




## EXAMINE THE ROLE OF AGRICULTURE TO MITIGATE THE CO<sub>2</sub> EMISSION IN BANGLADESH

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### ARTICLE HISTORY:

**Received:** 12-Mar-2020

**Accepted:** 14-May-2020

**Online Available:** 16-Jun-2020

### Keywords:

Carbon emission,  
Agricultural production,  
Economic growth,  
Energy consumption,  
Bangladesh

### ABSTRACT

The current study analyzed the optimum solution to mitigate CO<sub>2</sub> emission in Bangladesh. The significant factor of this study is agricultural productions and activities in Bangladesh are the superior carbon absorber. To estimate the effective result and findings this perusal conducts the Generalized Method of Movement with considering agricultural productions as a key variable to mitigate the CO<sub>2</sub> emission. The econometric result finds that agricultural production reduces carbon emission in selected models. An increase the agricultural activities and green harvesting significantly reduce CO<sub>2</sub> emission. Whatever, the empirical result also states that increasing agricultural production is not only a productive way to mitigate CO<sub>2</sub>, also, that CO<sub>2</sub> could be mitigated to invest in agriculture, provide initiative or subsidies in the agriculture sector. The current study provides a substantial way to mitigate carbon dioxide without any harms of economic growth.

### Contribution/ Originality

This study is the first attempt to investigate the role of agriculture to relieve the CO<sub>2</sub> emission in Bangladesh. It will also fill the gap of literature in this field in the country.

DOI: [10.18488/journal.1005/2020.10.1/1005.1.392.405](https://doi.org/10.18488/journal.1005/2020.10.1/1005.1.392.405)

ISSN (P): 2304-1455/ISSN (E):2224-4433



**How to cite:** Md. Hasanur Rahman, Shapan Chandra Majumder and Shantanu Debbarman (2020). Examine the Role of Agriculture to Mitigate the CO<sub>2</sub> Emission in Bangladesh. Asian Journal of Agriculture and Rural Development, 10(1), 392-405.

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## 1. INTRODUCTION

Carbon dioxide emission is one of the challenging and problematic issues in the global world. Technological development and economic growth make life easier but this kind of development generates many remonstrances by reducing the environmental quality or ambient quality. [Almozaini \(2019\)](#), [Saboori et al. \(2012\)](#) argue that CO<sub>2</sub> is the most burning issue for environmental concerns. The main sources of CO<sub>2</sub> are fuel consumption, deforestation, industrial garbage, smoke, and energy consumption. Energy consumption and industrialization are highly increased in Bangladesh and it has an upward trend that implies CO<sub>2</sub> emission also increases. The coal burning, fuel, transportation, industrial smoke are the main source of carbon in this country. In some of the regions, coal burning and industrial smoke and others are the vital sources to increase CO<sub>2</sub> like the region Nawapara, Narayanganj, Dinajpur. The ambient qualities of this region are gradually decreasing. The forest area in Bangladesh is also reduced day by day. According to [Haque et al. \(2014\)](#), deforestation or the insufficient forest area can't absorb properly. However, it is generally said that if the source of CO<sub>2</sub> fact identifies properly then it will be mitigated.

In the last decades, Bangladesh achieved a high GDP growth rate it is more than 6% that is taken as a role model of economic growth among the developing nations. [Asadullah et al. \(2014\)](#), [Uddin et al. \(2014\)](#) also gives a similar kind of statement. After independence in 1972 the economic growth rate was negative it was -13.92%, in 2000 it was 3.82%, in 2015 GDP growth rate achieved 6.55% and the 2017 growth rate increases to 7.68%. On the other hand, the forest area is considerably decreasing which is insufficient to operate the environmental balance. Bangladesh as an agricultural-based country, the total volume of agricultural production increases but decreasing the contributions on the percentage share of GDP by comparing service and industrial production. This is the case of the law of diminishing returns that's highly applicable for agricultural production in Bangladesh. [Udry \(1996\)](#) found similar results. Agricultural production value-added percentage to GDP in 1972 was 59.61% that means the economy vastly depends on agriculture, in 2005 the value-added rate was 18.57% and in 2017 it was decreased to 13.41% but the total volume of agricultural production increases that means the economy move to agricultural to industrial and service activities. Energy consumption like fossil fuel, renewable and non-renewable energy is increased whenever the industrialization and urbanization also increase in Bangladesh. In addition that the total percentage of the population is about 75% of people lives in rural areas ([Mendola, 2007](#); [Alam et al., 2009](#)) and the percentage is similar in other South Asian countries. So the impacts of CO<sub>2</sub> emission are largely affected in rural areas with consistent to urban areas. According to the IPCC 4<sup>th</sup> assessment report, the main reason for flood and drought is climate change and the rural belt are highly affected in agricultural productions with reduced natural resources, fisheries and forest area. According to [Parry et al. \(2004\)](#), [Nelson et al. \(2014\)](#) climate change affects agriculture productivity frequently.

