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FACTORS INFLUENCING THE ADOPTION OF FARM MACHINERY: A CASE FROM BANGLADESH

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Abstract — Mechanization is vital for sustainable agriculture development of agrarian countries, not only to feed the growing population, but also to save power and resources. The main purpose of the study is to determine the innovation capacity of farmers. Innovation capacity refers to the farmers' adoption of new farm machinery. The study was conducted in Rajshahi District of Bangladesh. Sixty (60) farmers were purposively selected to participate in the study. Data was collected through structured personal. The dependent variable of this study was the innovation capacity of the farmer. The independent variables were farmer education, farm size, annual family income, organizational participation, farming experience, knowledge about farm machinery, farm machinery training, and condition of farm equipment. Appropriate scales were developed and used in order to measure the independent variables. The findings revealed that two-thirds (75 percent) of the farmers had medium innovation capacity, while 18.3 percent had low innovation capacity, and only 6.7 percent of them had high innovation capacity. Results of multiple regression analysis revealed that knowledge about farm machinery, farm machinery training, and condition of farm machinery are the influential factors for determining innovation capacity of farmers.

Keywords **— Adoption, Bangladesh, farmers, farm machinery, innovation capacity**

INTRODUCTION

Bangladesh is a small agro-based country with an area of 1, 47,610 square kilometers. The total population of the country is 158.9 million with an annual growth rate of 1.37 percent (BBS, 2017). The Bangladesh economy is vastly dependent on the agriculture industry. Agriculture represents directly and indirectly almost 15.96 percent of its Gross Domestic Product (GDP) and 80 percent of its employment opportunity (BBS, 2017). In addition to supporting the economy, agriculture is also important because of the role it plays in providing food for the people of Bangladesh. In the past, the agriculture sector was largely dependent on manual and labor-intensive practices. Increasing yields was difficult because manual labor is very time consuming. Today farm machinery that replaces labor-intensive activity is more widely available for use in Bangladesh agriculture. Adopting use of modern agricultural farm machinery provides opportunity to increase crop production while also decreasing manual labor and increasing the quality of life for the farmer. Many innovative types of machinery were discovered in the 20th century. The agricultural sector is converting from dependence on manual labor to mechanization. Mechanization is imperative in the rural development process not only in terms of feeding the population, but also for saving power and resources. Rural development requires careful mechanization through the adoption of suitable machinery for various agricultural operations. Mechanization is essential for increasing the production efficiency of rice farming in Bangladesh (Saha,2015). Cropping intensity and production of food crops has recently increased significantly due to adoption of mechanized tillage, irrigation, and spraying operations (Sarkar and Prahaladachar, 2000). Mechanical inputs currently used in Bangladesh are Shallow Tube Well (STW) and Deep Tube Well (DTW) for irrigation, power tiller and tractor, disc plough, disc harrow, weeder, sprayers, and threshers. Multiple research studies emphasize the importance of appropriate farm mechanization as an important policy and development goal in Bangladesh (Mandal, 2002; Mandal, 2014 and Zhang et al., 2014). Compared to other South Asian nations, farm machinery use has advanced considerably in Bangladesh [Justice and Biggs, 2013], particularly for land preparation, irrigation, and post-harvest activities.

There are many types of innovative farm machinery, but farmers do not adopt it as expected because they lack knowledge about the machinery and possible benefits. As a result, there is still lack of innovation capacity of the farmers. Farmers have been recognized as one of the key sources of innovation. Many studies on agricultural innovations continued to consider farmers as adopters of externally driven innovations (World Bank, 2011; Hayami and Ruttan,1985). Over time, farmers have been accepted as innovators and experimenters and not just adopters of introduced technologies. There are even claims that some of the technologies developed by the scientists were actually based on the ideas and practices originated by local farmers (Roling, 2009; Chambers et al., 1989; Rhoades, 1989). However, food production in Bangladesh is the major sector in agricultural development (Khan and Sadid, 2005). Over time, the population in Bangladesh has increased to 158 million people rapidly increasing the gap between crop production and need for food. However, the agricultural production can be increased to produce more food if farmers adopt innovative farm machinery. In turn, this will allow Bangladesh to work towards achieving the United Nations Sustainable Development Goal No. 2, eliminating hunger.

