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Gross Value Added of Agriculture Sector in Bangladesh: An Econometric Investigation

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Abstract

In this paper we investigate how different factors, namely, land utilization, irrigated area, consumption of pesticide, area under forest, consumption of fertilizers and improved seeds affecting the Gross Value Added of agriculture sector in Bangladesh. The relationship between the concerned variables and their overall impact on the Gross Value Added of agriculture sector in Bangladesh have been examined through econometric modeling followed by various statistical measures like multivariate regression analysis, residual analysis, autocorrelation test, multicollinearity test and testing for the linearity of the regression. The results of this study suggest that all of the independent variables under consideration significantly influence the dependent variable. It is evident that the 89.60% variation in the dependent variable can be explained by the variation in the independent variables. All the properties of residual analysis (zero mean and constant variance) have been satisfied in this study and the results of both Run test and Durbin-Watson test show that residuals are uncorrelated. Finally, our regression model has been found to be approximately straight line whereas the results of Farrar-Glauber test indicate that multicollinearity exists in the model and all of the independent variables are found to be collinear. However, this could be removed with the help of Principal Component Analysis and other advanced techniques in further studies. The findings of this paper have important implications in identifying the factors which can accelerate growth in the agriculture sector of Bangladesh economy.

Keywords: *GVA of agriculture, Land utilization, Irrigated area, Consumption of pesticides, Area under forest, Consumption of fertilizers, Improved seed*

1. INTRODUCTION

Agriculture has been the mainstay for the economy of Bangladesh since its independence (1971). It is still contributing around 23.50 percent to GDP. Besides providing employment to 48.1 percent labour force, this sector accommodates 62 percent manpower of the nation, and 84 percent of the population of Bangladesh living in rural areas, directly or indirectly depends upon agriculture for their livelihood. It also provides raw material to industry and contributes to country's exports. So any policy change for agriculture sector will affect the economy and a large segment of population in the country. Recent data shows that GDP sharing of agriculture sector is lower than other sectors while agriculture consumes a bigger portion of human resources and fund (Alam, 2008). Numerous studies (Yanrui, 1995; Bravo-Ureta and Pinheiro, 1997; Fan, 1999; Mathijs and Vranken, 2000; Rattso and Stokke, 2003; Mundlak, 2005; Swinnena and Vrankena, 2006) have compared technological change, technical and allocative efficiency and productivity for the agriculture and industrial sectors for both developed and developing countries. However, less attention is given in developing and testing an econometric model that helps determine the major factors that significantly affects value-added agriculture growth in Bangladesh. Hamid and Ahmad (2009) show that the agriculture productivity in Pakistan is much below its potentials and growth of value-added in this sector still depends on traditional factors of production. Rattso and Stokke (2003) have analyzed the relationship between productivity, growth and foreign spillovers for the agriculture and industrial sectors of Thailand. Their analysis indicates a long run relationship between productivity growth and foreign spillovers in both agriculture and industry.

Alam et al. (2009) demonstrate that agriculture has been the main economic sector with an employment of 95% of total population with a share of 78% of Gross Domestic Product (GDP) in 1971. Currently, 75% of the populations' professions are agriculture industry and contribution towards GDP is only 22%. They have examined the probable underpinning reasons causing agriculture as a less productive industry. With many reasons, it is noted that education system is not currently supporting the development of agriculture industry. Indeed, currently the earning of GDP is significantly lower compared to the vast majority of populations are employed at the agriculture sector. There are many reasons for the low level of contribution of agriculture sector. These are mainly related to non-skilled workforce, use of low level and time-consumed technology and old fashioned cultivation that deserve a revolutionary change (Bryceson, 2000 and Barrett et al. 2003). However, there has been increasing use of modern machinery along with high yielding varieties of seed and fertilizers which, has helped in increasing agriculture value-added growth and overall GDP growth in Bangladesh. This paper aims to investigate how different factors, namely, land utilization, irrigated area, consumption of pesticides, area under forest, consumption of fertilizers and improved seeds are affecting the Gross Value Added of agriculture sector in Bangladesh. It also intends to measure the relationship between the concerned variables and their overall impact on the Gross Value Added of agriculture sector in Bangladesh.

The rest of the study is organized as follows. The data and methodology are explained in Section 2. The empirical results are discussed in Section 3. Findings and concluding remarks are discussed in the last section.

