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Research Note

IMPACT OF PARTIAL MECHANIZATION ON FARM PRODUCTIVITY, INCOME AND EMPLOYMENT GENERATION: A CASE OF TRISAL UPAZILA IN MYMENSINGH DISTRICT

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ABSTRACT

This study has examined the impact of partial mechanization on crop productivity, income and employment generation in Trisal Upazila of Mymensingh District. Gittinger's methodology (1994) was followed to appraise the profitability of the concerned equipment. The activity budget was used to find out the profitability of MV Boro paddy producing farmers considering `with' and `without' situations. The general findings of the study were that the investments in the selected mechanical equipment were profitable. The sensitivity analyses suggested that the profitability of the concerned equipment, as expected, was highly correlated with 10 percent increase in O& M costs and/or 10 percent decrease in benefits. The results revealed that the individual users and owner-cum-users group earned more income than the non-users group of mechanical equipment. It was also found that the per hectare labour use in MV Boro paddy production in equipment user groups was lesser than that of non-users group. This implied that there was a negative impact of partial mechanization on employment with respect to MV Boro production. However, multiple uses of mechanical equipment created more non-farm employment opportunities in rural Bangladesh like repairing workshop, driving and operating of DSSTWs, PTs etc., shops for equipment, spare-parts, fertilizers, diesel, insecticides and transportations.

I. INTRODUCTION

Farm power plays an important role in crop production system of Bangladesh. Timeliness and intensive uses of some key inputs such as: labour, water, fertilizers etc., are needed for increasing per hectare yield and quality of products, which can possibly be achieved through mechanization. Farmers in Bangladesh have traditionally used draught animal power (DAP) for various farm activities. But at present, use of mechanical sources of power has gradually been increasing. Due to excessive sub-divisions and fragmentation of holdings, small farm size and capital constraints, complete mechanization is a time-consuming matter in Bangladesh. Despite these constraints, some farmers have mechanized their farming activities partially. They adopted and used different combinations of mechanical devices such

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as: mechanical irrigation, power tiller (PT) and/or tractor, weeder, sprayers and threshers in their farming activities. A common picture of Bangladesh agriculture is that there is a shortage of agricultural labour in the peak period while surplus labour in lean period. At present, some farmers are practicing partially mechanized farming following a few selective mechanical devices.

Some farmers are now arguing in favour of partial mechanization while others are opposing it. They also argue that the labour employment opportunities have gradually been increasing due to adoption of different mechanical devices in farming activities. But these views are based on guesses, since little hard data are available on the impacts of partial mechanization. Under the circumstances, the question of mechanization needs thorough investigation to assess whether there is any impact of partial mechanization on farm productivity, income and employment generation. This study is, therefore, a modest step to have the real answer to the above-mentioned problematic situation of the farmers.

The main objectives of the study were:

i. to assess the profitability of using some major farm power equipment;

ii. to evaluate the socio-economic impacts of adopting small-scale mechanization on modern variety (MV) Boro production, employment and income; and

iii. to suggest some policy guidelines/recommendations.

The following hypotheses were set for the study:

(a) There is no difference in profitability of investing in different mechanical devices for farm mechanization from the viewpoints of individual investors.

(b) There is no difference in profitability of MV Boro paddy production between users and non-users of mechanized devices.

(c) Partial mechanization has no effect on productivity, income and employment.

This paper is organized as follows: Section II briefly discusses the sources of data and the analytical techniques used for the study. The major findings of the study are presented in Section III. Policy implications and concluding remarks have been drawn in Section IV.

II. RESEARCH METHODS

Data Source

To fulfil the objectives of the study six villages namely Babupur, Konabari, Bir-Rampur, Kanhar, Shakhua and Boilor of Trisal Upazila were purposively selected. However, another village Singrail of the same Upazila was also selected purposively, where a vast majority of farmers, were not using farm power equipment like PTs and paddle thresher, although mechanical irrigation water was extremely being used by them. A stratified random sampling

technique was followed. In total 80 farmers were selected for collecting necessary information for the study. Considering that seed-water-fertilizer technology was common to all groups or strata, 10 farmers were randomly selected from equipment owners group, 10 farmers from equipment owner-cum-users group, 30 farmers from only equipment users group and 30 from the non-users of equipment. Since various mechanical devices are usually used to a greater extent in Boro season, data of Boro season of 2001 were collected. A formal survey was conducted during the period from June to August 2001, by using well-designed survey schedule.