The literature indicates the capacity, boundaries, and types of activities define innovation capacity for farmers. To help

overcome the shortcomings in innovation studies and particularly in understanding the concept of the innovation capacity, this research aims to identify and analyze the innovation capacity of farmers in adoption of innovative farm machinery, identify and analyze the farmers' problems in adopting innovation or innovative farm machinery to address the acute food problem

Thus, it can be said that development of the country is only depend when the innovation capacity of farmers in adoption of farm machinery are increased in agricultural sector. On this scope the present study is anticipated to assess the capacity of the farmers in adoption of innovative farm machinery.

Objectives of the study

The purpose of this study was to determine the innovation capability of farmers in adoption of farm machinery. In achieving the general objective, the following specific objectives can be formulated:

1. To measure the status of innovation capacity of the farmers to adopt farm machinery;
2. To assess and explain the role socio-economic characteristics play in the farmers in adoption of farm machinery; and
3. To explore the factors associated with farmers' innovation capacity in adoption of farm machinery.

Theoretical Framework

During the late 1980s and early 1990s, the concept of capacity development came into surface as a prominent theme in international development, such as agricultural extension and adult education, in response to the disapproval of the reduced impacts of technical cooperation on millions of smallholder farmers in low-income nations. However, lack of state competences for economic development, human well-being and ecological justice are overall concerns for sustainable development (Clarke and Oswald, 2010; Morgan, 2006, Morgan, 1989). Similarly, the literature on competence development, particularly in post-secondary training and education, grew during the 1970s and 1980s, initially in the United States and later in Europe in response to the limitations of theory-based teaching and learning (Mulder, 2011, Mulder, 2007; Wolf, 2001 and Kerka, 1998).

The contemporary literature on learning and innovation competence development in agricultural education and extension interconnects the independently developed fields of competence-based learning and learning-based competence. While, competence-based learning philosophies came out in response to the limitations of theory-based teaching and learning that are largely supply driven. Theory and practice of learning-based competence advanced within the field of capacity development.

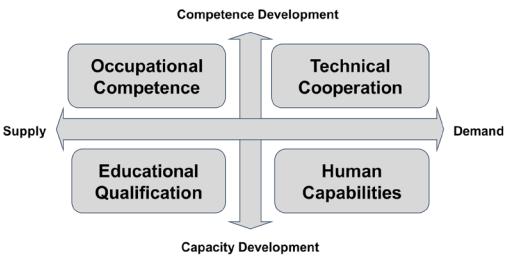

Fig. 1. Learning and Innovation competence development framework.

Capacity development, in general, involves positive changes at four ontological levels. The individual level includes changes in cognitive, affective and psychomotor domains of learning. The organizational level; network and system level; and the broader enabling environment, such as institutions, policy and governance.

For the necessity of this research, the framework as modifiedslightly by adding an extra dimension which is economic capabilities. The new modified framework is given in Figure 2.

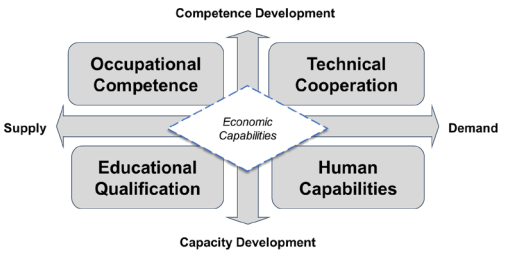

Fig. 2. Learning and Innovation competence development framework (modified).

In other words, capacity development is about transformational changes that empower individuals, leaders, groups, organizations, networks, systems and societies to put knowledge and other capitals into use (UNDP, 2009; CIDA, 2000). Thus, in the modified framework economic capabilities was added to assess innovation capacity of the respondent.

MATERIALS AND METHODS

Study Area

The study was conducted in two Sub-districts (Upazila) named Paba and Mohonpur under Rajshahi District of the northern region of Bangladesh. Two villages were purposively selected for the study in consultation with the experts, i.e., Upazila Agriculture Officers (UAO) and Upazila Rural Development Officers (URDO) of the selected sub-districts. These two villages are Haripur and Mougachi. Paba sub-district is located at 24°26.6′ North latitudes and 88°37.7′ East longitudes and Mohonpur sub-district is located at 24°33.8′ North latitudes and 88°39′ East longitudes. Moreover, these two villages have good facilities and people of these villages are familiar with the farm machinery. Figure 3 shows the study area.

