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## Impact of Technology Adoption on Agricultural Productivity

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**Abstract:** This research work examines the impact of technology adoption on agricultural productivity. It considers the south-west region of Bangladesh as the study area. Since most of the farmers in the study area are engaged in rice production, this study surveys randomly selected 60 rice farmers in the IRRI season of year 2015 through using a questionnaire. This study finds sufficient variation in frequency and degree of technology adoption in agricultural practices among the surveyed farmers. The analysis results indicate that farmers are adopting high level of technology in seed variety and irrigation phases, medium level of technology in land preparation, pest management and fertilizer application phases and low level of technology in weeding and harvesting phases. There is a statistically significant difference in productivity between high and low degree technology adopters. Education and land holdings are the statistically significant variables in determining technology adoption level. According to the study findings, a one percent increase in technology adoption leads to increase in productivity by 0.22 percent, holding other factors constant, and this influence is statistically significant at one percent level. Therefore, this study concludes that there is a scope for further increase in productivity through planned manipulation of technology adoption level in different phases of agricultural production.

**Keywords:** Technology adoption; Productivity; Agriculture; South-west Bangladesh.

### 1. Introduction

The economy of Bangladesh is basically agrarian. Agricultural sector accounts for about 17.2 percent of GDP [1]. In rural areas of the country, economic activities are mostly focused on direct participation in agriculture, especially rice cultivation which remains the major sector in terms of both livelihood and employment. Ensuring food security for the vast population of Bangladesh is directly related with the agricultural development of the country. To enhance GDP contribution and to meet food demand for increasing population, adoption of advance technology is an essential prerequisite. Improved agricultural technologies can also contribute to environmental improvement. We tried to study this issue by focusing on the relationship between technology adoption and productivity in agricultural sector in the south-west region of Bangladesh. Here, rice production is used to represent agricultural output as most of the farmers are engaged in rice production in the study area and country.

A majority of the existing literature on agricultural technology adoption is focused on green revolution technologies such as irrigation, fertilizer use, and the adoption of HYV seeds. However, the operational definition of technology in this study refers to the way, method and technique that involve introduction of technology and equipment in the agricultural production process. Improved agricultural technology adoption can lead to the desired increase in productivity, ensure national and households' food security and can also be a way out of the threat of rural poverty in Bangladesh.

There is a rapidly growing literature evaluating the impact of agricultural technology on its productivity. Implementation of new agricultural technologies like high-yielding varieties, can leads to significant increase in agricultural output and stimulate the transition from low-productivity, subsistence agriculture to a high-productivity and ultimately towards the agro-industrial economy [2]. According to Olagunju and Salimonu [3], appropriate land use pattern and intensification of technology give opportunity to higher increase in farm productivity and income levels. Revenue of farmers after the adoption of new technology is significantly higher than revenue generated before adoption on an average [4]. Technological innovation in agricultural sector has attracted considerable attention among development economists as most of the population of less developed or developing countries are directly depend on this sector [5].

Development of agricultural technology is an essential strategy for increasing productivity, insuring food self-sufficiency and reducing poverty and food insecurity among marginal farmers in sub-Saharan Africa. This strategy is predominantly applicable for the smallholders in the sub-region because they are disadvantaged in many ways,

which makes them a priority for development efforts [6]. There exists a positive and significant impact of composite infrastructure index, fertilizer and HYVs on agricultural productivity [7].

Technological innovation has helped to increase productivity, reduce poverty level and environmental degradation [8]. Higher agricultural output, food security and nutrition can be achieved through better agricultural practices [9]. One of the key strategies for poverty alleviation through higher agricultural output is to encourage the use of high yielding crop varieties [10]. Better technology can stimulate agricultural output and hence increase household income level and high labor demands [11].

