Bangladesh Journal of Political Economy

Vol. 29, No. 1, June 2013, pp.169-188
Bangladesh Economic Association
(ISSN 2227-3182)

Impact of Farm Mechanization on Productivity and Profitability of Rice Farm in Rajshahi District

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Abstract *Rajshahi is a district of North Bengal part of Bangladesh, which is basically an agricultural area, where growing crops is the main activity of the people although some people engaged are also in non-farm activities. Rice is the main crop of the study area. Farmers can grow rice very easily in the Barind area under the Barind Multipurpose Development Project where farmers get irrigation facility at cheap cost. Due to shortage of rainfall and shortage of underground water farmers of Puthia, Charghat and Bagha thanas are dropouts from rice cultivation and transform their agricultural land into fruit tree as well as wooden tree plantation (Noman and Joarder, 2011). The finding of the study is that among the three categories of tillage methods such as power operated, animal operated and power plus animal operated (pooled) tillage, most of the farmers use power tiller/tractor for tilling their land and still some farmers use animal power for tilling. Combine tillage method (power and animal operated) is also found in the study area. It is found from the study that the actual productivity of the inputs is very low compared to the optimal attainable production. Due to lack of modern technology, high input cost, and low market price, the profit margin is very low of Boro and Aman paddy. Farmers in the study area have faced different kind of problems in the case of using modern technology and rice production. Poor buying capacity, small farm holding, high market price of machines and spare parts and labour shortage are the major constraints in the improvement of mechanization. Natural disaster like drought hampers the crop production.*

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The price of fertilizer, mainly the price of urea has doubled within the last three years. Price of diesel has increased day by day, which greatly affects the Boro production. On the other hand, farmers do not get the fair price of their crops. As a result farmers lost their interest in crop production and migrate to industrial areas for searching jobs or to transform their land into mango orchard or wooden garden and sometimes large farmers lease their land to the marginal farmers or give their land to the sharecroppers.

Key Words: *Farm Mechanization, Resources Productivity, Profitability*

1. Introduction

Bangladesh is a small country in South Asia with a population of about 152.5 million, increasing at a rate of 1.37 percent, adding 2 million labour to the existing 72 million every year (BBS 2011, final census report July 2012). Agriculture is the principal economic activity and the basic source of employment (47.33 percent labour force engaged in agriculture sector, Labour Force Survey 2010, BBS), income and export earnings of Bangladesh. It plays a vital role in the economic growth and stability of the country. Despite four decades of planned development efforts and attempts to industrialize the economy, Bangladesh Economy has still remained a rural based economy. Agricultural performance has direct impact on macroeconomic objectives like poverty alleviation, employment generation, development of human resources and attainment of food self sufficiency.

In Bangladesh, agriculture is the third largest sector of the economy (Bangladesh Economic Review 2011), where service is the first and industry is the second largest sector. In FY 1972-73, agriculture sector was the largest sector (49.76 percent of total GDP) but gradually the contribution of agriculture sector has decreased and at present (FY 2011-12) the contribution of agriculture sector is only 19.42 percent (provisional) of total GDP. Though the direct contribution of agriculture sector has been falling, the indirect contribution has been increasing day by day because our service sectors like, wholesale and retail trade, hotel and restaurant, transport and communication as well as the supply of food for industrial labour are strongly supported by the agriculture sector.

Bangladesh agriculture has grown at 3.2 percent annually during 1991-2005 and the dominant source of this growth was the crop sub-sector, which grew at 2.3 percent per annum. Over the last 40 years, Bangladesh has greatly increased its food grain production from 19.06 million metric tons in 1995-96 to 26.69 million metric tons in 2002-03 and 31.12 metric tons in 2007-08. The total food grain production in 2010-11 was 36.06 million metric tons. The contribution of rice in

total food-grain production was 93.0 percent in 2010-11and it was 94.56 percent in 2009-10 (Bangladesh Economic Review 2012). Despite the fact agriculture is still the driving force of the Bangladesh economy, it is a tough job to feed the 152.5 million people from 8.2 million hectares of cultivable land. Every year almost 3.0 million people are being added to the total population whereas the estimated annual shrinkage of agricultural land is about 0.08 million hectares due to various non-agricultural activities like construction of houses, offices, roads, mills and factories (BRRI 2009). So, there is no better option to feed the county's huge population except increasing productivity of the existing land.

"Food for all" and "food security" are the prime commitments of the Bangladesh Government. As such, government has given top priority to the agriculture sector to achieve self sufficiency in food grain by 2013 through increased production. Total production or domestic supply of food grains was 36.06 million metric tons in FY 2010-11 and at the same time 5.15 million metric tons of food grains was imported of which 1.55 million metric tons was rice and 3.60 million metric tons was wheat. From this, it can be said that Bangladesh is not self sufficient in food grains production. For attaining food self-sufficiency through increased crop production the use of modern technology, chemical fertilizers, modern varieties of inputs, irrigation facilities and pesticides should be increased.