The agricultural production or the green growth activity is a substantial impact to protect environmental degradation where it includes forestry to secure environmental balance and sustainable food productions. The agricultural activity must play a role as the lifeline of an economy especially in South Asian countries, that's why every country concentration on significant economic development and ensure sustainable agricultural activities and increases the forest area. Electricity accelerates carbon emission found by ([Shahbaz et al., 2016](#)). CO<sub>2</sub> discharge from electricity and heat production in Bangladesh is 52.80%, gaseous fuel emit 62.80% and transport is emitted 14.19% from fuel consumption. The CO<sub>2</sub> scenario expects that agricultural productions and afforestation are to be able to absorb the greenhouse, carbon gasses, and other pollutions in Bangladesh.

The main purpose of the current study is to examine the optimum solution to mitigate CO<sub>2</sub> escape in Bangladesh. The mitigating factor is the agricultural productions and activities with considering

economic growth, forest, fossil fuel consumption, energy use, and industrialization. This study conducts the GMM to estimate the empirical results. That is cover the existing literature gap and provides unique CO<sub>2</sub> mitigation in Bangladesh.

The next section of this study will be discussed in section 2 about the literature review, section 3 includes the objective, the hypothesis development in section 4, the methodology is present in section 5, empirical results and findings discussed in section 6 and finally conclude section 7.

## 2. LITERATURE REVIEW

The previous study analyzed in this section to examining the optimum solution to mitigate CO<sub>2</sub> emission in a brief. The forest area, agricultural production, renewable energy, increasing the harvesting of land used as mitigating factors to mitigate CO<sub>2</sub> emission. [Schneider and McCarl \(2003\)](#), [Lal \(2004\)](#), [Adams \(1989\)](#) concentrate on agricultural production and activities to reduced carbon emission. According to [Amin and Rahman \(2011\)](#) Energy consumption and GDP has unidirectional causality, a time series analysis in Bangladesh. [Asgar \(2008\)](#), [Jumbe \(2004\)](#), [Soytas et al. \(2001\)](#) also measure similar kinds of findings. For bound testing among energy consumption, GDP, and CO<sub>2</sub> emission showing the long-run relationship ([Nain et al., 2015](#)). Granger causality test and a cointegration test examine by [Almozaini \(2019\)](#) in China long-run between GDP and EC, in the USA GDP cause gas emission, in Saudi Arabia Energy discharge cause of gas. A time-series analysis in Saudi Arabia [Alkhathlan and Javid \(2013\)](#) demonstrate that per capita carbon emission increase with the rise of per capita income increase respect to energy, GDP growth, and CO<sub>2</sub>. To measure the importance between economic growth and CO<sub>2</sub> emission [Omri \(2013\)](#) state that energy expenses cause CO<sub>2</sub> and growth and CO<sub>2</sub> have a bidirectional causal relationship. By using the variables Energy, industrial growth, and carbon discharge [Rahman and Kashem \(2017\)](#) state the empirical analyses state that industrial production and energy outlay have a positive impact on carbon discharge. [Zhao et al. \(2010\)](#), [Yang and Chen \(2011\)](#), [Khanna et al. \(2008\)](#), [Gokmenoglu et al. \(2015\)](#) measure the cause between energy consumption, industrialization, and carbon emission. And an inverted U shaped EKC curve found by ([Dong et al., 2017](#)). An analysis of pollution and urbanization results explain that the environment was negatively affected by urbanization ([Khan and Khan, 2015](#)).

Analyzing the importance of agricultural production and related measure to carbon emission, [Popp et al. \(2010\)](#) show that the global agricultural non-CO<sub>2</sub> emissions significantly increase. Agriculture and GDP has a positive impact, while the increase in temperature has a negative effect found by ([Dumrul and Kilicaslan, 2017](#)). Another empirical study in Ghana [Asumadu-Sarkodie and Owusu \(2016\)](#) showed that the carbon discharge, cereal production, and biomass-burned crop residues both have bidirectional causality concerning the agricultural ecosystem, Carbon dioxide emissions and [Sarkodie \(2018\)](#) also state that excessive use of agriculture, energy, growth, crop, fertility, the birth rate has a significant impact on environmental degradations. To measuring the reductions of carbon emission state that agriculture reduced CO<sub>2</sub> emissions to the variables CO<sub>2</sub> emission agriculture, forest, renewable energy ([McCarl and Schneider, 2000](#)).