The project appraisal technique suggested by Gittinger (1994) was followed in this study. Considering the objective as well as the hypothesis (a), only financial analysis was done and three discounted measures were employed. These are: (i) benefit-cost ratio (BCR), (ii) net present value (NPV) and (iii) internal rate of return (IRR). Mathematical formulations of these discounted measures are presented in appendix.

Benefits of different mechanical devices

The items included under the benefits of different mechanical devices are:

(a) Money received during the year from client farmers as rent of the concerned mechanical equipment; and

(b) Salvage value.

Benefits of DSSTW owners. The owners of deep-set shallow tubewell (DSSTW) received Tk 5,928/ha and Tk 6,669/ha, respectively for electric operated and diesel operated DSSTW as water charge from the client farmers, who cultivated MV Boro paddy.

Benefits of PT owners. The owners of PT received Tk 1,580.80/ha for ploughing the cropland twice from the client farmers.

Benefits of owners of sprayers. The owners of sprayer received Tk 152.84/ha as hiring charge for sprayer.

Benefits of owners of weeder. The owners of weeder received Tk 15.00 as hiring charge for weeder on per day basis.

Benefits of owners of PThs. The owners of paddle thresher (PTh) received 2.5 kg paddy per maund i.e., per 37.32 kg on the basis of total amount of paddy threshed by the thresher in the whole year.

Salvage value

In consultation with the traders and mechanics of the relevant mechanical equipment and also taking into account the views of the owners of the concerned equipment of the study area, the average life of the individual DSSTW, PT, weeder, sprayer and PTh were set at 10 years, 7 years, 4 years, 2 years and 3 years, respectively. Accordingly, salvage values were estimated

on their initial prices at 30 percent for PT and 10 percent for each of the selected DSSTWs, weeders, sprayers and PThs. The salvage values of the relevant equipment were treated as benefits and added to the benefit streams at the end of the equipment life.

Costs of different mechanical devices

The costs of different mechanical devices from the viewpoints of individual investors were classified under the following two heads:

(a) Investment costs – included capital cost of different mechanical devices.

(b) Operation and maintenance (O & M) costs – involved the cost of fuel/electricity, cost of spare-parts, mechanics fees, salaries of field-men and operators.

Discount rate

The result of benefit cost analysis is highly sensitive to the discount rate. The interest rate on agricultural equipment credit was 13 percent during the period of this study. To capture the real world situation, 13 percent discount rate was, therefore, chosen for financial analysis of the concerned equipment.

To test the hypotheses (b) activity budgets for users and non-users groups were prepared using the following algebraic equation:

$$\pi = Py \cdot Y + Pb \cdot B - \sum_{i=1}^{7} (Px_i \cdot X_i) - TFC$$

where,

π = per hectare net return or profit of MV Boro paddy (Tk/ha);

Y = total quantities of paddy (main product) per hectare (kg/ha);

Py = per unit price of paddy (Tk/kg);

B = total quantities of by-product (straw) per hectare (kg/ha);

Pb = per unit price of straw (Tk/kg);

X_i = total quantities of ith inputs used for producing per hectare MV Boro paddy;

Px_i = per unit price of ith inputs;

TFC = per hectare total fixed cost involved in producing MV Boro paddy; and

i = 1, 2, 3, ……, 7 (i.e., human labour, seedlings, urea, TSP, MP, manure / cowdung, pesticide, etc.)

Apart from this, undiscounted measure of benefit-cost ratio (BCR) of MV Boro paddy production was calculated simply dividing per hectare gross returns by its gross costs.

III. RESULTS AND DISCUSSION

First of all, the financial analysis together with sensitivity analysis of different equipmenl and then the results of costs and returns analysis of MV Boro paddy and finally the effect o1 partial mechanization on farm productivity, income and employment are presented.

Financial analyses of different equipment

The financial analysis has been done to assess the profitability of the concerned mechanical devices from the viewpoints of individual owners. Three types of discounted measures such as BCR, NPV and IRR, as stated before, have been employed in this study.