In 1980-81 the cropping intensity of Bangladesh was 159.69 percent, and it increased to 175.9 percent in 2000-2001 (BBS 2006). To meet the food requirements of the ever growing population of the country in 2015, an additional 5 million metric tons of food grains will be needed to produce from the continuously decreasing lands. So, to achieve this target, there is no other option than to increase production per unit of land as well as cropping intensity, which can be increased up to 250 percent. This will need much heavier investment in technological improvement and modern methods of cultivation.

1.2 Problem Statement

Farm mechanization is the main plank of modern agriculture. Many developed countries revolutionized by using farm mechanization, which resulted in tremendous production and productivity gains. However, the conditions under which it was introduced in those countries differ greatly from Bangladesh context. Two of the most important conditions were the shortage of labour and large size of farm. But as the pressure of population on land is increasing steadily, the solution lies in mechanizing agriculture, which would realize the goal of achieving targeted food gains production in Bangladesh.

The main driving force of the economy of Rajshahi district is agriculture and hence the expansion of agricultural production which is concentrated in rice, wheat, sugar cane, jute and vegetables production. Nevertheless, the potential of agricultural production lies in crop diversification. The crop diversification can be enhanced by farm mechanization in this region. Moreover, the shortage of draught power encourages farmers to use the mechanized system. Farm mechanization helps increase the cropping intensity by providing temporal and partial adjustment in crop production activities so that least time is lost between the two cropping seasons and farmers can raise more number of crops in a given time. The inherency of lobour shortage in agriculture during important field operations like transplanting, weeding, fertilizer application, etc. can be minimized by economic and efficient use of machines. Further, certain activities like deep ploughing in wetland demands the use machinery to improve the quality of operations. The post-harvest operations like threshing, if undertaken, using machines not only reduce the losses but also improve the quality of the product in some cases. The main question to be answered in this study is whether mechanization would help in achieving the objectives of increasing the farm income, inter-alia taking into consideration the more use of farm machineries.

A study of resource productivity on mechanized, non-mechanized and pooled farms may explain the marginal value productivity of inputs among the three categories of farms and justify the investment demands. The measurement of profitability involves the comparison of profit margin among mechanized, non-mechanized and pooled farms.

Further, there is a need to study the changes in the composition and use of the farm machinery in the farms over the years to find out the changes in technology and its adoption by farmers.

1.3 Objectives of the Research

The following objectives are formulated keeping in view the importance of farm mechanization and challenges faced by it.

a. To measure profit margin of rice production under different categories of farms.
b. To analyze productivity changes in agriculture under mechanized and non-mechanized farm.
c. To identify the constraints of using farm machinery and develop the policy initiatives for adoption of mechanization.

Rajshahi district is comprised of nine upazilas named Poba, Tanore, Mohonpur, Godagari, Puthia, Bagmara, Durgapur, Charghat and Bagha. Each upazila is divided into several unions, mouzas and villages. The area of Rajshahi district is 2407 square kilometer and the total population is 2.57million, of which the male population is 1.30 million and female population is 1.25 million (BBS, 2012). Rajshahi is a district of North Bengal region, which is basically famous for agricultural activities. There are some small and medium industries where agricultural commodities are used as raw materials.

Most of the people of Rajshahi district are farmers and agriculture is the main activity of the people along with some non-farm activities. The farmers of the study area grow two or three crops in a year in their land and their major crops are rice, wheat, sugarcane, jute, pulses, oilseeds, maize vegetables etc. It is observed that there have been significant variations of the cropping patterns among upazilas as well as among farmers. From the field survey, it is clear that rice is the main crop of the study area. Farmers can grow crops very easily in the Barind area because under Multipurpose Development Project farmers get irrigation facility with cheap cost. Because of the shortage of rainfall and underground water, farmers of Puthia, Charghat and Bagha thanas are not interested to cultivate rice.

To get a clear insight and comparison of productivity and profitability, we divided the rice farms into three categories such as power operated, animal operated and pooled (power plus animal operated) farms on the basis of tillage methods. In the study area, most of the farmers use power tiller/tractor for tilling their land and a small fraction of farmers use animal power. Farmers in the study area use deep tubewell, low lift pump or shallow tubewell for irrigation and weed out their land by hand and sometimes they use medicine to kill the grass of the field. Farmers harvest their crops manually because of small farm size and no harvesting machine. Threshers are available in the study area. Some farmers have their own threshers and some rent it from others. In the case of crop production farmers have faced different kinds of problems. Natural disaster like shortage of rain hampers the rice production. The price of fertilizer, mainly the price of urea, has doubled over the last three years. Price of diesel has increased day by day which greatly affects the Boro production. On the other hand, farmers do not get the fair price of their crops. As a result farmers lost their interest in crop production and migrate to industrial areas for searching jobs.