This study shows the way to mitigate CO<sub>2</sub> by using agricultural productions and activities as a key of interest variable or the mitigating factor. Whatever the agriculture productions and activities in Bangladesh are the superior carbon absorber with including forest area. The significant role of agricultural production has been analyzed in a form of econometric modeling with considering economic growth, forest, fossil fuel consumption, energy use, and industrialization. This study conduct to examining the optimum solution to mitigate the CO<sub>2</sub> emission in Bangladesh by using GMM econometric models, which are never been examined by any other researcher in the studied country.

### 3. THE OBJECTIVE OF THIS STUDY

The main objective of this study is to examine the optimum solution to mitigate CO<sub>2</sub> emission in Bangladesh.

The specific objectives are:

- i. To examine the empirical relation between CO<sub>2</sub> emission and agricultural productions
- ii. To evaluate CO<sub>2</sub> emissions and mitigation way in Bangladesh
- iii. To analyzes the importance of agricultural production with including forest area and policy analysis.

### 4. HYPOTHESIS DEVELOPMENT

The analysis of those hypotheses presented in Table 6 which concludes decisions based on empirical results and findings. However, those hypotheses are assumed as the null hypothesis. Those are given below:

H<sub>1</sub>: There is a positive and significant relationship between CO<sub>2</sub> and agricultural production.

H<sub>2</sub>: There is a negative relationship between CO<sub>2</sub> emissions and forest areas.

H<sub>3</sub>: Economic growth does not increase CO<sub>2</sub> emissions.

H<sub>4</sub>: There is a negative and insignificant relationship between energy consumption and CO<sub>2</sub>.

H<sub>5</sub>: Industrialization does not increase CO<sub>2</sub> emissions.

H<sub>6</sub>: Forest rent or deforestation increases carbon emissions.

H<sub>7</sub>: There is a positive and significant relationship between CO<sub>2</sub> and fossil consumption.

At the very first assumed the agricultural productions have a positive impact on CO<sub>2</sub> emissions. The current study suggests that this hypothesis should be rejected because agricultural production and activities work as a mitigating factor to mitigate CO<sub>2</sub> emissions (Johnson *et al.*, 2007), (Rosenzweig and Tubiello, 2007). H<sub>2</sub> presents there is a negative relationship between CO<sub>2</sub> emissions and forest areas which is supported by (Ruddiman and Ellis, 2009). The third hypothesis assumes the economic growth does not increase CO<sub>2</sub> emissions and H<sub>4</sub> states there is a negative relationship between energy consumptions and CO<sub>2</sub> emission which is rejected by (Long *et al.*, 2015). Industrialization and carbon discharge relation measures in H<sub>5</sub> which represent industrialization does not increase CO<sub>2</sub> emissions. H<sub>6</sub> states that forest rent or deforestation increases carbon emissions (DeFries *et al.*, 2002). H<sub>7</sub> states that fossil fuel consumption does not increase emissions, to rejecting this statement argued by (Long *et al.*, 2015).

### 5. METHODOLOGY OF THIS STUDY

Examine the optimum solution to mitigate CO<sub>2</sub> emission in Bangladesh, this study conceded time-series data from 1975 to 2017. World Development Indicators (WDI), Knoema, and Indexed Mundi are the main secondary data source for this study. In details of all variables are presented in Table 1.

**Table 1: Description of the variables**

Variable name	Description	Data source
CO <sub>2</sub> Emission	CO <sub>2</sub> emissions (kt)	World Development Indicators
Forest	Forest area (sq. km)	Knoema, WDI
AP	Agricultural Productions, value added (constant 2010 US\$)	WDI
Frent	Forest rents (% of GDP)	WDI
EG	GDP (current US\$)	WDI

Fossil	Fossil fuel consumption	Knoema, WDI
Enc	Energy use (kg of oil equivalent per capita)	Knoema, WDI
Ind	Industrial productions, value added (constant LCU)	WDI