Hypothesis (a), that investing in different mechanical devices for farm mechanization is unprofitable from the viewpoints of individual investors. It can, assuming null hypothesis to be true, be written as:

H_o: BCRs of different equipment are less than unity, or NPVs of different equipment are less than zero, or IRRs of different equipment are less than the opportunity cost of capital.

H_1: H_o is not true.

Table 1: Results of financial analyses of different mechanical equipment

Discounted measure	DSSTW (Electric operated)	DSSTW (Diesel operated)	Power tiller	Weeder	Sprayer	Paddle thresher
BCR at 13 %	2.13	1.71	2.71	3.94	1.17	2.07
NPV at 13 % (Tk `000)	403.09	304.24	100.23	1.09	1.34	25.68
IRR (%)	39	24	60	136	Undetermined	Undetermined

Source: Adapted from Amin (2001, p. 70)

The results presented in Table 1 indicate that investments on all the selected mechanical devices are profitable. It is also evident from the table that the BCRs of all the equipment are more than unity (1) and their NPVs are also more than zero (0) at 13 percent discount rate. The IRRs of diesel and electrically operated DSSTWs, PT and weeder were found higher than the possible opportunity cost of capital. It can, therefore, be concluded that the investments in all the selected mechanical equipment are profitable. The BCR at 13 percent discount rate was the highest (3.94) in the case of weeder and NPV was the highest (Tk 4,03,090.00) in the case of electrically operated DSSTW, respectively. The highest IRR (136 percent) was found in the case of weeder among all the selected equipment. Table 1 indicates that all the selected mechanical equipment are profitable. IRRs of sprayer and paddle thresher were undetermined due to their positive incremental cash flows over the project life. In other words, the results

presented in Table 1 clearly supported the rejection of null hypothesis (a). This implies that farmers could make profit by investing in the above mentioned equipment.

Sensitivity analyses of different equipment

The results of sensitivity analysis show how the value of the investment criteria changes due to changes in benefit stream of the concerned equipment. The profitability of the selected mechanical devices may be expected to be highly sensitive to changes in O& M costs and gross benefit of the equipment.

In this study sensitivity analysis was conducted based on the assumptions that all benefits and investment costs would remain the same, then what would happen in the profitability of different equipment, if O& M costs would increase by 10 percent. Again sensitivity analysis was done based on the assumption that all costs and salvage value would remain the same, then what happened in the profitability of different equipment if benefits would decrease by 10 percent. Under the changed circumstances, the financial analysis of Table 1 has been recalculated separately and the summary results are presented in Tables 2 and 3.

It is evident from Table 2 that the BCRs of all equipment at 13 percent discount rate considering the changed situation were greater than unity (1) for 10 percent increase in O& M costs. The IRR was found greater than the opportunity cost of capital (i.e., 13 percent) for all equipment with the exception of PTh. Table 2 shows that the IRRs were found undetermined for PTh due to positive incremental cash flows over the project life. This implies that a 10 percent increase in O& M costs had a great effect on the previous conclusion regarding financial profitability of mechanical devices from the viewpoints of individual owners. The results clearly imply that investments in mechanical devices such as: DSSTW, PT, weeder, sprayer and PTh were still highly profitable from the viewpoints of individual owners.

Table 2: Summary results of sensitivity analyses of different equipment considering 10 percent increase in O& M Costs

Discounted measure	DSSTW (Electric)	DSSTW (Diesel)	PT	Weeder	Sprayer	PTh
BCR at *13 %*	1.94	1.56	2.46	3.58	1.06	1.88
NPV at *13 %* (Tk `000)	367.38	260.68	94.37	1.06	0.55	23.28
IRR (%)	34	18	54	124	45	Undetermined

Source: Adapted from Amin (2001, p. 74).

It is evident from Table 3 that BCRs of all selected equipment were greater than unity and NPVs were positive considering the selected discount rates. IRRs were found higher than opportunity cost of capital in cases of electrically operated DSSTW, PT, weeder and sprayer. IRR of diesel operated DSSTW, was found slightly higher than the opportunity cost of capital considering 13 percent discount rate. The IRR of PTh was found undetermined due to

positive incremental cash flows over the project life. These results imply that if benefit decreased at the rate of 10 percent considering salvage value and other costs remaining same, investment on DSSTW, PT, sprayer, weeder and PTh would be profitable. It is also evident that a 10 percent decrease in benefit has a great effect on the previous conclusion regarding financial profitability of different mechanical devices. The results clearly imply that investments on different mechanical devices such as: DSSTW, PT, sprayer, weeder and PTh were profitable from the viewpoints of individual owners.