Sampling, Data Collection and Analysis

An updated list of all the farmers was collected from the Upazila Agricultural Officer (UAO). About 35 percent or 60 farmers were selected as the sample

Fig. 3. Map of Rajshahi district showing Paba and Mohonpurupazila of Bangladesh.

following simple random sampling method. A structured interview schedule was developed for collecting data for assessing the status of innovation capacity in adoption of farm machinery by the respondents. An interview schedule was carefully prepared in English keeping in mind the objectives of the research and following the procedures of determining their selected characteristics and their extent of use of agricultural machinery and their innovation capacity. Appropriate scales were developed to operationalize the dependent and independent variables of the study. A draft interview schedule was pre-tested with 10 farmers from the study area that facilitated the researcher to identify faulty questions and statements in the draft schedule. On the basis of pretest results, necessary correction, alternations, additions, and modifications were done in the interview schedule, after examining the answer of the respondents.

Five dimensions were selected. Each of the dimensions had 5 statements obtained from the FGD. A four-point rating scale was used to measure the role of focus variable. Possible responses were high, medium, low and no with the corresponding scores of

3, 2, 1, and 0 respectively. The innovation capacity of the farmers was computed by adding all the scores obtained from each of the dimension of innovativeness from which respondents will be benefitted. Hence, the scale score ranged from 0 to 15 for each dimension, where 0 indicates no innovation capacity and 15 indicates high innovation capacity of the farmers for adoption of farm machinery. Ranking of the statements was done to prioritize the statements where informal education, interest towards machineries, social networking, good physical health and income were number one for each dimension respectively.

The collected data were coded, categorized, tabulated and analyzed scientifically using the Statistical Package for Social Science (SPSS) ver. 16.0 computer program. Both descriptive and inferential statistics were used to describe the data in this study. Pearson's Product Moment Coefficient of Correlation was used to identify association between the explanatory and focus variable. Besides, multiple linear regression and step-wise multiple regression were employed to identify the factors affecting the focus variable.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of the Respondents

The demographic and socioeconomic characteristics of the respondents are shown in Table 1. The mean age of the respondent farmers was 39.8 with standard deviation of 8.48.

The average education score of the respondents was 6.73 which means on average, participants in the study had a secondary education.

It is clear from Figure 4 shows that half (50 percent) of the respondent farmers have secondary education followed by a quarter (26.7 percent) having primary education. While, 15 percent of them were illiterate. Education is believed to facilitate diversified information sources and assumed to be positively correlated with the extent of adoption of new farm machinery (Forsman, 2011; Szeto, 2000; Shahil et al., 2013 and Rajalahti et al., 2008).

Table 1. Socio-economic Characteristics of the Respondents.

Category	Mean	SD*
Age (year)	39.48	8.48
Education (year of schooling)	6.73	3.62
Household Size (number)	4.97	1.52
Farm Size (Hectares)	.757	0.458
Annual Income ('000' BDT*)	76.77	64.42
Organizational Participation (Possible score: 0-24)	2.23	1.44
Farming experience (No. of years)	18.53	6.89
Knowledge on farm machinery (Possible score: 0-51)	30.0	6.45
Training received on farm machinery (No. of days)	2.11	2.98
Innovativeness (Possible score: 0-27)	13.78	2.33
State of using (Possible score: 0-48)	14.75	2.76

*SD = Standard Deviation; *BDT = Bangladeshi Taka

Farm size influences both access to technology adoption and increase innovation capacity towards farm machinery (Morshed and Lashgarara, 2011; and Hall et al., 2007). Table 1 also revealed that average farm size of the respondent farmers was 0.7 ha. and average annual family income 73,000 BDT. As family income is the key factor in the process of innovation capacity and adoption of new farm machinery. It is imperative to take necessary decisions towards innovation and adoption capacity apply machinery to the farm (Wang et al., 2008).

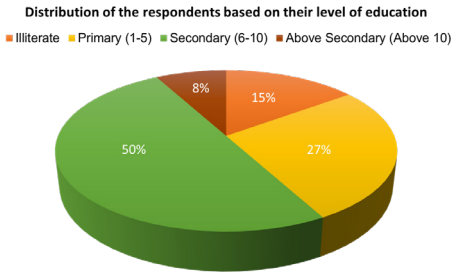

Fig. 4. Distribution of the respondents based on their level of education.

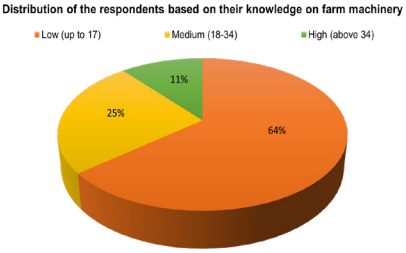

Fig. 5. Distribution of the respondents based on their knowledge on farm machinery.