**5.1. The model**

The current study investigates the impact of economic growth, agricultural production, forest, fossil fuel consumption, energy use, and industrialization on CO<sub>2</sub> emission for Bangladesh. The Implicated models are formulated by the author based on economic growth, rapid industrialization, energy consumption in production sectors, and transportations. The agricultural productions and activities including forest area support to increasing the ambient quality however, Bangladesh is known as an agricultural country (Shelley *et al.*, 2016). Contributions of forest rent to GDP accelerate deforestation which is a major concern for sustainable ambient quality. Moreover, the simple form of the model is as follows:

$$CO_2 = f(EG, AP, Forest, Frent) \dots \dots \dots (1)$$

$$CO_{2t} = \beta_0 + \beta_1 EG_t + \beta_2 AP_t + \beta_3 Forest_t + \beta_4 Frent_t + \varepsilon_t$$

Where CO<sub>2</sub> represents the emission of carbon dioxide and its measure in (kt). AP is the total volume of agriculture productions, measure in (constant 2010 US\$). The agriculture productions and activities help to absorb the CO<sub>2</sub> like a sink. Paustian *et al.* (1997), Paustian *et al.* (1998), Paustian *et al.* (2000) used agriculture as an element to the reduction of carbon emission. The term EG represents the economic growth which is measured by the volume of GDP in (current US\$). Forest is present the total area of forest in Bangladesh, its measure in (sq. km) of total land, in addition, that in this study this variable used as the insufficient forest area because every country must hold 25 % of the forest is in the geography (% of land area) where Bangladesh has only 10.95%, it's quite insufficient for Bangladesh as a densely populated country. One of the important variables for this country is Front and is measured as the forest rent (% of GDP). Forest rest is defined as the forest rents are Roundwood harvest times the product of average price that means it increases deforestation and reduces the forest area that's help to increase the carbon dioxide emission in nature.

$$CO_2 = f(EG, AP, Forest, Frent, Fossil, Enc) \dots \dots \dots (2)$$

$$CO_{2t} = \beta_0 + \beta_1 EG_t + \beta_2 AP_t + \beta_3 Forest_t + \beta_4 Frent_t + \beta_5 Fossil_t + \beta_6 Enc_t + \varepsilon_t$$

In model-2, fossil and energy consumption has been added in mode-1 to empirically examine the vital role of agricultural productions to mitigate CO<sub>2</sub> from fossil and energy consumption. Fossil fuel consumption is one of the greatest carbon sources in Bangladesh because of several uses of energy in industry and other production and transportations. Enc is representing energy use and it is a measure (kg of oil equivalent per capita) as the key element of production and transportation in Bangladesh.

$$CO_2 = f(EG, AP, Forest, Frent, Ind) \dots \dots \dots (3)$$

$$CO_{2t} = \beta_0 + \beta_1 EG_t + \beta_2 AP_t + \beta_3 Forest_t + \beta_4 Frent_t + \beta_5 Ind_t + \varepsilon_t$$

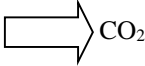
In model-3, industrialization added in model-1 to examine the role of agricultural productions and activities to reduce the CO<sub>2</sub> emission. In the case of Bangladesh, the industrial production increases the CO<sub>2</sub> escape and it has an upward trend. But this situation will be changed when the industrial growth takes a sustainable point the CO<sub>2</sub> escape can be decreased. As a growing industrial country, it is generally accepting economic theory and practices. Urbanizations is one of the vital factors in increasing the carbon emission with respect to industrialization, besides, that GMM estimation considers urbanization as an instrument variable.

$$CO_2 = f(EG, AP, Forest, Frent, Fossil, Enc, Ind) \dots \dots \dots (4)$$

$$CO_{2t} = \beta_0 + \beta_1 EG_t + \beta_2 AP_t + \beta_3 Forest_t + \beta_4 Frent_t + \beta_5 Fossil_t + \beta_6 Enc_t + \beta_7 Ind_t + \varepsilon_t$$

Finally, the current study goes about to investigate the role of agricultural productions and activities in CO<sub>2</sub> emission. However, all variables are included in model-4 and it examines how the mitigating factors work to reduce carbon emission. In addition that this model looks into the role of all variables in carbon emission. For the simplicity of this study, using log transformations of all variables in both models.