2. DATA AND METHODOLOGY

The study uses multi dimensional data drawn from nationally recognized Bangladesh Bureau of statistics (BBS). The yearly data is gathered by the institution over the period 1970 to 2004 specifying values of Gross Value Added of Agriculture and its different components like land utilization, fertilizer uses etc. The quality and the validity of the data specified by the institution i.e. Bangladesh Bureau of Statistics. The data is published every year by fiscal year basis. Gross Value Added (GVA) of Agriculture is considered as the dependent variable in this study while Land utilization (X_1), Area irrigated by methods (X_2), Consumption of pesticide (X_3), Area under forest (X_4), Fertilizer consumption (X_5), Improved seed (X_6) have been considered as the independent variables. Various statistical measures like multivariate regression analysis, residual analysis, autocorrelation test, multicollinearity test and testing for the linearity of the regression are applied to decide on the mathematical relationship between the concerned variables.

3. EMPIRICAL RESULTS

3.1 Fitting the regression model

It has been assumed that a linear relationship exist between the dependent variable Gross Value Added of Agriculture sector and six explanatory variables Land utilization (X_1), Area irrigated by methods (X_2), Consumption of pesticide (X_3), Area under forest (X_4), Fertilizer consumption (X_5), Improved seed (X_6). By applying ordinary least square estimation procedure, the estimated coefficients of the independent variables are found as follows:

Table 1: Unstandardized coefficients

Model	Unstandardized Coefficients (β_i)
Constant	-633239.53
X_1	14.16
X_2	1.607
X_3	16.018
X_4	24.646
X_5	1.707
X_6	2.405

Hence the fitted model is,

$$\hat{Y}_i = -633239.53 + 14.16X_{1i} + 1.607X_{2i} + 16.018X_{3i} + 24.646X_{4i} + 1.707X_{5i} + 2.405X_{6i} \quad (1)$$

To judge the significance of this model, technique of ANOVA is applied. The following ANOVA table confirms that the above model is statistically significant at 1% level of significance. It is evident that 89.6% variation in the GVA of Agriculture can be explained by the variation in the independent variables.

Table 2: ANOVA Table

	Sum of squares	d.f.	Mean square	F	R^2	R^2_{adj}	Sig
Regression	1.08E+12	6	1.800E+11				
Residual	1.21E+11	24	5060000000	35.57	0.896	0.88	0.000
Total	1.20E+12	30					

From the above model, it is also observed that the variables Area under forest (X_4), Consumption of pesticide (X_3) and Land utilization (X_1) have the most dominant impact on GVA of Agriculture while Area irrigated by methods (X_2), Fertilizer consumption (X_5) and improved seed (X_6) has comparatively less affect in the GVA of Agriculture.

3.2 Standard error of Y estimate and β_i

For the study, the standard error of Y estimates is S = 20875.325. In general, we know that the smaller the standard error (S) of Y estimates for any model, the better is the model and more precise. From the above estimate, we see that the S (=20875.325) is smaller, so it is better and more precise model. In general, the larger the standard error, the wider is the confidence interval. Put differently, the larger the standard error of the estimator, the greater is the uncertainty of estimating the true value of the unknown parameter. So the standard error of β_i is given:

Table 3: The standard error of Y estimate and β_i

β Coefficients	β_1	β_2	β_3	β_4	β_5	β_6
S. E. (β)	5.43	1.07	8.525	22.686	0.98	3.04
S. E. of Y			20875.325			

Table 3 shows that the standard error of Y estimates is S = 20875.325, which is smaller, so it is a better and more precise model. Furthermore, the minimum value of standard error (β_5= 0.98), which refers to the independent variable Fertilizer consumption (X_5) and the maximum value of standard error (β_4 = 22.686), which refers to the independent variable Area under forest (X_4). From the above, it is clear that the standard error of (β_5= 0.98) is the smallest, so the estimate of $\beta_{2\ \text{is}}$ most precise.

3.3 Confidence interval of βi:

Table 4 reports the confidence interval of the estimated β_i 's. It can be shown that the 95% confidence interval for β_0 is (-971951.606, -294527.460). It means that in the long run, in 95 cases out of 100 cases, the interval (-971951.60, -294527.4) will contain the true value of β_0. In the similar manner, we can interpret the confidence intervals for β_1, β_2, β_3, β_4, β_5 and β_6.

Table 4: Confidence interval of β_i

Model	95% Confidence Interval for βi	
	Lower Bound	Upper Bound
Constant	-971951.606	-294527.460
X_1	2.954	25.384
X_2	0.02	2.006
X_3	-1.577	33.613
X_4	-22.176	71.468
X_5	-0.040	1.76
X_6	-3.885	8.695

3.4 Residual analysis

In the process of fitting the regression model it is assumed that all ε_i have zero mean, the variance of ε_i is constant in each period and they follow a normal distribution.