It is evident from Table 1 that organizational participation score of the respondent farmers were relatively poor as the average score was only 2.2. However, they had sufficient farming experience that stimulates the farmers to take necessary actions in response of any farming problems during using of farm machinery. It is found that the average farming experience score of the respondents was 18 years with standard deviation of 6.89. It is assumed that experienced farmers can have better understanding the importance of innovation and use of farm machinery to the field and hence, are able to take immediate measures to on and off field farm activities (Nambisan et al., 1999).

The Figure 5 also revealed that more than half of the farmers (64 percent) have low knowledge on farm machinery followed by a quarter (25 percent) had medium knowledge on farm machinery and only 11 percent of them had higher knowledge on farm machinery. The mean score of knowledge on farm machinery of the respondents was 30 which indicate also poor knowledge of the farmers on farm machinery.

Farmers Innovation Capacity in Adoption of Farm Machinery

Farmers' innovation capacity is an important attributes of a farmer to adopt a new machinery to maintain his farm in an efficient and cost-effective manner. Thus, farmers' innovation capacity in adoption of farm machinery was measured and shown in Table 2.

Table 2. Distribution of the respondents based on their innovation capacity.

Respondent Categories	Respondents		Mean	SD*
	No.	%		
Low innovation capacity (0-25)	11	18.3	34.96	10.85
Medium innovation capacity (26-50)	45	75.0		
High innovation capacity (51-75)	4	6.7		

In Table 2 indicate that two-thirds (75 percent) of the respondents had medium innovation capacity followed by 18.8 percent had low innovation capacity. In the study area innovativeness and the knowledge about farm machinery is medium, so we can say that farmers adopt new machinery as earliest as possible time and they are also willing to congregate knowledge on machinery use in future. It is evident from Table 2 that the majority of the respondents farmers had low to medium level of innovation capacity for adoption of farm machinery.

Table 3. Dimensions-wise innovation capacity of the farmers. Possible score (1-15).

Dimensions of Innovation Capacity	Respondent Categories	Respondents		Mean	SD*
		No.	%		
Educational qualification	Low (0-5)	36	60.0		
	Medium (6-10)	23	38.7	5.3	2.38
	High (11-15)	1	1.0		
Occupational competence	Low (0-5)	18	30		
	Medium (6-10)	33	55	7.4	2.71
	High (11-15)	9	15		
Technical co-operation	Low (0-5)	18	30		
	Medium (6-10)	35	58.3	7.3	2.76
	High (11-15)	7	11.7		
Human capabilities	Low (0-5)	7	11.7		
	Medium (6-10)	47	78.3	8.2	2.15
	High	6	10		
Economic capabilities	Low (0-5)	22	36.7		
	Medium (6-10)	35	58.3	6.6	2.74
	High (11-15)	3	5		

Actually, five dimensions were used to assess the innovation capacity of an individual in adoption of farm machinery (Table 3). In the Table 3, the mean of dimensions represents that farmer had low educational qualification but compared to educational qualification they had good field in occupational competence, technical cooperation and also human capabilities. Economic capabilities are also higher rather than educational qualification.

Additionally, the specific statements under each of the dimension for measuring farmers' innovation capacity for adoption of farm machinery were rank ordered and shown in Table 4. On the basis of these aspects of different dimensions of innovation capacity the overall innovation capacity of an individual was measured. It is evident in Table 4 that in the case of educational qualification dimension informal education ranked 1st position, while formal and non-formal education ranked 2nd and 3rd position respectively. It means that though farmers' agricultural technical education level is poor but they are rich in informal education as they learn a lot from their surroundings. They had also a good level in formal education (Figure 4). So, they can adopt new machinery for running their farming activities. Among the occupational competence aspects farmers' interest on machineries ranked 1st position, knowledge on use of machinery and ability to modify the machinery to some extent according to his need ranked 2nd and 3rd position respectively.

It means that a farmer having willingness and fair knowledge on machinery will lead him to adopt innovative machinery. Similarly, in the case of technical cooperation, social networking of a farmer ranked 1st position while in the case of human capabilities good health stand 1st position. Farmers from the study area mentioned in the focus group discussion (FGD) sessions that "They use different farm machinery for minimizing their labor forces as well as sow and harvest

crop on time". However, in the case of economic capabilities income and access to credit of a farmer is found as crucial in line with their innovation capacity. This findings is supported by the findings of Wang and Pervaiz, 2004; Yam et al., 2011 and Santamaria et al., 2009.