**Table 2: Model structure**

Baseline Model	
Economic Growth	
Agricultural Productions	
Forest Area	
Forest Rent	
Fossil Fuel	
Energy Consumption	
Industrialization	

**5.2. Unit root test**

**5.2.1. ADF technique**

The simple unit root stochastic process follows the procedure

$$Y_t = \vartheta Y_{t-1} + \mu_t \text{ where, } -1 \leq \vartheta \leq 1 \dots \dots \dots (5)$$

$$Y_t - Y_{t-1} = \vartheta Y_{t-1} - Y_{t-1} + \varepsilon_t \dots \dots \dots (6)$$

$$Y_t - Y_{t-1} = (\vartheta - 1) Y_{t-1} + \varepsilon_t \dots \dots \dots (7)$$

$$\delta Y_t = \partial(Y_{t-1}) + \varepsilon_t \dots \dots \dots (8)$$

Where;  $\partial = (\vartheta - 1)$  and the 1st difference operator is  $\delta$   
 if  $\partial = 0$  then  $\vartheta = 1$  meaning that the series have unit root as the condition of  $H_0$ .  
 if  $\partial = 0$  then;  $\delta Y_t = Y_t - Y_{t-1} = \varepsilon_t \dots \dots \dots (9)$

Since,  $\varepsilon_t$  is an error term, describe it is stationary, meaning that the time series is stationary after taking the first difference. Now ADF test has the following equations:

$$\delta Y_t = \gamma_1 + \gamma_{2t} + \partial(Y_{t-1}) + \alpha_t \sum_{i=1}^f \delta Y_{t-i} + \varepsilon_t \dots \dots \dots (10)$$

Where;  $\varepsilon_t$  is an error component and ADF  $\delta Y_{t-1}$  is the lagged selection criteria.

*P-P technique*

A technique of nonparametric stochastic unit root processes has proposed by (Maddala and Wu, 1999), (Choi, 2001). ADF test enhances the P-P technique without lagged term and considers as error term has serial correlations.

$$\Delta Y_t = \alpha_1 + \partial(Y_{t-1}) + \sum_{j=1}^k \delta_j \Delta Y_{t-j} + \alpha_{2,t} \partial + \varepsilon_t \dots \dots \dots (11)$$

Where; first difference showed by  $\Delta$ ,  $k$  is the constant and  $Y_{t-1}$  represent the optimum time-lagged for developing the null hypothesis ( $H_0$ ) is data has a unit root and task hypothesis ( $H_1$ ) represents no unit root or stationary.

## 6. RESULTS AND DISCUSSION

### 6.1. Descriptive statistics

The descriptive statistics conduct with all studied variables like as agricultural productions, economic growth, forest area, forest rent, fossil fuel consumption, energy use, and industrialization with respect to mean, median, minimum value, maximum value, standard deviation, kurtosis, and skewness are importantly describing in table 3. For the simplicity of this study, log transformation of all variables is used for all estimations.

**Table 3: Descriptive statistics**

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Sum Sq. Dev.
CO <sub>2</sub>	10.000	10.087	11.466	8.491	0.869	-0.036	1.839	31.681
AP	23.141	23.141	24.235	22.275	0.498	0.467	2.578	10.412
Forest	6.243	9.575	9.612	9.563	4.624	-0.634	1.402	897.909
Fossil	3.912	4.027	4.379	3.206	0.338	-0.507	2.049	4.794
Frent	-1.060	-1.109	0.884	-1.817	0.592	1.257	4.793	14.721
EG	24.519	24.561	26.244	22.990	0.853	0.258	2.211	30.591
Ind	27.133	27.105	28.712	25.758	0.855	0.163	1.885	30.693
Enc	4.960	4.928	5.499	4.564	0.287	0.452	1.954	3.451

The mean value of energy consumption is 4.960 with 5.499 maximum and 4. 564 minimum values. Industrial value-added in GDP has presented industrialization with mean value 27.133. The maximum and minimum value of this variable is 28.712 and 25.758 respectively. Economic growth represents the mean value of 24.519 with a standard deviation of 0.853. The forests rents are Roundwood harvest times the product of average price, that’s present the negative mean value - 1.060 with maximum and minimum value is 0.88 and -1.817 respectively. The mean value of fossil fuel consumption is 3.912 with a maximum value of 4.379 and a minimum value of 3.206. Carbon dioxide discharge measured in (kt) which shows the mean value of 10.000, maximum value 11.466 and the minimum is 8.419 with std. dev. 0.869. The agricultural activities and productions present the mean value 23.141, where the maximum 24.235 and the minimum value is 22.275. The std. dev of agricultural production is 0.498. The descriptive statistics conclude that the behaviors of variables are acceptable and reliable.

### 6.2. Results of unit root tests

To test the stationarity of selected variables, this study considers two popular techniques like as ADF technique which is developed by (Dickey and Fuller, 1979). Maddala and Wu (1999), Choi (2001) developed the Philips Parron -PP technique used to measure the unit root based on t statistics and individual p -values.