Figure 1: Scatter plot of residuals

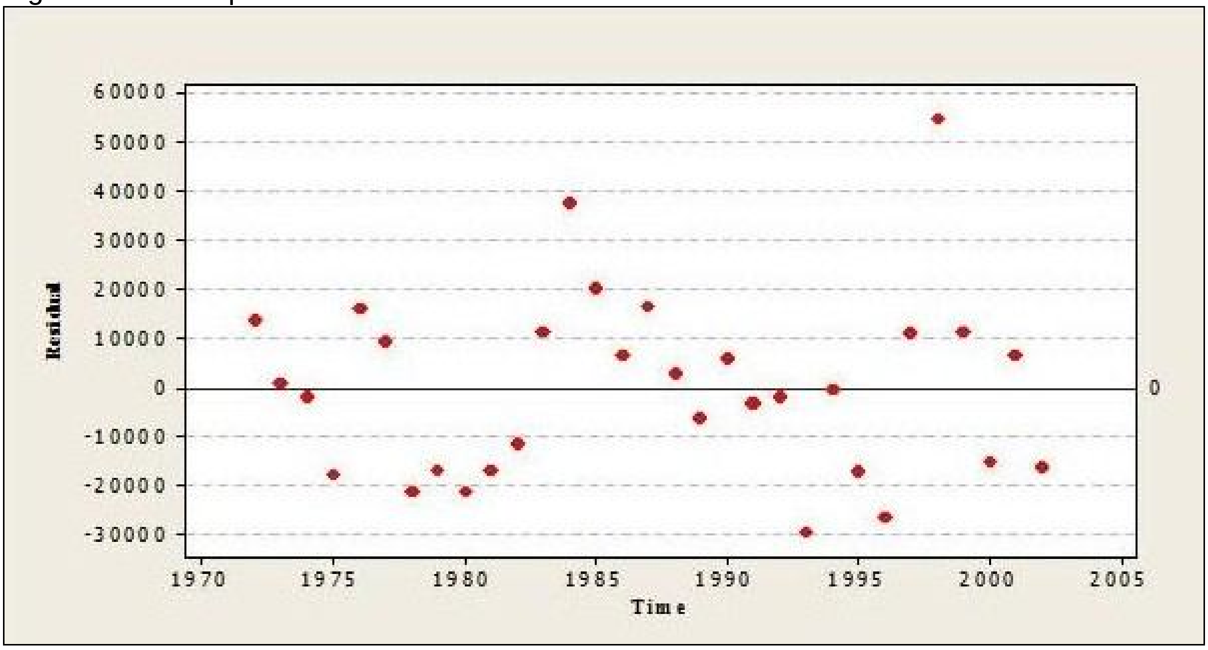


Figure 2: Scatter plot between predicted Y and residuals

