An assessment of the correlation amongst of Fertilizer usage, Agricultural Nitrous Oxide and Methane emission on Food Production of Bangladesh

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Abstract

Bangladesh is a middle-income country with a large population. Nevertheless, it has inadequate arable land for cultivation and faces environmental constrain during agricultural production. The excessive use of fertilizer in the cultivation process could harm food production alternatively affect the environment. This study, therefore, intended to identify different aspects of fertilizer consumption, methane emission, and nitrogen trioxide emission on the food production of Bangladesh. The study used secondary data from World Development Indicator from 1971 to 2008. The objective of this study is to create structural econometric modeling. Hence, it will identify the actual scenario of the following variables alternatively formulate effective policy. In the preliminary stage, this study conducted the Augmented Dickey-Fuller test and Phillips Perron test to analyze the presence of the unit root. The results of both procedures indicated that the variables are stationary at I(1). Therefore, it is theoretically sensible to run the cointegration test to evaluate whether there is any long-run association between variables or not. After testing the unit roots this study, moves forward to run the Johanson Co-integration test. The test result found no co-integrating in the model. The test result of the Johanson Co-integration test found that the optimum lag length is two and further opened up the door to run Vector Auto Regression. The Vector Auto Regression found Food Production Index as strongly endogenous. It also indicated that the one period lagged value of FPIBD has significant effect on the present value of FPIBD and can increase FPIBD by 93 percent. FCBD, AN2OBD, and ACH4BD, on the other hand, are highly exogenous and have only a little effect on the FPIBD. FPIBD's two-period lag has a significant impact on FCBD, with a 238 percent rise in FCBD. Furthermore, the one-period lagged value of AN2OBD has a little effect on FCBD, increasing it by just 1%, and ceteris paribus, the AN2OBD is substantially impacted by its one-period lagged value. By its one-period delayed value, it suggests a 94 percent raise. As a response, the one-period lagged value of ACH4BD seems to have a substantial impact on the present value of ACH4BD, implying that the one-period lagged value of ACH4BD displays a 59 percent rise in the present value of ACH4BD. The following will help to formulate policies and also enrich literature in the particular field.

Keywords: Food Production Index, Fertilizer Consumption, Methane emission from agricultural sector of Bangladesh, Nitrous Oxide Emission from agriculture sector, Vector Auto regression.

Introduction

The overall production of food in Bangladesh is engaged in several economic activities. In the last 30 years, food production has increased exponentially [6]. The result is not different in Bangladesh because another report also published by FAO concludes that almost 9.5 million pre-school age children are affected by malnutrition, which is a direct cause of inadequate food security of the country [7]. Consequently, the relationship of food production with fertilizer consumption can formulate effective results to intensify the food security of Bangladesh. Climate change is the main driving force in food production. Researchers found solar radiation, temperature, and precipitation are some reasons for decreased crop production in Bangladesh [9]. The consumption of fertilizer increased over time in Bangladesh to increase food production. Researchers always worried about the excessive use of chemical fertilizers in different sectors of food production. After the independence, Bangladesh could not produce enough food to support its large population. However, gradually agricultural expansion and excessive chemical fertilizer use made it possible for Bangladesh to achieve self-sufficiency [3]. However, the use of chemical fertilizers has increased exponentially over time. In 1961, the average consumption of fertilizer per hector was 2.61475886 kilogram only where it increased up to 318.466863 kilograms per hector. Human health does not determine only by food availability but it is an indicator to analyze different portions of the population's health status of a country. The growing population creates excess demand for food in the economy and intensive agricultural production can be the alternative option. The most common insight is excessive use of chemical fertilizers and pesticides that affect human health and the surrounding environment. Instead, the different chemical components like nitrogen trioxide, methane intended to step up tend to increase along with increasing agricultural production and chemical fertilizer use. Hence, the use of excessive nitrogen sources in cropland can intensify nitrogen trioxide emissions from agricultural production [21]. Many studies observed methane (CH_4) emissions from the agricultural sector of Bangladesh. The study also witnessed the methane emission from rice or paddy cultivation is significant and suggests an alternative approach to reduce the emission of CH_4 from agricultural production. Some studies suggested using alternative Wetting and Drying (AWD) methods in rice cultivation to avoid methane emission [23] p. (79-92). Therefore, this study intends to identify the effects of fertilizer, N_2O_3 emission, and CH_4 emission on food production of Bangladesh.