**Table 4: Results of unit root tests**

Test → Variables ↓	Unit root test (baseline model)			
	ADF		PP	
	At Level	At 1 <sup>st</sup> difference	At Level	At 1 <sup>st</sup> difference
CO <sub>2</sub>	4.540	-4.060**	11.986	-4.803***
AP	-0.940	-8.125***	-1.080	-7.859***
Forest	-1.604	-6.378***	-1.644	-6.379***
Frent	-3.564*	-8.590***	-3.191	-6.731***
EG	1.129	-4.562***	0.957	-4.804***

Ind	0.330	-9.043***	-1.069	-9.398***
Enc	-0.418	-8.221***	-0.193	-8.221***
Fossil	-1.586	-6.345***	-2.955	-6.995***

**Notes:** All the variables are performed in trend and intercept for the series. SIC, AIC used to select lagged length.  $H_0$  is a data series that has a unit root. \*\*\*, \*\*, and \* represents 1%, 5%, and 10% level of significance respectively

Table 4, present the ADF and PP test results, where the variables consider at the level and 1<sup>st</sup> difference with trend and intercept. The selected variables are stationary at 1<sup>st</sup> difference and all variables are non-stationary at the level. The nominal hypothesis is the variable is the unit root where, the task hypothesis is, the variable has no unit root with considering a 5 percent level of significance. The variable forest rest is shown exceptions because the ADF test shows the stationary at the level in ten percent significance.

### 6.3. GMM regression estimations by considering agricultural production

This study conducts agriculture productions as the key variables to mitigate CO<sub>2</sub> emission. Table 5 demonstrates the econometric result of model 1-4 by using GMM estimations. The model-1 presents the fundamental model that examines the impact of agricultural production, economic growth, forest area, and forest rent on CO<sub>2</sub> emission. Econometric evidence shows that economic growth positive and significant effect on CO<sub>2</sub> escape. Increasing 1 percent volume of economic growth exhilarates the CO<sub>2</sub> discharge 1.982 percent which is significant at 1 percent level. [Amin et al. \(2012\)](#), [Alam \(2014\)](#) found a similar result of measuring emission. Forest rent defined as the wood harvesting at different times in a year it's known as deforestation. The marginal effect of deforestation on carbon discharge is 0.160 percent, it is positive and significant. Forest area is known as the insufficient forest area in Bangladesh these variables demonstrate that 0.02 percent positive effect on CO<sub>2</sub> emission whenever, the forest area decrease. The mitigating factor explains that the negative effect on CO<sub>2</sub> emission as an expected sign of this study. The coefficient of agricultural production is -1.746 and it is significant with a 1 percent level, indicate that agricultural production and increasing agricultural activities mitigate carbon dioxide emission.

**Table 5: GMM results**

Variables	Estimated Models			
	Model-1	Model-2	Model-3	Model-4
CO <sub>2</sub> Emission				
Forest	0.023***	0.012***	0.019***	0.009**
AP	-1.764***	-0.378**	-1.105***	-0.191
Frent	0.160**	0.007	0.076*	0.001
EG	1.982***	0.430*	1.133***	0.185
Fossil		0.797***		0.763***
Enc		1.304***		0.834***
Ind			0.460*	0.326***
C	2.254	1.492*	-4.768	-6.117***

**Note:** \*\*\*, \*\*, \* represents 1%, 5%, and 10% level of significance respectively

The GMM estimation results of model-2 are represented in the second column. Model-2 is the extended form of model-1, where added fossil fuel and energy outlay. In model-2 demonstrates that the coefficient of forest areas is 0.01 percent and it is positive. Forest rent showing the coefficient 0.007 and it is insignificant. One percent increase in economic growth accelerates CO<sub>2</sub> emission by 0.430 percent with a ten percent level. The consumption of energy is positive and significant to increase the carbon escape where fossil fuel has the coefficient value 0.797 percent and significant at a one percent level. In model-2 the marginal effect of agricultural productions is -0.378 that's, which contains an expected sign meaning that agricultural productions have a significant impact to mitigate CO<sub>2</sub> discharge.



Column 4 in Table 5 represents the model-3, which endeavours to analyze the role of the industrialization on CO<sub>2</sub> emission in Bangladesh. Industrialization added in fundamental model-1 which shows That the industrialization has a positive effect on CO<sub>2</sub> discharge. The coefficient is 0.460 and it is veritable with considering at a ten percent level. Whatever the coefficient of insufficient forest area shows a positive relation to accelerating the CO<sub>2</sub> escape. Forest rent shows a plus sign where the economic growth consists of increasing CO<sub>2</sub> discharge at a 1 percent level. The marginal effect shows that the coefficient value is 1.133 percent to accelerate carbon escape. This model demonstrates that agricultural production still a negative and significant impact that is expected to mitigate CO<sub>2</sub> discharge.