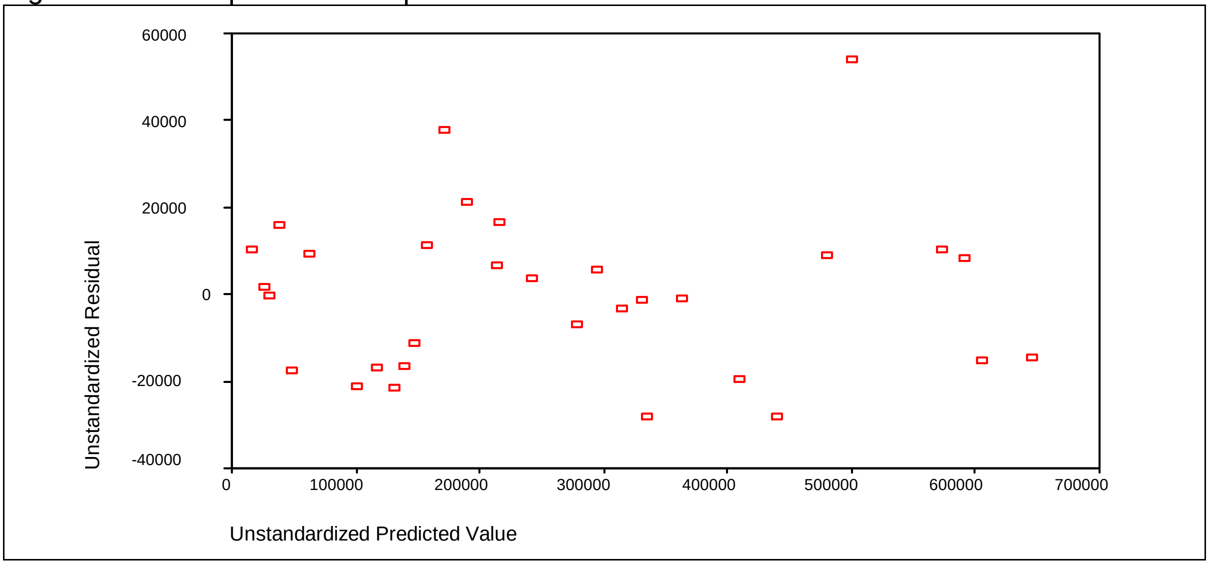


Figure 3: Normal P-P plot of residuals

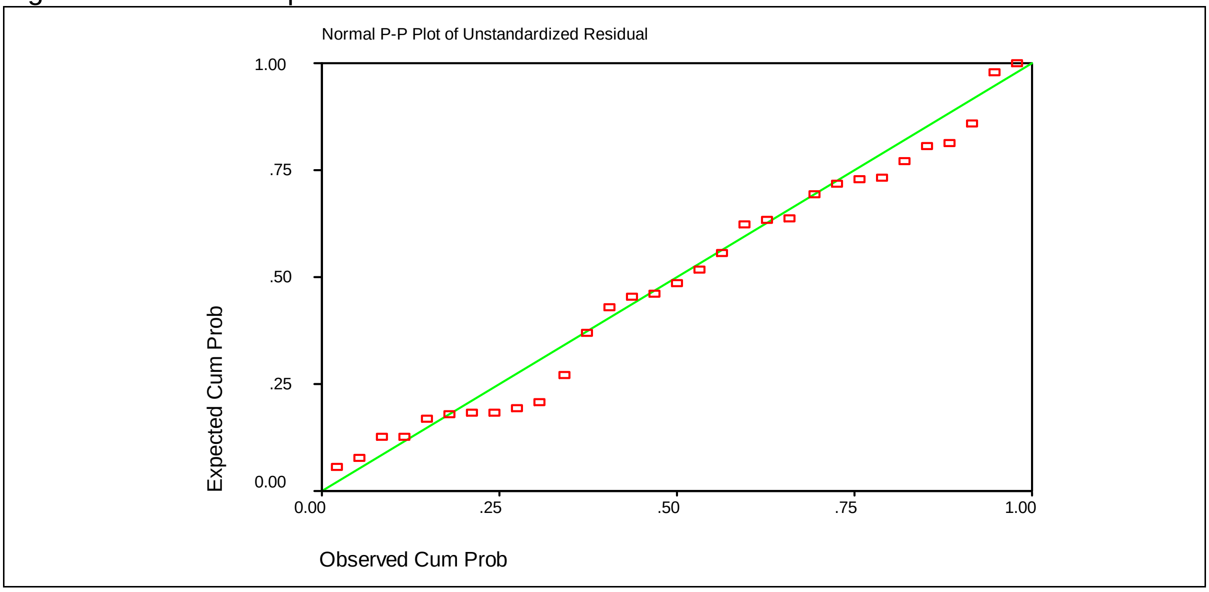
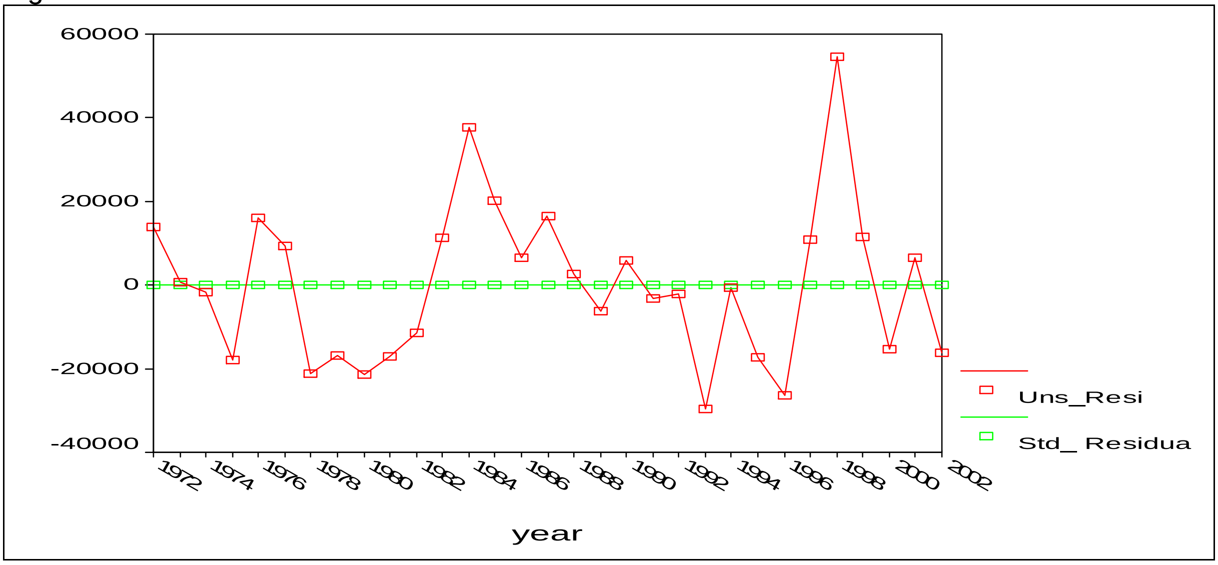