High yielding rice varieties are used to increase productivity and to reduce disease and insect problems. The growth of productivity is fueled by the introduction of high-yielding, modern rice varieties, appropriate use of recommended fertilizers and adoption of integrated pest management system [12]. HYVs increase rice production as compared to local varieties. According to Hossain, *et al.* [13], HYV rice acreage had increased from 15 percent to 52 percent of the total acreage during mid-seventies to mid-nineties in Bangladesh.

According to Hossain, *et al.* [14], agricultural output has increased gradually in Bangladesh over the time period. The country has achieved significant improvement in agricultural productivity, mainly in paddy production since her independence. This significant improvement in agriculture can largely be attributed to rapid expansion of modern technology in the country over the last several decades. During the last three decades Bangladesh have had a tremendous growth in agriculture. The rapid expansion of the new technology has had a positive impact on food grain production. The significant improvement in agriculture can highly be attributed to a steady dissemination of the new technology over the last three decades [15].

Adekambi, *et al.* [16] found an increase in productivity of rice farmers, following the adoption of NERICA varieties in Benin. Technology adoption is important in enhancing agricultural productivity for food security and poverty alleviation. It can help to reduce poverty through direct and indirect effects. The former comes from gains linked to the effect of the technologies over income and productivity enhancements of beneficiaries, while the latter are represented by gains derived from adoption by others leading to decreasing food prices, employment creation, and growth linkage effects [17].

Although there is a bunch of literatures on agricultural productivity, however any composite and specific study covering all phases of agricultural production, for example, land preparation, seed variety, pesticide, irrigation, fertilizer, weeding, harvesting and so on, is scarce. Similarly, any such study focusing on the issue in the context of the south-west region of Bangladesh is also scarce. Since agricultural activities depends on geographic setting, weather condition and other locational aspects, this study attempts to address the agricultural technology adoption issue in the south-west region of Bangladesh. Accordingly, the main objective of the study is to investigate the impact of technology adoption on agricultural productivity. The corresponding research questions are:

- What is the frequency and degree of technology adoption by the farmer?
- What are the factors that influence technology adoption by the farmer?
- What is the relationship between the level of technology adoption and productivity?

## 2. Methodology

The economy of the south-west region of Bangladesh is predominantly agriculture based [18]. This study purposively selects two upazilas (*Batiaghata* and *Tarokhada*) of the region to collect primary data. Consequently, three villages are randomly selected from the two upazilas and 60 farmers are selected from the three villages randomly taking 20 from each village. It follows a cross sectional study design considering IRRI season of year 2015 as the study period. A questionnaire survey is administered on the respondents to collect socio-economic and agricultural field level data covering land preparation, seed variety, pesticide, irrigation, fertilizer, weeding, harvesting and such other aspects.

Descriptive statistics is used to answer the first research question of the study regarding the frequency and degree of technology adoption. A comparison is also drawn among the farmers regarding level of technology adoption. We have constructed a technology index considering seven phases of production process including (i) land preparation, (ii) use of improved variety seed, (iii) weed control, (iv) irrigation practice, (v) pest management, (vi) fertilizer use and (vii) harvesting techniques. The respondent farmers are asked about the degree of technology usage at the said seven phases. A five-point likert scale is used to note down the responses of the farmers indicating 1=very poor, 2=poor, 3=average, 4=good and 5=very good level of technology adoption.

Multiple regression analysis is used to answer the second research question regarding the factors that influence technology adoption by the farmers. The dependent variable of the model is the technology index formed from the responses of the farmers in the seven phases of production. The value of the index is converted in the scale of 0-5 through considering the responses on the seven phases. The corresponding explanatory variables of the regression model are age (*A*), education (*E*), capital availability (*K*), experience (*X*) and land (*L*) (Equation 1).

$$D_i = \beta_0 + \beta_1 A_i + \beta_2 E_i + \beta_3 K_i + \beta_4 X_i + \beta_5 L_i + u_i \dots \dots \dots (1)$$

Where,  $\beta_0$  = Intercept of the regression line,  $\beta_i$  = Coefficients of the explanatory variables,  $D_i$  = Degree of technology adoption (Technology index).