Table 3. Summary results of sensitivity analyses of different mechanical devices considering 10 percent decrease in Benefits

Discounted measure	DSSTW (Electric)	DSSTW (Diesel)	PT	Weeder	Sprayer	PTh
BCR at 13 %	1.92	1.54	2.45	3.56	1.06	1.87
NPV at 13 % (Tk `000)	327.81	231.09	85.05	0.95	0.45	20.73
IRR (%)	28	14	44	93	15	Undetermined

Source: Adapted from Amin (2001, p. 75).

Cost and returns of MV Boro paddy

To test the set hypothesis (b) that there is no difference in profitability of MV Boro paddy production between users and non-users of mechanical devices, a simple activity budget (Dillon and Hardaker 1993) of per hectare MV Boro paddy was prepared.

Here profitability was measured by per hectare net return from Boro paddy production. It can be seen from Table 4 that the average per hectare gross returns as well as net return from MV Boro paddy under partial mechanization were higher than those of non-users of mechanical devices.

Table 4. Per hectare costs and returns of MV Boro paddy production.

Farm Category (Equipment user / non-user)	Gross return (Tk `000/ha)	Gross cost (Tk `000/ha)	Net return (Tk `000/ha)	BCR (Undiscounted)
Only users	38.71	35.70	3.01	1.08
Owner-cum-users	40.30	37.04	3.26	1.09
Non-users	38.11	35.89	2.22	1.06

Source: Adapted from Amin (2001).

Per hectare net returns (i.e., profits) were found respectively Tk 3,260.00, Tk 3,010.00 and Tk 2,220.00 for the owner-cum-user, only user and non-user groups, respectively. Undiscounted BCRs of owner-cum-user, only user and non-user groups were also found greater than unity, which indicated that per hectare MV Boro paddy production was highly profitable for all the producers of the selected groups. But BCRs of both the user groups (1.09 and 1.08) were relatively higher than that of non-users group (1.06), which indicated that MV Boro paddy production was more profitable for users than for the non-users group. It is

evident from the results presented in Table 4 that all the farmers were making profits from MV Boro paddy production, though there were some variations in net returns among the selected categories of farmer. These findings clearly supported the rejection of null hypothesis (b), implying that all the farmers made profit from MV Boro paddy production, but non-user groups of mechanical equipments made lower profit than the other (Users and owner-cum-users) groups.

Effect of partial mechanization on farm productivity, income and employment

This section is attempts to find out the effect of partial mechanization on farm productivity, income and employment; and also to test the set hypothesis (c).

Effect on farm productivity. In this section, the effect of partial mechanization on farm productivity, user and non-user groups of different mechanical devices were compared. Table 5 shows the per hectare yield of different categories of Boro paddy producers. It was found that per hectare yield of MV Boro paddy of user groups was relatively higher than that of the non-user group of mechanical devices.

Table 5. Per hectare yield of irrigated Boro paddy

Farm Category (Equipment user / non-user)	Yield (Kg/ha)	Difference with non-user group (Kg/ha)
Owner-cum-users	6875.00	(+) 265
Only users	6610.00	(+) 95
Non-users	6515.00	-

Source: Adapted from Amin (2001, p 86).

Effect on income. Partial mechanization had a great effect on the income of different categories of farmers. Average yearly per farm total income of selected groups are shown in Table 6. The average yearly per farm income was found the highest in owner-cum-user groups, while this was the lowest in the case of non-users group, because owner-cum-users group earned money from both the mechanical equipment as well as from crop production.

Table 6. Average per farm yearly income of selected groups

Farm Category (Equipment user / non-user)	Average Income from			Total income (Tk/year)	Difference of income with non-users group (Tk)
	Equipment (Tk/year)	Crops (Tk/year)	Business and services (Tk/year)		
Owner-cum-users	85280.80	83496.15	47250.00	216026.95	(+) 94801.29
Only users	-	78123.70	45454.54	123578.24	(+) 2352.58
Non-users	-	76225.66	45000.00	121225.66	-

Source: Field Survey (2001).