1.4 Rationale of the Study

Though Bangladesh is an agricultural country, our farmers are not familiar with modern technology in farming. The use of modern technology has increased in the

recent decade compared to 80s and 90s of the last century but the rate is still not satisfactory. Still our farmers do their agricultural activities in traditional way which takes more time and increase production cost. On the other hand, using modern technology saves time and reduces production cost and also increases cropping intensity. Though our local producers have manufactured light machines and spare parts, the diesel engine and heavy machines (tractor, harvesting machine etc.) are imported from abroad. So, it is very necessary to find out the level of mechanization and the constraints which hampered the enlargement of mechanization. World food security and increasing food price in international market are the major concern of policy makers and economic planners. Still Bangladesh couldn't achieve self-sufficiency in food grain production and so, there is no chance of self-content in this matter. Every year more than 1 million metric ton additional food grain will be needed to meet up the over-growing demand of population. To increase the production, it is crucial to find out the productivity of different inputs. Cob-Douglas production function and profit function are used in measuring the productivity and profitability of rice production. This study helps us to find out the gap between actual production and optimal attainable production that can be achieved by readjusting inputs. Since there are very few studies in this area, the findings of the study have filled up some of the gaps in the literature of mechanization and productivity measurement. We hope this research work will help the government, policy makers, and international agencies in policy formulation and its implementation. Finally, future researchers may also benefit from this research work in terms of getting ideas and guidelines for their work.

2. Review of Literature

There has been a continuous debate on the impact of mechanization in agriculture since the days of green revolution. The last few years have added more to the controversy on power tillers and tractors, further complicated by the latest biological and mechanical innovations. It is, therefore, not surprising that apart from the massive amount of research work done by individuals and organizations, there have been frequent demands from the policy makers to undertake further specific studies in this area. Hence the important work carried out on this aspect is reviewed comprehensively to understand the direction of research carried out so far and to evolve a possible improvement over such available studies. Majumdar *et al.* (2009) have explored the difference in the efficiency and productivity among owner, cash tenant and crop share tenant. Total cash expenses as well as total gross costs for producing HYV Boro rice was highest in owner

farms and lowest in crop share tenant's farm. When individual inputs were concerned it was observed that expenses on human labour shared a major portion of total expenses in the production of HYV Boro rice where owner operators used more hired labour in comparison to other groups. However, the cash tenant farmers were more efficient than owner and crop share tenant farmers. Due to poor resource base the crop share tenants were unable to invest on modern farm inputs. It may be mentioned that in Bangladesh the predominant tenancy arrangement is share cropping, which is an inefficient form of tenure arrangement compared to cash tenancy.

The Organic method of rice production was more productive than LEISA (low external input sustainable agriculture) and conventional methods. Only 52 USD was spent and 277 McCall of energy used in producing 1 ton of paddy rice through the organic method while 63 USD was spent and 501 McCall of energy were used in LEISA (Mendoza, 2002). The agrochemical input (fertilizer/ pesticides) accounted for 61% of the fossil fuel based energy inputs and 84% of the cash cost of production in the conventional system. Organic rice farmers earn 7 dollars per 1 dollar cash expense while only 2 dollars in conventional and 5 dollars in LEISA. The findings in this case study have shown that the organic method of production is a cost effective (and energy efficient) means of solving the recurring credit problems of capital-scarce rice farmers in the Philippines. The Government extension program should equally promote the organic method of rice production.

Ahmed (1983) has shown that power tiller farms allocated more land to cash crops than animal farms, where food crops (44.5% of land area) and fodder crops (18.7%) occupied larger areas. Yield per acre of major crops was higher on power tiller farms than animal farms. Higher yield rates were the result of greater use of water and fertilizer in addition to power tillerisation on these farms. Total labour input per cropped area was 19.8 percent less on these farms as compared to animal farms. Gross income and total cost per acre were higher by 37.5% and 10.3% on power tiller farms as compared to the animal farms.

Sidhu and Grewal (1990) have found that in spite of replacement of animal power by power tillers and higher use of weedicides, which are labour saving in nature, the area under labour intensive crops like sugarcane, potato and paddy increased. Uses of fertilizers enhanced production and enabled the power tiller farms to employ more human laborers as compared to animal farms.

