by the sum of individual elasticity coefficients of factors include in the Cobb-Douglas production function. Increasing, constant or decreasing returns to scale were said to exist, accordingly as the sum of coefficients was greater than, equal to, or less than unity. Based on this criterion, the sum of elasticity of the factors (Table 1) showed that there is no increasing return to scale in the case of Boro and Aman on power tiller, animal operated and pooled farms. Irrespective of the crops, returns to scale of all the crops is less than unity indicating the decreasing returns. Put in another way, unit increase of these factors of production would result in diminishing returns of all these cases.

Resource Use Efficiency

Resource Use Efficiency of Different Inputs under Power Tiller Operated Farm

The Table 2 has shown that the ratio of marginal value product of human labour to wage rate of human labor was positive but less than one for both Boro and Aman paddy indicating that too much resources are used and hence use of these resources need to be adjusted to bring it closer to unity. The MVPs for fertilizer and seed are positive and more than one, which implied that, more profit can be obtained by increasing investment on these inputs.

Table 2. Resource use efficiency of different inputs under power tiller operated farm

Various Inputs	Boro			Aman		
	Geometric Mean	Co-efficient	MVPs	Geometric Mean	Co-efficient	MVPs
Human Labour	14764.78	0.104	0.629	16155.25	0.085	0.47
Fertilizer	2038.56	0.060	2.63	1863.10	0.166	8.04
Seed	1863.10	0.181	8.67	1719.86	0.037	1.94
Insecticides	727.77	0.033	4.05	749.94	0.008	0.96
Irrigation	6124.17	0.024	0.35	6374.11	-0.059	-0.83
Power tiller	4675.07	0.021	0.41	4447.04	0.280	5.68
Gross Return	89321.72			90219.42		

Source: Author's Calculation

Under power tiller operated farm the MVP of use of insecticides is positive but greater than one in Boro paddy and less than one in Aman paddy. So, more return can be obtained by increasing investment in fertilizer in Boro paddy but in the case of Aman paddy increasing the use of insecticides need to be adjusted to bring it closed to unity. The MVP of irrigation is negative in the Aman paddy indicating that the farmers would be losing by applying additional irrigation in Aman production. Here the irrigation system is need to be adjusted in the production of Boro paddy because the MVP is less than unity. Much use of power tiller in the Boro paddy has decreased the return but has positive impact on Aman paddy.

Resource Use Efficiency of Different Inputs under Animal Operated Farm

The ratio of marginal product of fertilizer, seed, insecticides, irrigation and animal power to its price is greater than unity in Boro paddy under animal operated farm (Table-3). This has implied that fertilizer, seed, insecticides, irrigation and animal power use could be increased in Boro paddy.

Table 3. Resource use efficiency of different inputs under animal operated farm

Various Inputs	Boro			Aman		
	Geometric Mean	Co-efficient	MVPs	Geometric Mean	Co-efficient	MVPs
Human labour	14617.86	-0.044	-0.26	14044.69	0.010	0.059
Fertilizer	1540.71	0.078	4.43	1352.89	0.126	7.83
Seed	1635.98	0.146	7.81	2038.56	-0.003	-0.12
Insecticides	812.40	0.043	4.63	1754.60	0.008	0.38
Irrigation	4447.06	0.085	1.67	6185.72	0.011	0.15
Animal Power	4536.90	0.277	5.34	4023.87	0.692	14.46
Gross Return	87553.03			84120.04		

Source: Author's Calculation

The MVP of human labour is negative in Boro paddy indicating that the farmers would be losing by applying additional labour forces in Boro production. In the case of Aman paddy the MVPs for fertilizer and animal power are greater than one, which implied that more profit can be obtained by increasing investment in these inputs. The MVPs of human labour and insecticides are less than one implied that too much use of these resources and hence use of these resources need to be adjusted to bring it closer to unity. In Table 2, it is seen that the ratio of marginal value product to the price of animal power is very high in the case of Aman Paddy, whereby increasing the use of animal power, profit can be maximized to a greater extent than compared to the other inputs.

Resource Use Efficiency of Different Inputs under Animal plus Power Tiller (Pooled) Operated Farm

The results of the efficiency have shown that the ratio of marginal value product of human labour to wage rate of human labour is less than unity for Boro and Aman crops. This indicates that the use of human labour was more than the profit maximizing levels in the Boro and Aman crops on pooled farms.

Table 4. Resource use efficiency of different inputs under pooled farm

Various Inputs	Boro			Aman		
	Geometric Mean	Co-efficient	MVPs	Geometric Mean	Co-efficient	MVPs
Human Labour	14764.78	0.052	0.31	15367.34	0.023	0.12
Fertilizer	1881.83	0.061	2.87	1669.03	0.105	5.29
Seed	1790.05	0.206	10.17	1826.21	0.015	0.69
Insecticides	749.94	0.042	4.95	992.27	0.023	1.94
Irrigation	5597.07	0.005	0.79	6124.17	-0.036	-0.49
Animal & Power Tiller	4628.55	0.045	0.85	4402.81	0.504	9.62
Gross Return	88432.95			84120.04		

Source: Author's Calculation

The employed of human labour could be decreased particularly on pooled farms, so as to maximize the returns to human labour. It has been noted that the ratio of marginal value product of fertilizer, seed, insecticides, irrigation and animal plus power tiller to its cost are greater than unity in Boro paddy on pooled farm. This is corroborating the fact that there is a greater scope for fertilizers, seed, insecticides, irrigation and animal plus power tiller employment on pooled farms. The marginal value product of human labour and seed to its price is less than unity in pooled farms and this implied that human labour and seed use could be decreased in Aman production. In the case of Aman paddy the ratio of marginal value product of irrigation to its cost is negative indicating that the farmers would be losing by applying more additional irrigation in Aman production.

Findings from this study revealed that rice producers were technically inefficient in the use of farm resources. The inefficiency of the farmers may be directly or indirectly linked to the excess use of family labour, high cost of fertilizer, insecticides and improved seeds. Technical efficiency of rice production in Sylhet region could be increased through better use of fertilizer, seeds and insecticides. Government and research institutions should play vital role to improve the efficiency of the farmers providing the modern rice production technology. There should be improvement in extension services delivery at the farmers level. The provision of improved rural infrastructures and enabling policies such as making available all agricultural inputs required at the right time and affordable prices. Capital machinery such as power tiller, tractor, shallow tubewell, harvesting machine and thresher should be supply at low price. In addition, there should be policies that encourage the creation of alternative employment opportunities to absorb the excess labour used in rice production.

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