Effect on employment. Table 7 shows a comparative picture of distribution of total human labour used for MV Boro paddy production by the owner-cum-user, user and non-user groups of mechanical devices. It was observed that for using different mechanical devices the use of human labour for ploughing, weeding and threshing was reduced. It was also revealed that due to use of different mechanical devices, use of family labour for different activities was reduced and use of hired labour was increased. The table shows that non-user group of farmers used more human labours for producing MV Boro paddy than the user groups of mechanical equipment. In other words, total human labour employment in per hectare MV Boro paddy production reduced due to adoption of partial mechanization.

Table 7. Activity-wise human labour used in producing per hectare MV Boro paddy.

Farming activity	Number of human labour used (Man-days/ha)		
	Owner-cum-user farms	Only user farms	Non-user farms
Land preparation	7	7	29
Transplanting	75	67	58
Weeding	9	9	19
Application of fertilizer and insecticides	8	14	8
Harvesting	74	68	64
Threshing	-	-	7
Winnowing and drying	13	12	10
Total	186	175	195
Difference with non-user group (man-days)	(-) 9	(-) 20	-

Source: Adapted from Amin (2001, p. 88).

The respondent farmers, however, mentioned that development of backward and forward linkage activities due to use of mechanical equipment created more non-farm employment opportunities in rural Bangladesh like repairing workshop, driving and operating of DSSTWs, PTs, etc., shops for fuel/oil, spare-parts, fertilizers, insecticides, transportations, etc. From the above mentioned discussions it can be concluded that partial mechanization decreased employment opportunities in farm activities but creates a greater scope for employment opportunities in other non-farm activities in rural Bangladesh.

From Table 5, it is found that per hectare yield of MV Boro paddy was higher in the case of user groups (6,875 kg and 6,610 kg) than that of non-user group (6,515 kg). From Table 6, it is found that average per farm income was higher in cases of partially mechanized farms (Tk 2,16,027 and Tk 1,23,578) than that of non-mechanized farm (Tk 1,21,226). It is also revealed from the study (Table 7) that per hectare labour use in MV Boro paddy production was lower in cases of partially mechanized farms (189 man-days and 178 man-days) than that

of non-mechanized farms (195 man-days). However, It is evident from the results presented in Tables 5, 6 and 7 that partial mechanization had positive effect on productivity and income but some negative effect on employment, which support the rejection of the set null hypothesis (c). This implied that partial mechanization had some positive effects on irrigated Boro farming for the farmers of Bangladesh.

IV. POLICY IMPLICATIONS AND CONCLUSION

The present study aimed at determining the impacts of partial mechanization. It is rather difficult and complex to assess the impacts of adopting mechanical devices both for the user and non-user groups. It was found in the study that the partial mechanization has direct effects on the users group and indirect effects on the non-users group. In the process of testing the hypotheses and considering the major findings of the study, the following conclusions and some important policy considerations are stated below:

The present study, however, confirms that the users of different mechanical devices are earning relatively more profits than the non-users group. The policy makers and extension personnel can, therefore, take necessary steps to encourage farmers for using modern mechanical devices in crop production activities rather than using traditional technology.

The study clearly indicates that using of modern and mechanical devices for cropland cultivation provides a greater scope for higher returns per hectare to farmers. Mechanical devices are time-saving, labour-saving and cost reducing technology; so the farmers get higher profit from crop production using mechanical devices. On the other hand, the use of mechanical devices reduces human labour from crop sector. But adoption of partial mechanization has indirect effects on developing agro-based activities like repairing and manufacturing workshops of different mechanical devices. Moreover, partial mechanization creates wider scope for displaced labour force in the non-agricultural activities like small trading, rickshaw/van pulling, driving and operating different mechanical devices, working in the repairing and manufacturing workshops of different mechanical devices, etc. The policy makers should therefore encourage farmers to adopt partially mechanized cultivation and provide necessary support services for establishment of backward and forward linkage activities.

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APPENDIX

$$\text{BCR} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)}}{\sum_{t=i}^{n} \frac{C_t}{(1+i)}}$$

$$\text{NPV} = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)}$$

IRR is that discount rate i at which

$$\sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)} = 0$$

where,

B_t = benefits derived from uses of the concerned equipment in each year;

C_t = costs incurred for using a concerned equipment in each year;

t = 1, 2, 3, ……., n;

n = number of years; and

i = interest (discount) rate.