Sharma (1995) has shown in his study that employment of hired human labour was more on power tiller operated farm, which showed an upward trend among

medium and large farms in case of Hissar whereas it showed a reverse trend in Joipur. The average net income was found to be higher in the case of power tiller operated farms at both the phases. A comparison between the elasticity coefficients of animal power and power tiller horse power showed that the use of power tiller increased the output more than by the use of animal power and the sum of the production elasticities were nearly unity indicating constant returns to scale on all the sizes of farms in all the cases

Pandey (2004) discussed that farm equipment are used in farming operations, including immediate post harvest activities, with a view to increasing 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.

The different studies reviewed, have investigated extensively on the effects of Power tillerisation on farm labour employment, output and farm income levels. The changes in the cropping patterns and cropping intensity due to the process of mechanization were also studied. There were also attempts on the part of researchers on the policy implications of mechanization strategies and the factors affecting the process of power tillerisation.

3. Methodology

A requisite micro-level study based on the primary cross-section data has been designed to attain the objectives of this study. The methodology has mainly dealt with the sampling procedure, collection of data and analytical framework that are used in this study.

3.1 Sampling

For collecting data, three-stage stratified random sampling design has been used. The present study is conducted in Rajshahi District and the study area lies in nine thanas such as Poba, Tanore, Mohonpur, Puthia, Bagha, Charghat, Durgapur, Godagari and Baghmara. A sample of 135 farmers has been taken from nine thanas for the study. From each thana we have selected one union and then randomly selected three villages for collecting 15 samples of farmers. To select village, we have given priority to those areas where large numbers of machinery are used. Since the study has focused attention on technology adoption and its determinants in a predominantly rice growing area, an attempt is made to choose the villages which had an average level of agricultural performance in their respective sub-regions. We also got agricultural information from thana

agricultural office. The sample is selected in such a way that the farmers of each village are the representative of this village.

3.2 Collection of Data

Following the conventional survey technique, primary data on resource availability and their use, input-output levels, prices of farm produce and inputs and some other relevant information were collected by interviewing the farmers personally with the help of suitably designed and pre-tested questionnaire. Secondary data regarding location, climate, soil irrigation, major crop enterprises, population, land utilization pattern, insecticides and fertilizer consumption in of the region were compiled from the records of district and other government publications.

3.3 Analytical Framework

The data were subjected to tabular analysis for examining the cost and returns at different levels of adoption for farm business as a whole and for different crop enterprises separately. The standard cost and income measures were used in this part. The information on level of adoption by constructing suitable indexes has been presented separately.

3.4 Profit Function

Profits for each of the individual crops in the three categories of farms (power operated, animal operated and pooled) were calculated separately. The activity budget as suggested by Dillon and Hardaker (1980) was employed for deriving the profit equation. The profit equation of the following form is used:

$$\pi_1 = P_{yi}.Y_i + P_{bi}.B_i - \sum_{i=1}^{n} \left[\left(P_{xji}\right].X_{ji}\right) - TFC$$

Where

Π_I = profit per acre from ith output,
P_{yi} = per unit price of ith output,
Y_i = total quantity per acre of ith output,
P_{bi} = per unit price of ith by-product,
B_i = total quantity per acre of ith by-product,
P_{xji} = per unit price of jth input used in producing ith output,
X_{ji} = total quantity of jth input used for the production of per acre ith output,
TFC = total fixed costs involved in producing per acre ith output,
I = the number of individual crops produced by the farmers,

J = the number of individual inputs used for producing the relevant product,
n = 1, 2, 3, ... n.

For the lack of exact information, the fixed cost (rent of land) is omitted from analysis.

3.5 Resource Productivity

Production function analysis is used to obtain the marginal value productivity of inputs used in crop production at different levels of technology adoption. For judging the marginal value productivity of the three categories of farms separately, namely the power operated farm, animal power operated farms and pooled farms for different inputs such as labour, seed, fertilizers and insecticides on sample farms, the Cobb-Douglas production function has been used. The impact of farm mechanization on human labour use, fertilizer application, tillage, seed use, irrigation and the net returns of the farms are examined under optimized resources situation. The utility of Cobb-Douglas production function in solving this type of problems precisely and quickly is well known. In general, Cobb-Douglas production function can be written as:

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

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

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

Where,

Y_{ij} = per acre output of ith crop on jth type of farm,
X_{ij1} = wage of human labour (work days) per acre for ith crop on jth type of farm,
X_{ij2} = value of manures and fertilizers per acre for ith crop on jth type of farm,
X_{ij3} = value of seed per acre for ith crop on jth type of farm,
X_{ij4} = cost of irrigation per acre for ith crop on jth type of farm,
X_{ij5} = cost of animal or power tiller per acre for ith crop on *jth* type of farm,
X_{ij6} = cost of insecticide per acre for ith crop on jth type of farm,
u_i = error term,
a = technical efficiency coefficient,
b_1, b_2, b_3. . .= production elasticity of the corresponding inputs

4. Results and Discussion

4.1 Profitability

Profitability measures the amount where revenue outweighs the cost. Profit comes out by using some fixed amount of inputs. In order to find out comparative profitability of different cropping patterns, costs and returns of Aman and Boro paddy have been considered. The profitability is measured based on full cost basis by taking consideration of the opportunity cost of the different inputs.