Hypothesis testing and production function estimation are the analytical tools for addressing the third research question regarding relationship between the level of technology adoption and agricultural productivity. In hypothesis testing, we are interested to test whether there is any difference in productivity between low and high degree technology adopter farmers. Farmers having technology index score between the range of 1.00-2.50 are considered as low-degree technology adopter, while whose score is between the range of 2.50-5.00 is considered as high-degree technology adopter. Accordingly, the corresponding null and alternate hypotheses are:

- $H_0$ : There is no difference in productivity between low and high degree of technology adoption.
- $H_A$ : There is statistically significant difference in productivity between low and high degree of technology adoption.

In order to ascertain the impact of technology adoption on agricultural output, a Cobb-Douglas production function is estimated for the sample farmers. Equation 2 illustrates the form the production function. The dependent variable of the model is the agricultural output. The corresponding explanatory variables of the model are cost of land preparation ( $L$ ), cost of seed ( $V$ ), cost of weeding ( $W$ ), irrigation cost ( $I$ ), pesticide cost ( $P$ ), fertilizer cost ( $F$ ), cost of harvesting ( $H$ ) and technology index ( $T$ ) (Equation 2).

$$Q_i = \alpha_0 L_i^{\alpha_1} V_i^{\alpha_2} W_i^{\alpha_3} I_i^{\alpha_4} P_i^{\alpha_5} F_i^{\alpha_6} H_i^{\alpha_7} T_i^{\alpha_8} e^{\epsilon_i} \dots \dots (2)$$

### 3. Results and Discussion

The mean age of the respondents is 48 years with minimum 30 and maximum 77 years. About one-fourth of them fall in the age group of 30-39 years and another one-fourth fall in the age group of 50-59 years. Most of the surveyed farmers are experienced in farming activities having 30 years farming experiences on an average. The average year of schooling of the surveyed farmers is 8 years with maximum 16 years and minimum 3 years educational attainment. The highest number for respondents (35 percent) falls in the 6-10 years of schooling experience. The mean income of the respondents is US\$ 125 per month with maximum 375 US\$ to minimum 50 US\$ per month. About half of the respondents are living in *semi-pacca* house. We find that, the housing pattern of the respondents is linked with their monthly income. Farmers having higher income live in better houses compared to the lower income group. From landholding perspective, about one-fourth of the farmers have 0.1-2.0 *bigha* land and the frequency of farmers decrease for an increase in landholding size. Thus, most of the farmers are smallholders.

**Table 1** describes the operational definition of the scale used to identify technology adoption level for seven phases of production process including land preparation, use of improved variety seed, weed control, irrigation practice, pest management, fertilizer use and harvesting techniques. A well-prepared field controls weeds, recycles plant nutrients and provides a soft soil mass for transplanting and a suitable soil surface for direct seeding. The respondents of this study are mostly using tractor for land preparation in the study area. They also use different types of fertilizer during land preparation to improve soil fertility. Based on the five-point likert scale this study finds that more than one-third of the respondents' are adopting higher level of technology scoring four to five in a scale of five in land preparation phase. In contrast, more than half of the respondents' score is one to two in a scale of five.

Better quality seeds ensure good grain quality, maximum tillage capacity for weed control and tolerance to major diseases, insects, and other stresses. Factors affecting crop management, such as soil type, planting method, fertilizer efficiency, amount of rainfall, climate, and disease pressure are some other factors that have some sort of influence on seed variety selection. The study findings indicate that about 40 percent of the respondents' are adopting higher level of technology scoring four to five in a scale of five. In contrast, more than forty percent of the respondents' score is one to two in a scale of five in seed variety selection phase.

Weed control is important to prevent losses in yield and production costs, and to preserve good grain quality. Specifically, weeds decrease yields by direct competition for sunlight, nutrients, and water. However, **Table 1** states that none of the respondents' are adopting higher level of technology scoring four to five in a scale of five in weed control phase. In contrast, more than ninety five percent of the respondents' score is one to two in a scale of five in weed control phase.