Figure 1 and Figure 2 show that the residuals are scattered around zero indicating they have zero mean and the horizontal band indicates no abnormality, respectively. However, we can see that there are two observations outside the band indicating may be outliers. Later on the outliers will be examined. Moreover, Figure 3 supports that the residuals follow a normal distribution. It is clear in Figure 3 that the random dispersion of the ε_i's within a constant distance around the regression line, which is a strong characteristic in favour of homoscedasticity.

3.5 Tests of Autocorrelation

Three different methods have been applied for detecting autocorrelation. They are graphical method, The Runs test and Durbin –Watson test. We have plotted the residuals against time in the following graph.

Figure 4: Residuals and standardized residual on GVA

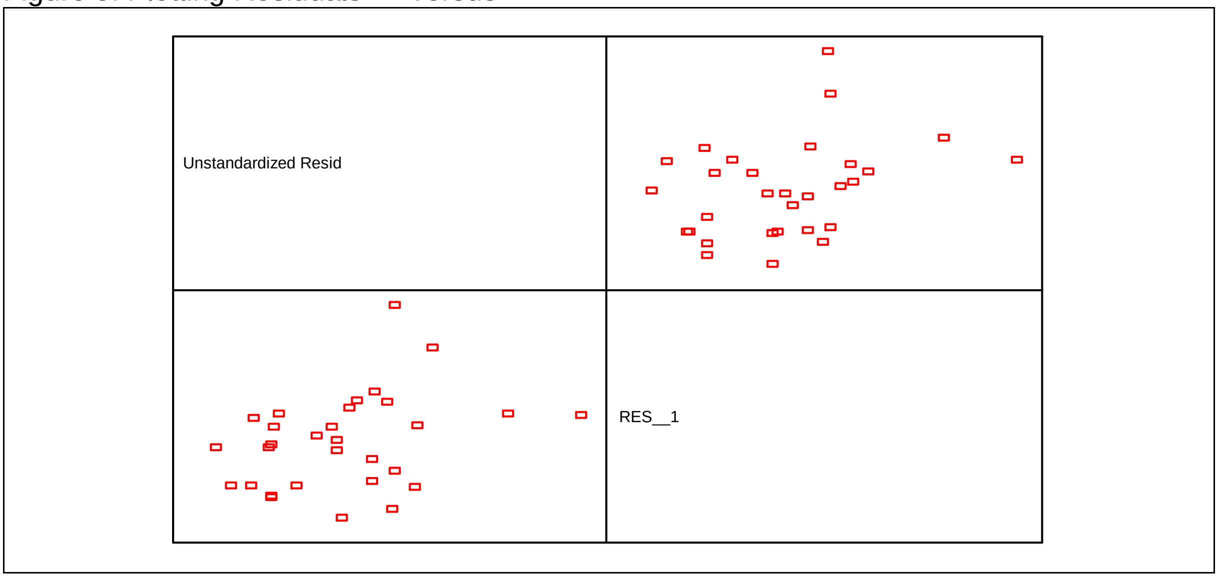


Examining the time sequence plot given in above figure, we observe that perhaps there is autocorrelation in the function.

3.6 Plot $\hat{\varepsilon}_t$ against $\hat{\varepsilon}_{t-1}$

To check whether residuals are correlated or not, we can simply plot $\hat{\varepsilon}_t$ against $\hat{\varepsilon}_{t-1}$.

Figure 5: Plotting Residuals $\hat{\varepsilon}_t$ versus $\hat{\varepsilon}_{t-1}$



For detecting autocorrelation in the residuals this graph indicates perhaps there is autocorrelation. Now to examine autocorrelation exits or not, we will have to conduct two test procedures.

3.7 The Runs test

In the study, n_1 =15 and n_2 =16.The number of runs is k = 12. We have also obtained E (k) = 16.48, σ^2_k = 7.4706 and σ_k = 2.734. Hence the 95% confidence interval is $[16.48 \pm 1.96(2.734)]$ = (11.124, 21.839). Since the number of runs 12, falls this interval. Therefore, we may conclude that the observed sequence of residual is random with 5% level of significance.