As can be seen in Table-1, the input cost as well as the output value of Boro paddy is higher than Aman paddy of all three categories of farms. The output value of Boro paddy (per acre) in power operated farm is Tk. 45331.58, whereas the total input cost is Tk. 32261.85 and farmers have to spend maximum money for hiring labour and buying fertilizers since the cost of both inputs has increased in the last few years. In Bangladesh the opportunity of non-farm activities has increased because of the flourishing garments industry and expansion of service sector. The rural agricultural labour has migrated to urban industrial areas and as a result labour shortage has occurred in planting and harvesting period. This labour

Table 1 : Profitability of Boro and Aman Paddy of Different Categories Farms in Rajshahi District

Farm Category	Gross value	Labour Cost	Fertili. Cost	Seed Cost	Insect. Cost	Irrigation Cost	Tillage Cost	Total Cost	Profit
Boro (power)	45331.6	16462.1	7443.9	1132.1	1182.6	3390.0	2651.0	32261.8	13069.7
Aman (power)	35122.5	15333.0	5848.3	1098.7	820.5	1795.5	2826.0	27722.1	7400.4
Boro (animal)	47146.3	14655.0	8507.6	1213.5	1428.5	4515.7	2417.7	32738.1	14408.1
Aman (animal)	32740.0	14216.0	6203.6	1033.3	908.6	1821.6	2334.0	26517.3	6222.6
Boro (pooled)	46407.9	16234.1	7126.6	1057.3	1182.2	3825.0	2950.9	32376.3	14031.6
Aman (pooled)	32685.0	15793.5	5963.7	1050.6	1822.5	1822.5	2961.0	29413.8	3271.1

Source: *Author's Own Calculation*

shortage has increased labour wage as well as production cost of agriculture in the rural area. Moreover, in 2009 the price of urea fertilizer was doubled from Tk. 10 per kg to Tk. 20 which sharply increased the cost of production. Moreover, urea is the most necessary and highly used fertilizer for rice cultivation. The same scenery has been seen in the case of Boro paddy in animal operated and pooled farms.

The output value of Aman paddy varies between Tk. 32000 and Tk. 35500 of all categories of farms whereas the total input cost ranges from Tk. 27000 to Tk. 29500. In the case of Aman paddy, labour cost is alarmingly high like Boro paddy in all categories of farms. The fertilizer cost of Aman and Boro paddy is almost the same since farmers used more fertilizer in the production of Aman paddy to get higher yield. Since the Aman paddy is cultivated in rainy season, irrigation cost is almost half compared to Boro paddy and low irrigation cost in Barind area has also reduced the average irrigation cost in the study area. If we compare the irrigation cost in Barind area with non-Barind area then it is found that the irrigation cost is double in non-Barind area.

If we compare the profit margin between two crops in power operated farms then it is seen that the profit of Boro paddy is twice compared to Aman paddy because per acre yield of Boro paddy is higher than Aman paddy though the total input cost is little bit higher in Boro production. One of the most important findings of our study is that the tillage cost is high in pooled farm (Tk. 2950.9 per acre) compared to power (Tk. 2651.0 per acre) and animal (Tk. 2417.7 per acre) operated farms in Boro production. The same scenery is found in Aman paddy where tillage cost is higher in pooled farm compared to power and animal operated farms. The profit margin of Boro and Aman paddy supports the comment of the farmers that agricultural activity is no more profitable. Per acre net income from Boro paddy varies from Tk. 13000 to Tk. 14500 whereas the net income from Aman paddy varies from Tk. 3000 to Tk. 7500. If the profit margin remains at this level, farmers in near future will quit agricultural activities and the sign is already seen in Rajshahi District where agricultural land is transformed into mango garden.