Table 4. Rank order of the statements for measuring farmers' innovation capacity.

Aspects of Dimensions	Score	Rank Order
Educational qualification		
Formal education	92	2
Non-formal education	43	3
Agricultural education	35	4
Technical education	28	5
Informal education	124	1
Occupational competence		
Interest on machineries	125	1
Knowledge on use of machinery	106	2
Skill using machinery	65	4
Previous experience of using machinery	106	2
Ability to modify to some extent according to his need	69	3
Technical cooperation		
Social networking	145	1
Participation on workshop and seminar about machinery	97	2
Maintenance of farm machinery	77	4
Ability of minor troubleshooting	81	3
Access to spare parts	47	5
Human capabilities		
Good physical health	146	1
Communication exposure	116	2
Leadership capacity	70	5
Decision making ability on farming activities	105	3
Self-efficiency on farm machinery	74	4
Economic capabilities		
Income	135	1
Access to credit	98	2
Purchasing capacity of machineries	78	3
Installment scope in case of buying machineries	49	4
Scope of buying machineries	37	5

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Econometric Estimation of Factors Affecting Farmer's Innovation Capacity and Adoption of Farm Machinery

Multiple linear regression analysis was employed to determine the factors and their contribution in predicting the focus variable, i.e., farmer's innovation capacity and adoption of farm machinery. Table 5 presents the outputs of the analysis.

The results show that seven explanatory variables out of eleven were significant with the F value of 11.36** and adjusted R2 value of 0.659. Therefore, the results imply that about 65.9 percent of the variation in the innovation capacity in adoption of farm machinery of the farmers was explained by the combined effects of explanatory variables. The findings showed that sfive out of eleven variables (farm size, knowledge on far machinery, training received on farm machienary, innovativeness and state of using farm machinary) are the significant in explaining innovation capacity of the farmers in adoption of farm machinery. The results imply that these factors influenced the farmer's innovation capacity and adoption of farm machinery in the study area. The results exhibits that farm size had a positive

coefficient with adoption of farm machinery. Farmers who have large family need more food production and farm machinery is the most helpful to do this job. The results show that the large farm size thrusts the farmers in practicing more farm machinery. This may be because the practice of agricultural machinery requires large farm size (Wettasinha et al., 2008). A study conducted by Amlaku (2012) found that land area has positive and significant influence on innovation capacity. Knowledge on farm machinery was positive and significant for the practice of farm machinery by the farmers in the study area. The result implied that increase of farm machinery knowledge augments the adoption rate of agricultural machinery. Farmers are afraid of taking risks associated with the adoption of new machinery. Therefore, the result may be due to the fact that higher knowledge and skill of the farmers to the machinery holds less risk and they do not need to pay for high damage. Training on farm machinery also emerged as a positive and significant factor in adoption of farm machinery and innovativeness of the farmers. It may be because the farmers having training on machinery management can easily operate a farm machine (UNDP, 2009). These platforms bring them in contact with different skill with different insights. They can learn from training regarding any kind of machine problems and can fix their problems accordingly. This result is in line with Rahman (2004). Innovativeness was also found to have positive and significant relation with the innovation capacity and adoption of farm machinery by the farmers. This implies that increasing innovation and adoption facilitates the farmers' practice and adjustment to the farm machinery in the study area. According to Tidd et al. (2005) farmers exposed to adoption of farm machinery are more are more capable to increase production than others. The results also exhibited that state of using farm machinery have positive and significant relationship. It is due to use of machinery in different sector can bring more production than manual way of cultivation. This result is in line with Beinecke, 2009; Laursen and Foss, 2003; Link and Siegel, 2007, and Verde et al. 2011.

Table 5. Summary of multiple linear regression analysis.