3.8 Durbin-Watson (d) Test

Running the Durbin-Watson test we got the value of the test statistic is, d = 1.33, Here, observations, n= 31, and Regresses, k = 6. At 5% level of significance, the critical d values are d_L = 1.020 and d_U = 1.920. On the basis of the usual d test, we cannot say whether there is positive correlation or not because the estimated d value lies in the indecisive range.

3.9 Detection of Multicollinearity: Chi-Square test

To check the multicollinearity we have applied the Chi-Square test. For this study, sample size, n=31, number of independent variable, k=6, v=15 and Value of the standardized determinant |R|= 0.0001806115. Applying the testing procedures, we found that χ^2_{cal}= 234.154 and $\chi 2_{tab}$= 25. So $\chi 2_{cal} > \chi 2_{tab}$, which indicates that the multicollinearity exists.

3.10 F-test

To find out the variables which have multicollinearity, we also compute the multiple correlation coefficients and their associated F-statistics within the set of explanatory variables.

Table 5: F-test results for multicollinearity

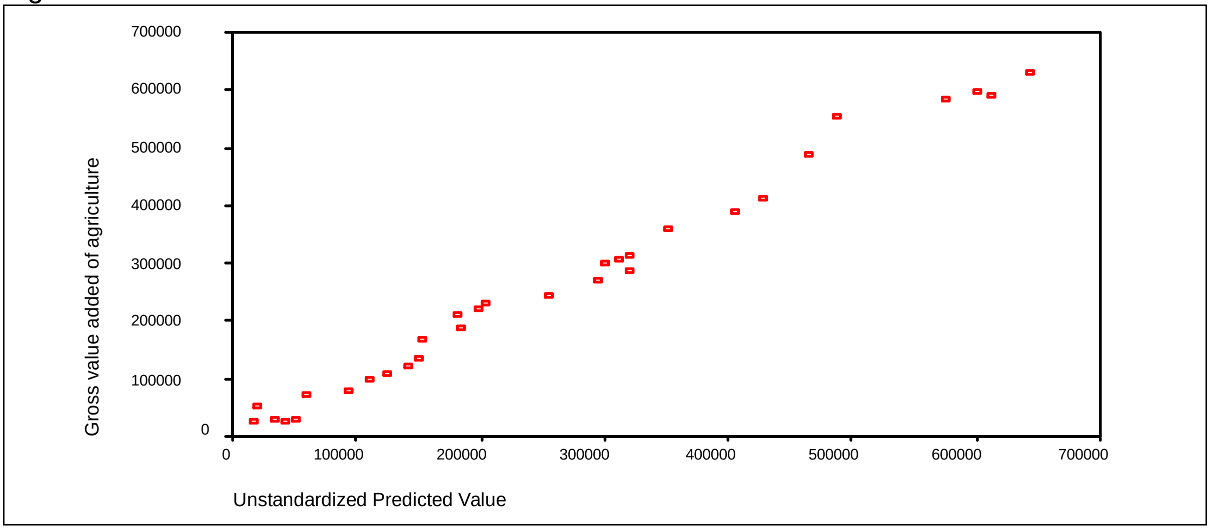
$R^2_{x1:\ x2, x3........x6}$ = 0.881	Fx_1 = 24.027
$R^2_{x2:\ x1, x3........x6}$ = 0.993	Fx_2 = 851.14
$R^2_{x3:\ x1, x2........x6}$ = 0.992	Fx_3 = 744
$R^2_{x4:\ x1, x2........x6}$ = 0.901	$Fx_{4\,=}$ 54
$R^2_{x5:\ x1, x2........x6}$ = 0.984	Fx_5 = 294
$R^2_{x6:\ x1, x2........x5}$ = 0.986	Fx_6 = 422.57

From the above results, it reveals that all the independent variable Land utilization (X_1), Area Irrigated (X_2), Consumption of pesticide (X_3), Improved Seeds (X_4), Fertilizer consumption (X_5) and Improved Seeds (X_6) are multi-collinear.

3.11 Linearity of the regression

To check the linearity of the regression, we can plot observed response verses predicted response. The graph suggests an approximately straight-line relationship. That is, we can conclude that the linearity in regression is valid.

Figure 6: Observed Y verses Predicted Y



3.12 Detecting outlier

After case wise diagnostic, we have found 27th observation is an outlier which gives unusual result. The following table shows the outlier.

Table 6: Case wise diagnostic for detect outlier

Casewise Diagnostics [a]

Case Number	Std. Residual	Gross value added of agriculture	Predicted Value	Residual
27	2.597	554755.0	500878.94	53876.06

a. Dependent Variable: Gross value added of agriculture

Omitting this observation, the coefficients of β_i's have been calculated and the following results are obtained.