In addition, Model-4 estimates the following variables: forest area, forest rent, economic growth, energy, fossil, and industrialization. The econometric evidence impending in column-4 shows the insufficient forest area has a positive and significant impact on CO<sub>2</sub>, Where the forest rent is not significant. Fossil fuel takes an equitable and significant impact to accelerate CO<sub>2</sub> emission by 0.763 percent. The coefficient of energy use is 0.834 percent to extend the marginal effect of carbon discharge. This finding is similar in (Shahbaz *et al.*, 2016). The coefficient of agricultural production is -0.191 which is not significant but it still shows a negative sign that's expected to mitigate CO<sub>2</sub> discharge, where the agricultural productions show significant in previous models. The overall up of the estimations is that that economic growth is quite significant to accelerate carbon emission, insufficient forest area is unable to absorb the carbon gases properly that's why the coefficient shows a positive sign. Deforestation, energy, and fossil increase the carbon emission, where agricultural production as a mitigation factor works to reduce carbon emission.

The overall study conveys that energy consumption, fossil consumption, forest rent, economic growth, and industrializations still work to increase CO<sub>2</sub> emission. By completing this analysis it is clear that agriculture significantly contributes to reducing CO<sub>2</sub> emission. So the CO<sub>2</sub> emission policies should consider those emissions factors to get success.

#### 6.4. Hypothesis analysis

To measure the relationship between agriculture and carbon emission, The nominal hypothesis is that agricultural productions have a positive impact on CO<sub>2</sub> emissions. Whatever the decision criteria state that in Table 6 for several models. The empirical findings rejected the nominal hypothesis by accepting the task hypothesis. Agricultural production does not increase carbon dioxide emissions (Liu *et al.*, 2017). In the second case insufficient forest area state, the hypothesis is rejected. The economic growth accelerates the carbon discharge that's present in third cases.

**Table 6: Hypothesis analysis**

Null Hypothesis (H <sub>0</sub> )	Decision criteria			
	Model-1	Model-2	Model-3	Model-4
H <sub>1</sub>	Reject the H <sub>0</sub>	Reject the H <sub>0</sub>	Reject the H <sub>0</sub>	Reject the H <sub>0</sub> (insignificant)
H <sub>2</sub>	Reject the H <sub>0</sub>	Reject the H <sub>0</sub>	Reject the H <sub>0</sub>	Reject the H <sub>0</sub>
H <sub>3</sub>	Reject the H <sub>0</sub>	Reject the H <sub>0</sub>	Reject the H <sub>0</sub>	Reject the H <sub>0</sub> (insignificant)
H <sub>4</sub>			Reject the H <sub>0</sub>	Reject the H <sub>0</sub>
H <sub>5</sub>		Reject the H <sub>0</sub>		Reject the H <sub>0</sub>
H <sub>6</sub>	Fail to reject the H <sub>0</sub>	Fail to reject the H <sub>0</sub> (insignificant)	Fail to reject the H <sub>0</sub>	Fail to reject the H <sub>0</sub> (insignificant)
H <sub>7</sub>		Fail to reject the H <sub>0</sub>		Fail to reject the H <sub>0</sub>

**Note:** For the cases of (insignificant), that means the sign of the coefficient is expected but doesn't significant in 5% level

In the fourth and fifth cases, the null hypothesis assumes that Industrialization does not increase CO<sub>2</sub> emissions, in this section the empirical findings help to reject the nominal hypothesis. Fossil fuel consumption increases carbon emissions which are rejected the null hypothesis as fossil fuel consumption does not increase emissions. Forest rent or deforestation is unable to reduce carbon gases however this study fails to reject the H<sub>0</sub> in the case of forest rent.

### 6.5. Diagnostics test results

There are two diagnostic tests as known as the normality test and regressor endogeneity tests are used in the econometric procedure. Agricultural productions (AP) used as the endogenous variable in GMM estimations. The IV diagnostics, H<sub>0</sub> is the AP is exogenous and the task hypothesis AP is not exogenous intent which indicates that AP is an endogenous impact on estimated models. In the normality test, H<sub>0</sub> is that residuals are normally distributed and H<sub>1</sub> is that the residuals are not normally distributed. Table 7 conveys the diagnostic test by taking into account J-statistics for endogeneity tests and J-B statistics for normality tests to makes decisions. Diagnostics test for model-1 is present the J-B is 0.08 to accept the H<sub>0</sub> and J-stat is 0.02 to accept the task hypothesis as the agricultural production is endogenous.