Literature Review

Fertilizer consumption is one of the major driving forces in the food production sector in Bangladesh. Because of the increased demand for food, farmers started to depend more and more on excessive use of fertilizer to intensify production. Many studies found that the fertilizer in crop production was 313 thousand tons in 1975, which rose to 3223 thousand tons in the 2000-2004 period. The study concerned about the actual consumption of fertilizer that way higher than the recommended dose of fertilizer in the cultivation process in Bangladesh [1].

Phosphorus is very common as fertilizer used in crop production as well as in livestock production. The increased food demand tends to increase the consumption of phosphorus in the production process. As per studies, the production of rice in Bangladesh increased more than 50% from 2000 to 2016. The phosphorus consumption in rice production and livestock production in Bangladesh was around 49.96-kilo tons and 6.00-kilotons in the same period [4].

A study conducted by [22] identified the effect of the phosphorus cycle in both rural and urban individual populations. The individual consumes meat, egg, milk, and many other foods and through that, they indirectly consume phosphorus. Their study projected a 145% increase in Phosphorus consumption by 17 different consumer groups within 2030 in Bangladesh.

The growing food demand in Bangladesh must need advanced technological support to intensify its food production. Therefore, the invention of new high-yield crops and improved soil fertility is necessary. Through this process, Bangladesh already started to maximize food production. However, the increasing use of chemical fertilizers and pesticides is affecting the environment and human health [19].

The population growth of Bangladesh increased the demand for food grain over time. Nowadays, an intensive agricultural production system is essential to intensify the production of food grain. The increasing demand for chemical fertilizer is very alarming for both environment and population health. In the late 19th century, the supply and production of organic fertilizer were enough to fulfill soil nutrition. But, as the yield of the crop increased there has been a shortage of organic fertilizer. However, to recover that nutrition, chemical fertilizer becomes the mandatory alternative. In addition, the usage of chemical fertilizer increased at a very large portion, which is a threat to the green production system and human health [8] p. (50-55).

Heavy metals are always a health hazard for people. Chromium, Nickel, Copper, Acrylonitrile, Styrene and Lead were detected in diverse foodstuffs in a study carried out in the one of the district of Bangladesh. It is from the soil, which results from excessive chemical fertilizer usage, that hazardous heavy metal. Due to this heavy metal in food, the author added noncarcinogenic health concerns [18] p. (462-469).

Studies have projected that Bangladesh will reach a population of 195 million within 2025. The growing population is the main challenge for Bangladesh to achieve self-sufficiency in food production. Bangladesh is the seventh populous country in the world, consisting of the 3000th part of the world’s land space. Therefore shifting toward an advanced agricultural production system including genetically improved crop seeds and use of excessive chemical fertilizer is an alternative for increased yields of the crop [9].

The study found the presence of radioactive molecules as excessive chemical fertilizer is being used in Bangladesh for increased crop yield. A researcher found the presence of radioactive elements because of the use of triple superphosphate (TSP), single superphosphate (SSP), di-ammonium phosphate (DAP), phosphor-gypsum, muriate of potash (MOP), and other chemical fertilizer used in cultivation. The researcher analyzed the ratio of radium to thorium by the use of gamma spectrometry using high purity germanium (HPGe) detector [15] p. (1165-1168).