Table 7: Comparison of the coefficients after omitting outlier

Omitting outlier		Including all observation	
Model	Unstandardized Coefficients β_i	Model	Unstandardized Coefficients β_i
Constant	-686918.502	Constant	-633239.53
X_1	11.58	X_1	14.16
X_2	2.066	X_2	1.607
X_3	9.42	X_3	16.018
X_4	42.804	X_4	24.646
X_5	1.02	X_5	1.707
X_6	3.426	X_6	2.405

We can see from Table 7 that the coefficients of X_2 (Area irrigated by methods), X_4 (Area under forest) and X_6 (Improved seed) are increased after omitting the outlier. Similarly, it has been found that X_1 (Land Utilization), X_3 (Consumption of pesticide) and X_5 (Fertilizer consumption) are slightly decreased. It has been found that two points are staying out of the horizontal band while examining the homoscedasticity of residuals in Figure 2. However, Figure 7 evinces that the horizontal band does not have any abnormality after omitting the outlier. From the Figure 8 we can see that residuals follow a normal distribution i.e. $\varepsilon_i \sim N(0,\sigma^2)$. The figure shows that the random dispersion of the ε_i's of graph (a) within a constant distance around the regression line which is straighter than that of graph (b).

3.13 Linearity of the regression (after omitting outlier)

To check the linearity of the regression after omitting the outlier, we can plot observed response verses predicted response. Figure 9a) shows that the regression is straighter compared to Figure 9b). However, Figure 9b) still shows linearity excluding the outliers.

Figure 7: After omitting outlier, scatter diagram between predicted Y and residuals

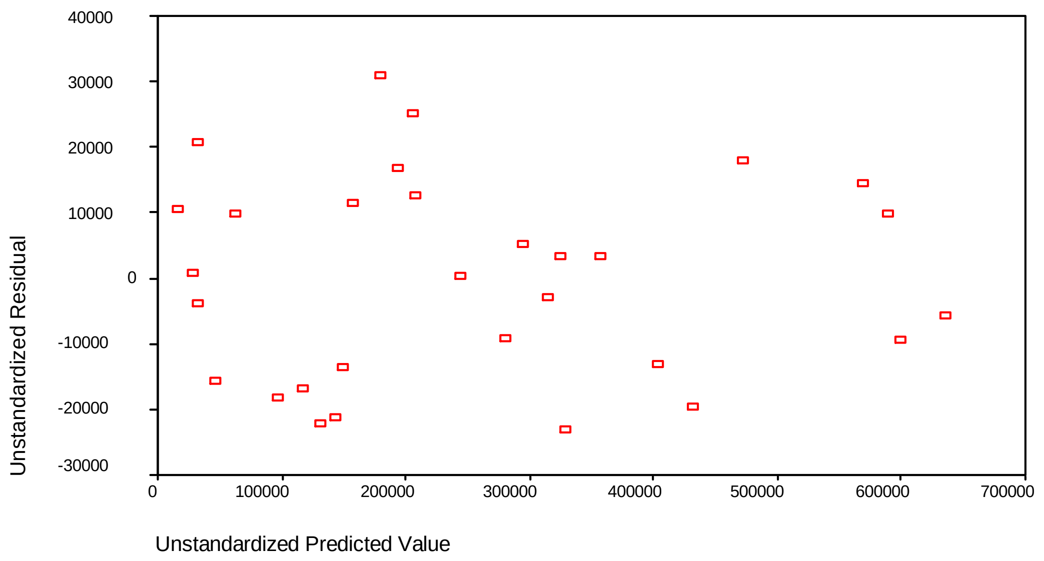
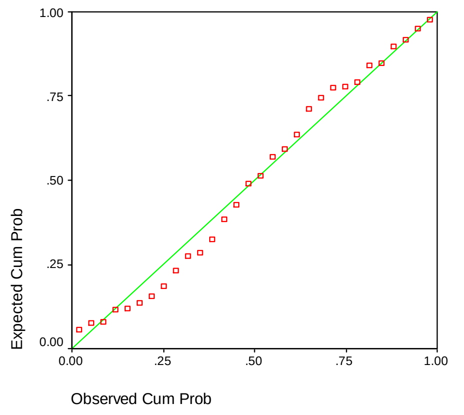


Figure 8: Normal P-P

a)



b)