**Table 7: Diagnostics test results**

Diagnostics test for baseline models				
Model	Test Statistics	Hypothesis	J -stats/J-B (p-value)	Decision
Model-1	Regressor endogeneity test	H <sub>0</sub> = AP are exogenous	0.02	Reject the H <sub>0</sub>
	Normality test	H <sub>0</sub> = Errors are normally distributed	0.08	Fail to reject H <sub>0</sub>
Model-2	Regressor endogeneity test	H <sub>0</sub> = AP are exogenous	0.03	Reject the H <sub>0</sub>
	Normality test	H <sub>0</sub> = Errors are normally distributed	0.27	Fail to reject H <sub>0</sub>
Model-3	Regressor endogeneity test	H <sub>0</sub> = AP are exogenous	0.04	Reject the H <sub>0</sub>
	Normality test	H <sub>0</sub> = Errors are normally distributed	0.72	Fail to reject H <sub>0</sub>
Model-4	Regressor endogeneity test	H <sub>0</sub> = AP are exogenous	0.18	Accept the H <sub>0</sub>
	Normality test	H <sub>0</sub> = Errors are normally distributed	0.09	Fail to reject H <sub>0</sub>

In model-2, the endogeneity test rejects the H<sub>0</sub> and residual diagnostics sighting the normality test where J-B stat. is 0.27 which fails to reject H<sub>0</sub>. Test for the model-3 state that, J-B stat. is 0.72 to accept the nominal hypothesis and J- stat. is 0.04 to reject the H<sub>0</sub>. Diagnostics test for model-4 present endogeneity test fail to reject H<sub>0</sub> and residual diagnostics of normality test J-B value is 0.09, the model is normal. However, the diagnostics test state that the behavior of estimated models has no inconsistencies.

## 7. CONCLUSION

The current study endeavour to examine the role of agriculture in carbon emission; where agricultural productions and activities are a carbon absorber in Bangladesh. This study conducts considering other reliable variables like economic growth, forest, fossil fuel consumption, energy use, and industrialization to examine the carbon emission. Agricultural production and activities used as the mitigating factor because agriculture is in generally reduced carbon dioxide. The GMM used to examine the empirical result with consideration of endogenous factors is agricultural

productions. The empirical result demonstrated in selected models is that economic growth accelerates the carbon emission, the expansion of economic activities increases the carbon gases. The insufficient forest area is unable to absorb CO<sub>2</sub> where the forest rest is quite significant to accelerate CO<sub>2</sub> emission. Energy consumptions and fossil fuel show a positive impact on carbon emission in selected models. In this section, the mitigating factor as agriculture works to reduce carbon discharge. This study also demonstrated that in the future, the studied country achieved stable and high economic growth and moved to be a developed country. Whenever, after achieving a certain level the economy works to reduce carbon emission which is the fundamental concept of the Environmental Kuznets Curve (EKC) hypothesis. [Suri and Chapman \(1998\)](#), [Miah et al. \(2010\)](#), [Diao et al. \(2009\)](#) substantiate similar kinds of findings as to the inverted U shape of EKC. The government and regulatory authorities need to take initiatives to increase agricultural productivity. This study demonstrated the importance of reform agricultural policy and regulations to increase agricultural production and activities with limited use of chemical and toxic elements in agricultural activities. The forest area is also included in agricultural productions and strict rules and laws also required to reduce deforestation or illegal forest harvesting. Forest harvesting is positive relation to accelerating the CO<sub>2</sub> emission, that's why this study recommended that the forest rent is not necessary to accelerate the total volume of GDP. The current study provides a substantial way to mitigate carbon dioxide without any harms of economic growth. The current study works as a pioneer one, as per our sequential knowledge, this has afforded to examine the induction of agriculture to carbon mitigation in Bangladesh. The current study collaborates the policymakers to increase agricultural activities to alleviate carbon emission, without affecting other economic variables like energy consumption, industrialization, and afforestation.

**Funding:** This study did not receive any specific financial support.

**Competing Interests:** The authors declared that they have no conflict of interests.

**Contributors/Acknowledgement:** All authors participated equally in designing and estimation of current research.

Views and opinions expressed in this study are the views and opinions of the authors, Asian Journal of Agriculture and Rural Development shall not be responsible or answerable for any loss, damage or liability, etc. caused in relation to/arising out of the use of the content.

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