Explanatory Variable	Stand. Coefficients (B)	Stand. Coefficients (B)	't' value	F value
Age (X_1)	-.041	-.032	-.252	
Education (X_2)	.371	.124	1.35	
Household size(X_3)	.733	.096	1.14	
Farm size (X_4)	4.347	.192	2.11*	
Annual family income (X_5)	.013	.077	.896	
Organizational participation (X_6)	.232	.032	.351	
Farming experience (X_7)	-.073	-.047	-.381	11.36**
Knowledge on farm machinery (X_8)	.385	.229	2.18*	
Training received on farm machinery (X_9)	4.223	.331	3.17*	
Innovativeness (X_{10})	1.614	.193	2.17*	
State of using farm machinery (X_{11})	1.696	.197	2.23*	
Adjusted R^2 = 0.659				

Step-wise Multiple Regression Analysis

To understand the contribution of each variable to the respondents' variation in innovation capacity and adoption of farm machinery in the study area, a step-wise multiple regression analysis was conducted. Table 6 represents the output of the analysis. The findings indicate that out of seven significant socio-economic characteristics obtained from the multiple linear regressions, three such as farm size, training and knowledge on farm machinery entered into the model. The findings also indicate these three variables together (R^2 = .659) explained 65.9 percent variation in the farmers' innovation capacity in adoption of farm machinery in the study area.

The first variable entered into the model was knowledge on farm machinery of the farmers (R^2 = .445) which had the highest contribution (44 percent) in explaining the variation in the focus variable.

Table 6. Summary of stepwise multiple regression analysis.

Model	Variables entered	Multiple R	Multiple R^2	Variation explained (%)
Constant + X_8	Knowledge on farm machinery (X_8)	.667	.445	44.5
Constant + X_8 +X_9	Training received on farm machinery (X_9)	.737	.543	9.8
Constant + X_8 +X_9 +X_8	Farm size (X_8)	.779	.607	6.4
Constant +X8 + X9 +X8 + X10	Innovativeness (X_{10})	.814	.663	5.6

This implies that with the increase of knowledge, the farmers are more likely to adopt farm machinery. The farmers with more knowledge and skill are usually more capable to adjust their farms with time and facilities (Rahman, 2004; and Courvisanos, 1996). This may be due to that educated farmer use farm machinery for their agricultural production. The second variable entered into the model was training of the farmers and it is shown that 9.8 percent variation of the focus variable was explained solely by the training of the farmers. The finding reveals that with the increase of training of the farmers, they are more likely to apply machinery to their field in the study area. This may be due to that taking risk does not affect their production although negative results may come (Barquin, 2001). However, knowledge and training on farm machinery of the farmers together (R2 = .543) had 54.0 percent contribution in the variation in innovation capacity of the farmers. The third variable entered into the model was farm size of the farmers which accounts for 6.4 percent contribution in explaining the focus variable. Farm size plays a significant role in adoption of agricultural machinery. The finding implies that with the increase in farm size, the farmers are more likely and able to use farm tools in the study area. The farmers with larger farm size use machinery for save time, money and labor (Sarker et.al, 2009). The fourth variable entered in to the model was innovativeness of the farmers. According to Courvisanos (1996) the innovative farmers have greater knowledge to understand and ability to adopt farm machinery as they have a wider exposure to different information sources. Innovativeness of the farmers helps them to indentify the farm machinery related problems and need of tools. Therefore, the finding implies the same.

CONCLUSIONS

In Bangladesh farmers innovation capacity in adoption of farm machinery are very important because the agricultural production not so well. The population is growing and the need for food is also growing. So farmers need to increase their innovation level in adoption of farm machinery. The study revealed that majority of the farmers had medium innovation capacity. Most of the farmers had small farm size and they did not have adequate money for adopting new farm machinery. As a result, medium innovation capacity was found among the farmers. The study showed that farm size, training, innovativeness and state of using farm machinery had significant contribution in explaining their innovation capacity in adoption of farm machinery. Better access to training on farm machinery along with better knowledge on farm machinery resulting in increasing innovation capacity of the farmers in adoption of farm machinery by the farmers. The study shows that among the different factors contributing to the innovation capacity in adoption of farm machinery of the farmers, knowledge on farm machinery contributed the highest bringing about the change in improving farmers' innovation capapcity. Thus, the knowledge on farm machinery

of the farmers may be considered as the most influential factors while taking policy measures for the extent of using farm machinery in the country. Other influential factors explored by the study are training received on farm machinery, farm size and innovativeness. Thus, it can be concluded that if it is possible to target the large farmers with the view of improving their knowledge and innovativeness through structured training on farm machinery may provide a big push in improving farmers' innovation capacity for adopting new farm machinery that will ultimately ensure sustainable crop production in the country. However, to let it happen an inclusive initiative is needed from concerened agencies (Department of Agricultural Extension and Bangladesh Agricultural Development Corporation) of the Ministry of Agriculture.

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