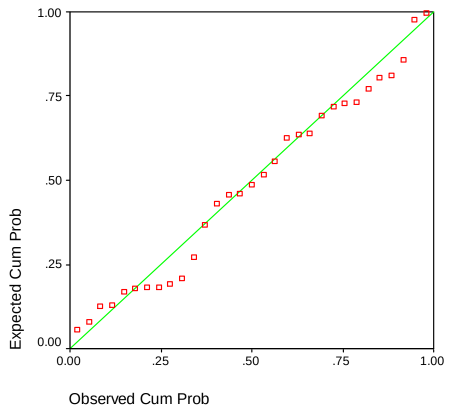
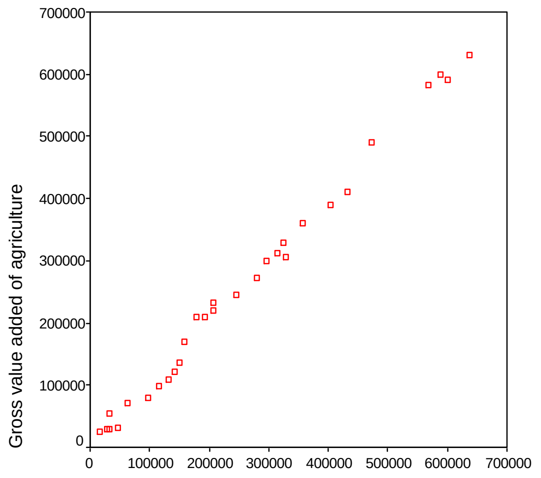
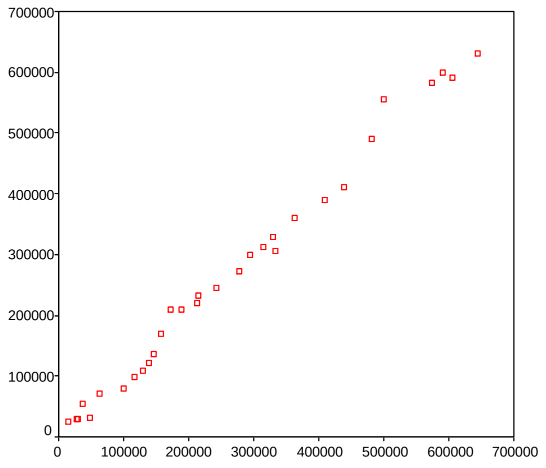


Figure 9: Observed Y verses Predicted Y

a) Predicted value



b) Predicted value (omitting outlier



4. FINDINGS AND CONCLUDING REMARKS

This article is an attempt to model a relationship for the independent variables Land utilization (X_1), Area Irrigated (X_2), Consumption of pesticide (X_3), Area under forest (X_4), Fertilizer consumption (X_5), and Improved Seeds (X_6) with the dependent variable Gross Value Added of Agriculture sector (Y). Performing the analysis of data, it has been found that independent variables are significant, which means that there is a significant effect on dependent variable, GVA of Agriculture. Performing the coefficient of multiple determination analysis R^2, it has been seen that dependent variable Gross Value Added of Agriculture sector is explained 89.6% of the total variations by the independent variables. Residual analysis has been done and all the properties are satisfied. Outlier has been detected and analysis is carried out excluding the outlier observations. After performing residual analysis, it has been found that residuals satisfied both the zero mean and constant variance property. Residuals are also found uncorrelated by performing run test and Durbin-Watson d test. Linearity of the regression model has been checked and it denotes approximately straight line. Outlier has been detected and analysis is performed excluding the outlier. Comparisons are made between the sets of observations, including and excluding the outlier and it has been found that if we exclude the outlier, the assumption of normality of residuals, homoscedasticity and linearity of the regression becomes more perfect than including the outlier. After performing Farrar-Glauber test procedure, multicollinearity is detected in the model. All the independent variables are found to be collinear. These could be removed with the help of Principal Component Analysis and other advanced techniques. But due to time constraint, further analysis could not be conducted.

From the model it can be concluded that the variable area under forest (X_4) has the maximum effect on the GVA of agriculture while Consumption of pesticide (X_3) and Land utilization (X_1) have secured the second and third position respectively, based on the impact scenario. Though variables Area irrigated by methods (X_2), Fertilizer consumption (X_5) and Improved seed (X_6) have less effect on the GVA of Agriculture but they still have significant effects. Increase in the level of area under forest, will contribute heavily to the gross value added of the agriculture which in turn will have a positive effect on the GDP of the country. Proper use of pesticide will increase the GVA of agriculture to the overall GDP of the country. In addition, proper utilization of land will also increase production which may contribute to the higher gross value added of agriculture GDP of the country. It has been observed from the model that fertilizer has relatively less effect on the GVA of agriculture to the GDP. We must realize that Bangladesh imports huge amount of fertilizer for its agricultural purpose. Though it is very important for agricultural production, still its production and import cost substitutes the values to overall agricultural production. So it has lesser effect on the GVA of Agriculture. Same scenario has been observed in terms of improved seed.

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