4.2 Net Returns

The allocation of farm resources does not mean only the change in the cropping pattern, but also to maximize the net returns of farmers. The farmer is more interested to continue his farming business and hence he should be able to get at least what he spends. The net return over variable cost of an activity or crop process was determined by deducting the variable cost from the corresponding

gross income and dividing the result by variable cost and expressing it in percentage. It can be seen in Table-2 that the net return of Boro paddy is high compared to Aman Paddy of all categories of farms. But the production cost is almost the same for the production of Boro and Aman paddy. We have a clear insight from the result that the net return from animal power using farm is higher than power (power tiller/tractor) using and pooled farms since the net return from animal power using farms is 44.01% whereas the net return from power using and pooled farm are 40.51% and 43.34%, respectively, in the case of Boro paddy. The net return of Aman paddy from pooled farm is very much less compared to power and animal operated farms.

Table 2 : Net Return over Variable Cost under Existing Plans on the Sample Farms

Crops	Total Return	Variable Cost	Return Over Variable Cost	Net Return (%)
Boro (power)	45331.58	32261.85	45331.58	
			32261.85	40.51%
Boro (animal)	47146.25	32738.10	47146.25	
			32738.10	44.01%
Boro (pooled)	46407.95	32376.32	46407.95	
			32376.32	43.34%
Aman (power)	35122.50	27722.10	35122.50	
			27722.10	26.69%
Aman (animal)	32740.00	26517.33	32740.00	
			26517.33	23.47%
Aman (pooled)	32685.00	29413.85	32685.00	
			29413.85	11.12%

Source: *Author's Own Calculation*

In the last few years the market price of rice has not increased on the one hand but on the other side the input cost has increased so much. Labour, fertilizer and irrigation cost has increased remarkably and due to lack of sufficient rain in the rainy season farmers have to irrigate their Aman paddy through power pump, which increased the production cost. Among three categories of farms, the net return from Aman paddy is the lowest in pooled farm since the labour and tillage cost is very high compared to power and animal using farms. Another reason of this low rate of return is that the total return is also minimal of the pooled farm.

4.3 Inputs Productivity

Agricultural productivity is most often assessed by measures of crop yield. These measures are expressed as product per unit of land, labour, fertilizer, seed, insecticide, tillage and irrigation.

The resource productivity of important crops grown on different categories of farms is examined with the help of Cobb-Douglas production function. Hence, Log-Linear regression equation was estimated through ordinary least squares method where the human labour, fertilizers, tillage, irrigation, seed and insecticide were regressed upon yield. Production function on per acre basis is estimated for Boro and Aman paddy. The estimated regression coefficients are presented in Table 3. It is observed in the table that the inputs, namely human labour, fertilizers, seed, insecticides, irrigation and tillage were jointly responsible for explaining about 16 to 57 percent variations in the yield of Boro and Aman paddy in three categories of 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 with a specified level of other inputs.

The coefficients of partial elasticity of the production of all six inputs (human labour, fertilizers, tillage, irrigation, seed, and insecticides) were less than unity with positive signs at all the levels of mechanization implying diminishing marginal productivity of input factors. In other words, by holding the other inputs constant at their geometric mean level, and increasing any of them, the yield would increase at a diminishing rate. The coefficients of partial elasticity of the production of inputs were greater or less than unity. The negative sign of the coefficients indicates that an increase in these inputs will have negative impact on total production of crops.

The intercepts of the estimated equations are positive in the case of Boro and Aman paddy on power, animal and pooled farms.

4.4 Productivity of Human Labour

It has been seen from Table-3 that the use of human labour in the crop production process is statistically significant in Aman Paddy under animal operated and pooled farms. The effect is significant at 10% and 5% level in Aman Paddy in animal operated and pooled farms, respectively. These results indicate that by increasing human labour it would be possible to change the returns of Aman Paddy of all farms especially in the animal operated and pooled farms. In the case of power operated and pooled farms human labour has a positive impact on Boro production, which means, if the farmers increase one percent of human labour, the output will increase 0.08 and 0.09 percent respectively. The output of Aman paddy will increase 0.03, 0.21 and 0.48 percent, if the use of human labour will increase by one percent in power operated, animal operated and pooled farms, respectively.

Table 3 : Production Functions of Selected Crops on Power Operated, Animal Operated and Pooled Farms in Rajshahi District