Irrigation facility helps to ensure sufficient production and control weeds. As per survey data, about three-fourth of the respondents' are adopting higher level of technology scoring four to five in a scale of five in irrigation practice phase. In contrast, very insignificant number of the respondents' score is one to two in a scale of five in irrigation practice phase.

Proper pesticide management and timely & accurate diagnosis can significantly reduce crop losses due to pest attack. It is evident that only less than one-fifth of the respondents' are adopting higher level of technology scoring four to five in a scale of five in pest management phase. In contrast, about two-third of the respondents' score is one to two in a scale of five in this phase.

Applying sufficient nutrients to the crop is essential in managing soil fertility so that the plants grow and develop normally. Fertilizer can mostly meet that need. Micro-elements are needed by plants in large amounts. These are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur. Rice crops need to have the optimum nutritional balance. If rice crops have more or less than the required amount of nutrients, the yield will not be optimal. The study results indicate that about one-fourth of the respondents' are adopting higher level of technology scoring four to five in a scale of five in fertilizer application phase. In contrast, about more than half of the respondents' score is one to two in a scale of five in this phase.

Harvesting is the process of collecting the matured rice crop from the field. Paddy harvesting activities include cutting, stacking, handling, threshing, cleaning and hauling. These can be done manually or through using a combine harvester. None of the respondents' are adopting higher level of technology scoring four to five in a scale of five in this phase. In contrast, more than ninety five percent of the respondents' score is one to two in a scale of five in harvesting phase.

In summary, the analysis results indicate that farmers are adopting high level of technology in seed variety selection and irrigation practice phases, medium level of technology in land preparation, pest management and fertilizer application phases and low level of technology in weed control and harvesting phases.

Hypothesis test results are listed in Table 2. The respondents are divided into two groups: high and low degree technology adopter. Farmers whose average score is between the range of 1.00-2.50 in technology index is considered as a low-degree technology adopter, and whose average score is between the range of 2.51-5.00 in technology index is considered as a high-degree technology adopter. The results indicate that there is a statistically significant difference in productivity between the two groups: high and low-degree technology adopter farmers. Accordingly, we can reject the null hypothesis and conclude that the productivity of high degree technology adopter farmers is significantly higher than that of low degree technology adopter farmers.

Table 3 lists the estimation results of equation 1. The regression results indicate that the coefficients of all of the considered explanatory variables have the expected positive sign, though not all of the variables are statistically significant. Education and land amount are the statistically significant variables. More specifically, if schooling increase by 1 year, then technology adoption increases by 0.15 level in a scale of 5, keeping other explanatory variables constant, and this influence is statistically significant at one percent level. Similarly, if land amount increase by 1 *Bigha*, then technology adoption increase by 0.09 level in a scale of 5, keeping other explanatory variables constant, which is statistically significant at five percent level. The  $R^2$  value (0.51) indicates that about 51 percent variation of the dependent variable is explained by the considered explanatory variables. The mean VIF value is 4.12, which means that the model is free from multicollinearity. Moreover, the model has no specification error and it is free from omitted variable bias.

Table 4 lists the estimation results of the Cobb-Douglas production function of equation 2. The regression results indicate that the coefficients of all of the considered explanatory variables have the expected sign, though not all of the variables are statistically significant. The response variable of the model is total amount of rice production (in *mound*). The explanatory variables land preparation, seed variety, weed control, irrigation, pesticide, fertilizer and harvesting are measured in BDT, while technology level is measured as an index (in a scale of 5.00). Model 1 is estimated excluding the technology variable while model 2 includes technology level as an explanatory variable.

Model 1 of Table 4 indicates that, land preparation has a positive and statistically significant relation with the total amount of production. If cost of land preparation increases by one percent, then production increases by 0.52 percent, holding other predictors in the model constant. Cost of irrigation and pesticide has also positive and statistically significant relation with the total amount of production. A one percent increase in cost of irrigation and pesticide lead to increase in output by 0.33 and 0.17 percent, respectively (Model 1).