Variables (in terms of log)	Power Operated Farm		Animal Operated Farm		Pooled Farm	
	Boro	Aman	Boro	Aman	Boro	Aman
Constant	1.6317	1.184	2.374	2.29	2.466	1.042
Human Labour	0.085	0.026	-0.060	0.211***	0.094	0.479*
	(0.099)	(0.269)	(0.059)	(0.131)	(0.158)	(0.206
Fertilizer	0.235**	0.148	0.010	-0.103	-0.658	0.123
	(0.100)	(0.102)	(0.049)	(0.080)	(0.370)	(0.269
Tillage	0.039	0.331	-0.088	0.048	-0.252	0.224
	(0.025)	(0.237)	(0.066)	(0.077)	(0.251)	(0.507
Irrigation	0.207	0.076	0.008	-0.001	0.411***	-0.639
	(0.148)	(0.109)	(0.079)	(0.042)	(0.209)	(0.936
Seed	-0.013	-0.214	0.090**	-0.218	0.430***	0.276
	(0.101)	(.168)	(0.039)	(0.078)	(0.259)	(0.190
Insecticides	0.107	0.542**	0.062	0.079***	-0.073	-0.087
	(0.105)	(0.223)	(0.044)	(0.047)	(0.124)	(0.103
R^2	0.562	0.535	0.168	0.217	0.420	0.374
F Value	2.569	2.496	1.778	1.766	1.808	1.295
Returns to Scale	0.660	0.909	0.022	0.016	0.098	0.376

Source: *Author's Own Calculation;*1% level of Significance ** 5% level of Significance *** 10% level of significance; Figures in the parenthesis show standard error of the respective co-efficient*

The insignificant effect of the use of human labour on output has been found in the case of Boro paddy in animal operated farms. The regression coefficient -0.060 indicates that for one percent increase of human labour in Boro paddy under power tiller operated farm the output will decrease by 0.060 percent.

The comparison of elasticity coefficients of the use of human labour in different categories of farms shows that in the production of Aman paddy, the elasticity of human labour coefficient is very high in pooled farms followed by the production in animal operated farm. It indicates that the increase of output will be maximized in the pooled farms by increasing the use of human labour on such farms.

4.2 Productivity of Fertilizers

The production elasticity coefficients of fertilizers are statistically significant at 5% level in the case of Boro paddy in power operated farms. In the same kind of

farms, fertilizer has positive impact in the production of Aman Paddy and if we increase one percent use of fertilizer, output will increase around 0.15 percent. The regression coefficient - 0.658 indicates that by increasing one percent fertilizer, the production of Boro in pooled farms will decrease by - 0.658 percent. The negative impact is also found in the production of Aman Paddy production under power tiller operated farms.

The comparison of elasticities of coefficient of Boro and Aman paddy which are produced in the three categories of farm shows the maximum return by increasing one percent use of fertilizer. Thus, the maximum return comes from Boro paddy followed by Aman paddy in power operated farms.

4.3 Productivity of Tillage

Though the use of tractor has positive impact on the production of Boro and Aman paddy, the elasticities of coefficients are not statistically significant. If the farmers will increase one percent of tillage, the output of Boro and Aman paddy will increase by 0.04 and 0.33 percent, respectively. Using power tiller/tractor has negative impact on the production of Boro paddy but has positive impact on the production of Aman paddy. The same result is found in the case of pooled farms.

If we compare the elasticities of coefficients of the use of tillage between Boro and Aman paddy then it is found that the coefficient of Aman Paddy is higher than Boro Paddy in power operated farm. In the case of Aman Paddy tillage has a positive impact in power operated, animal operated and pooled farms and the elasticities of coefficient are higher in power operated farms in Aman paddy than animal operated and pooled farms.

4.4 Productivity of Irrigation

Table 3 has shown that the production elasticities of coefficient of irrigation are statistically significant in Boro paddy under pooled farms and the effect is significant at 10 percent level. The irrigation has positive impact on the production of Boro and Aman paddy under power operated farms. The negative impact is found in Aman paddy under animal operated and pooled farms. The comparison of the elasticities of coefficients of the use of water resource in the production of Boro and Aman paddy under three categories of farms has shown that the maximum return comes from Boro Paddy under pooled farms by increasing one percent of irrigation.

4.5 Productivity of Seed

It has been seen from Table-3 that the seed has significant effect at 5 percent level in Boro production under animal operated farms and at 10 percent level under pooled farms. The seed has positive impact on Aman paddy under pooled farms but it is not statistically significant. The negative impact has been found in both Boro and Aman paddy under power operated farms. The comparison of elasticities of coefficient of the use of Boro and Aman seeds under different categories of farms has shown that in Boro paddy the elasticities of coefficient are maximized in pooled farms followed by Aman paddy under the same farms. This indicates the fact that the increase in the production of Boro paddy will be maximized in the pooled farms by increasing the use of seed.

4.6 Productivity of Insecticides

The elasticities of coefficients with respect to insecticides are statistically significant at 5 percent level in Aman Paddy under power operated farms and at 10 percent level in animal operated farms. The insecticides have positive impact on Boro paddy in both power and animal operated farms but the effect is not statistically significant. The negative impact has been found in both Boro and Aman paddy under pooled farms which means that by increasing one percent of insecticides the output will decrease by 0.07 and 0.09 percent respectively. If we compare the elasticities of coefficients of different crops under different categories of farms then it has been seen from Table 3 that the maximum return comes from Aman paddy under power operated farms.