Since the objective of this study is to find out the impact of technology adoption on agricultural productivity, we add technology as an additional variable measured in terms of technology index (in a scale of 5.00) derived from the responses of the farmers (Model 2). After including technology variable, we find that the trend and magnitude of the relationships among dependent and explanatory variables remain in the same direction as model 1. Moreover, study findings indicate that a one percent increase in level of technology adoption leads to increase in productivity by 0.22 percent, holding other predictors in the model constant, which is statistically significant at one percent level of significance (Model 2). Such results signal that technology is an important force in enhancing agricultural productivity.

Model 2 of Table 4 tries to trace out the impact of technology adoption on agricultural production. Since the degree of technology adoption is derived from the information of seven phases related to production, therefore considering that technology index along with the said seven issues in the same model might invite criticism. As a result, we consider phase-wise separate technology indices as explanatory variables and re-run the Cobb-Douglas production function of equation 2. The estimation results are listed in Table 5.

Model 3 of Table 5 indicates that the coefficients of all of the considered explanatory variables have the expected sign, though not all of the variables are statistically significant. More specifically, if technology is adopted at the very initial phases of production like land preparation, then a one percent increase in technology increases production by 0.29 percent, holding technology adoption in other phases constant, which is statistically significant at one percent level of significant. Similarly, a one percent increase in technology adoption in fertilizer and harvesting phase lead to an increase in output by 0.05 and 0.10 percent respectively, holding technology adoption in other levels constant. These impacts are statistically significant at five percent level of significance.

The  $R^2$  values of the models 1-3 are very high. The VIF test results indicate that the model is free from multicollinearity. Similarly, the models have no specification error and these are free from omitted variable bias. Such findings clearly indicate that there is scope to further increase in productivity through manipulating technology adoption level in different phases of agricultural production.

## 4. Conclusion

Agricultural technology adoption is an essential strategy for increasing agricultural productivity, achieving food self-sufficiency and reducing poverty and food insecurity among farmers. This study attempts to empirically estimate the impact of technology adoption on agricultural productivity in the south-west region of Bangladesh. Randomly selected 60 farmers are surveyed to focus the study objective.

The mean age of the respondent farmers is 48 years, having 30 years farming experience and 8 years of schooling on an average. The mean income of the respondents is US\$ 125 per month. Farmers having higher income live in better houses compared to the lower income group. Most of the farmers are smallholders.

This study finds sufficient variation in frequency and degree of technology adoption in agricultural practices among the surveyed farmers. We find that technology adoption level is comparatively higher in seed variety selection and irrigation practice phases. A medium level of technology adoption is observed in land preparation, pest management and fertilizer application phases by the surveyed farmers. However, the technology adoption level is very low in weed control and harvesting phases of agricultural production in the study area. The study findings indicate that there is a statistically significant difference in productivity between high and low degree technology adopter farmers.

This study finds that degree of technology adoption depends on age, experience, education, capital availability and land holdings of the respondents. All of these factors influence agricultural productivity positively, though not all of the variables are statistically significant. Education and land holdings are the statistically significant variables in determining technology adoption level. The estimation results also indicate that adoption of improved technology help to raise agricultural productivity in the study area. A one percent increase in technology adoption leads to increase in productivity by 0.22 percent, holding other factors constant, which is statistically significant at one percent level of significant. Therefore, this study concludes that there is a scope for further increase in productivity through planned and affordable manipulation of technology adoption level in different phases of agricultural production.