4.7 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 includes in the Cobb-Douglas production function. Increasing, constant or decreasing returns to scale are said to exist accordingly, as the sum of coefficients is greater than, equal to or less than unity. Based on this criterion, it has seen from Table-3 that the sum of the elasticity of the factors is not greater than one which indicates that there is no increasing returns to scale in the case of Boro and Aman paddy in power, animal 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, a unit increase of these factors would result in diminishing returns in such cases. However, there are a few inputs, which are contribute significantly to the yields. So it is possible to increase the returns by using more inputs.

5. Summary and Recommendations

The study has examined the impact of mechanization on Boro and Aman paddy production, profitability of rice farming and marginal productivity of inputs such as labour, tillage, irrigation, seeds, fertilizers and insecticides. The empirical results of profit function show that the profit margin of Boro paddy is higher than Aman paddy under power, animal operated and pooled farms. There is no significant difference in the profit margin of Boro paddy under three categories of farms but there is a variation in the profit margin of Aman paddy under the same farms. Among these, the profitability of Aman paddy in pooled farm is very low compared to other mechanized such as power and animal using farms. Though farm mechanization reduces the number of workers needed per acre or reduces per acre labour cost, the present increasing trend of labour wage outweighs the labour cost. So, per acre average labour cost is almost the same in mechanized and non-mechanized farms. The tillage cost in pooled farm is high compared to mechanized farms since the cost of tillage by draught power has increased very much and more number of tilling is needed if farmers use both methods. The difference between gross return of Boro and Aman paddy is very high compared to the difference between inputs cost of these two crops. There is no big difference among the net returns of Boro paddy in mechanized and non-mechanized farms. On the other hand, the net returns of Aman paddy in pooled farm is very low compared to the power and animal operated farms because the variable cost is very high and the per acre yield is very low.

From the results of the production function it is seen that the values of coefficient of determinations are quite low and most of the independent variables are not significant but have positive impact on output in the case of Boro and Aman paddy under three categories of farms. As it is seen from the results of regression analysis, most of the independent variables have negative impact on output in Boro and Aman paddy under animal and pooled farms.

The findings of the study show that the profits of Boro and Aman paddy are very low due to high input costs and low market price and also the inputs are not used properly under the three categories of farms. So, it is advisable for the farmers to adopt new technologies in their farms to reduce the number of hired human labour, which will not only reduce tilling cost but also reduce planting, weeding, harvesting and threshing cost. Specialize as well as commercial banks must ensure agricultural loans to buy modern technologies such as tractor, power tiller, thresher, fertilizers etc. More importantly, for spreading modern technologies among marginal farmers government can provide expensive machineries such as

tractor, power tiller, deep tube well and harvesting machine through co-operative society. Because of the lack of knowledge and proper training, farmers do not apply fertilizers and pesticides in right doses. To overcome these problems, government should take proper steps to spread education and training among farmers through agricultural extension programs. To expand irrigation facilities in the study area government should take new projects through Barind Multipurpose Development Authority. Finally, to save farmers from ruin and increase the profit margin, it is very much necessary to reduce fertilizers and diesel prices in one hand; and on the other hand government must ensure the fair market price of rice.

References

1. Ahmad, B. (1983). "Implications of farm mechanization for employment, productivity and income". *Agricultural mechanization in Asia, Africa and Latin America,* 14(2): 65-68.

2. BBS. (2012). *Statistical Year Book of Bangladesh*. Bangladesh Bureau of Statistics, Planning Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

3. Majumdar, M.K., Majumdar, L. and Roy, P.C. (2009). *Journal of Bangladesh Agricultural. University*, 7(2): 247–252, 2009 ISSN 1810-3030.

4. Mendoza, T.C. (2002). **"**Comparative productivity, profitability and energy use in Organic, LEISA and Conventional rice production in the Philippines". *Livestock Research for Rural Development* 14 (6) 2002.

5. Noman, A.N.K., Joarder, S. (2011). "Agricultural Transformation, Climate Change and Issue of Food Security in Bangladesh". *Bangladesh Economics Studies,* Volume 13, June 2011, PP (139-168).

6. Sidhu, K.S. and Grewal, S.S. (1990). "Factors affecting demand for human labour in Punjab agriculture: An economic analysis", *Indian Journal of Agriculture Economics,* 45(2) : 125-133.

7. Sharma, G. P., Sharma, B.M. Singh, Iqbal (1991). "A comparative study of income and employment of tractor and bullock operated farms in Chanausi block of Aligarh district, Uttar Pradesh". *Agricultural Situation in Indai,* Oct : 531-536.