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## Tables

Table-1. Phase-wise Definition and Adoption Level of Technology

Phase	Scale score	Definition	Percent of the Respondents
Land preparation	5	Use of: tractor -four times, fertilizer - more than four types	28
	4	Use of: tractor - three times, fertilizer - more than four types	10
	3	Use of: tractor - three times, fertilizer - four types	10
	2	Use of: tractor - two times, fertilizer - two types	17
	1	Use of: tractor - one time, fertilizer - one type	35
Seed variety	5	Use of: hybrid seed variety	18
	4	Use of: BRR1 29 variety	22
	3	Use of: BRR1 28, 47, 49 or 50 varieties	17
	2	Use of: BRR1 22, 23, 34, 40 or 41 varieties	33
	1	Use of: BRR1 14, 16, 33 or 39 varieties	10
Weed control	5	Use of: weeder machine or weedicide	0
	4	Control weed four times by using labour	0
	3	Control weed three times by using labour	3
	2	Control weed two times by using labour	50
	1	Control weed one time by using labour	47
Irrigation practice	5	Irrigating 32-36 times	32
	4	Irrigating 26-31 times	43
	3	Irrigating 16-25 times	23
	2	Irrigating 11-15 times	2
	1	Irrigating 0-10 times	0
Pest management	5	Use of: five or more than five types of pesticides	2
	4	Use of: four types of pesticides	17
	3	Use of: three types of pesticides	18
	2	Use of: two types of pesticides	28
	1	Use of: one type of pesticides	35
Fertilizer use	5	Use of: Four types of fertilizer (including Urea and Zink)	5
	4	Use of: Three types of fertilizer (including Urea and Zink)	23
	3	Use of: Two types of fertilizer (Urea and Zink)	14
	2	Use of: One type of fertilizer (Urea)	28
	1	Use of: Urea in insignificant amount irregularly	30
Harvesting technique	5	Harvesting through using combine harvester machine	0
	4	Harvesting manually through using 7-8 labor	0
	3	Harvesting manually through using 5-6 labor	3
	2	Harvesting manually through using 3-4 labor	64
	1	Harvesting manually through using 1-2 labor	32

**Table-2.** Productivity Difference between Low and High Degree Technology Adopter Farmers

Technology level	Observation (N)	Mean productivity	Standard Error
High technology	60	6.87	1.27
Low technology	60	2.15	0.21
Difference	60	4.72***	9.57

N.B.: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1; t-Value= 3.82\*\*\*

**Table-3.** Factors Influencing Degree of Technology Adoption

Variables	Coefficient	Std. Error	P> t
Age <sup>2</sup>	0.00	0.00	0.33
Education	0.15***	0.04	0.00
Capital	0.00	0.00	0.58
Land amount	0.09**	0.04	0.01
Experience	0.02	0.02	0.44
Constant	0.83**	0.38	0.03

Dependent Variable: Technology index; R<sup>2</sup> = 0.51; Adjusted R<sup>2</sup> = 0.51; N = 60

N.B.: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**Table-4.** Estimation of Production Function

Explanatory variable	Variable description	DV: Output (in mound per bigha)	
		Model 1	Model 2
Ln (L)	Cost of land preparation	0.52***	0.39***
Ln (V)	Cost of seed variety	0.06	0.08
Ln (W)	Cost of weed control	0.02	0.06
Ln (I)	Cost of irrigation	0.33***	0.21***
Ln (P)	Cost of pesticide	0.17***	0.13***
Ln (F)	Cost of fertilizer	0.02	0.03
Ln (H)	Cost of harvesting	0.05	0.07
Ln (T)	Technology level	-	0.22***
C	Constant	-4.04***	-1.94***
N	Number of observation	60	60
R <sup>2</sup>	R-squared	0.96	0.96

N.B.: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**Table-5.** Estimation of Production Function Considering Phase-wise Technology Level as Predictors

Explanatory variable	DV: Output (in mound per bigha)
	Model 3
Ln (Rank in land preparation)	0.29***
Ln (Rank in seed variety)	0.01
Ln (Rank in weed control)	0.03
Ln (Rank in irrigation practice)	0.09
Ln (Rank in pesticide application)	0.01
Ln (Rank in fertilizer use)	0.05**
Ln (Rank in harvesting technique)	0.10**
Constant	2.88***
N	60
R <sup>2</sup>	0.95

N.B.: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1