The nitrogen cycle in the soil is important for the soil's nutrients. The researcher found that the presence of nitrifying archaea bacteria in the soil is increases soil fertility. The excessive use of chemical fertilizer and pesticides are affecting the nitrogen cycle. The study also evidenced the adverse effect of chemical fertilizer and pesticides in the paddy field of Bangladesh [20] p. (243–249).

Agricultural food production in Bangladesh is affected by several variables; chemical fertilizers is one of the most significant. According to the study, agriculture loans and chemical fertilizer influenced Bangladesh's gross rice yield from 1995 to 2016. Data are judged to be stationary at 1% and 5% of importance using the Augment Dicky Fuller test. The study also shows that the consumption of rice by chemical fertilizers is having a favorable effect. [17].

Different studies found bad consumer culture and its negative influence on environmental services in Bangladesh. It examined social regulation, values, choices, and habits that remain conventional and low standard, unable to nurture individual life as well as socio-ecological elements. Agricultural inputs including fertilizer, pesticides, and energy are used indiscriminately and excessively in cultivation often cause environmental degradation [12] p. (243-252).

In a study conducted on Bangladesh Agricultural University farm, Mymensingh and Bhaluka found significant results on mitigating methane emission. They suggested 50% silicate fertilizer and 50% ammonium sulfate can be used in cultivation to decrease CH_4 emission. The combination will also result in higher production of crops [16] p. (179-185).

Nitrous oxide emissions are mostly produced by agricultural nitrogen fertilizer usage. A research discovered that nitrous oxide emissions varied significantly over time. In Bangladesh, nitrous oxide emissions rise during the Boro season compared to the aus and amon seasons [24] p. (370-379).

Studies found the adverse effect of chemical fertilizer and pesticides on soil degradation. It concludes excessive chemical fertilizer and pesticides destroy microbial communities living in the soil. Therefore, the fertility and beneficial properties of soil become compromised. The findings are very beneficial, and more attention should be paid to the potential for chemical and biological variables to be reduced in rice field soils [14] p. (828–833).

Farmers in Bangladesh were reportedly given chemical fertilizers and insecticides at a subsidized price. As a result, farmers increased fertilizer application frequency to boost yields.

These methods are still in use, and they have wreaked havoc on the ecosystem. The impacts of fertilizer broadcasting on excessive fertilizer usage and environmental pollution were also investigated in the literature [11].

Materials and Methods

Descriptions of Data:

This research collects time series information released by the World Bank in the World Development Indicator.

FPIBD: The dependent variable is assumed as the proxy variable for Bangladesh food production. This index includes food crops, which are regarded to be edible and contain nutrients. The exclusion of coffee and tea is because they have little nutritional benefit, however edible.

FCBD: The amount of plant nutrients utilized per unit of arable land are measured by the fecal consumption.
Nitrogen, potash and phosphate fertilizers are covered in fertilizer products (including ground rock phosphate). Traditional nutrients – manures of animals and plants – are not included. FAO has used the notion of a calendar year to transmit the information (January to December). Some nations gather fertilizer data over a calendar year, whereas others generate data over a split year. Arable land includes land classified by the FAO as temporary cultivated land (double-cropped areas should be counted once), temporary mud or grazing land, market land and kitchen gardens and temporary fallow soil. Land abandoned by changing crops is omitted

AN2O: Emissions of Nitrous oxide from the agriculture of Bangladesh is measured at thousands of metric tons of CO2 equivalent. Emissions from agricultural nitrous oxides include fertilizer usage (synthetic and animal manure) emissions, animal waste management, on-site (no energy), waste and burning of scrublands.

ACH4: Methane produced from farming is also considered as an independent variable. ACH4 is measured as emissions of agricultural methane (Bangladesh equivalent to thousands of tons of CO2).

The following variable data from 1971 to 2008 was used in this study. Web Address: https://data.worldbank.org/indicator/AG.PRD.FOOD.XD, https://data.worldbank.org/indicator/AG.PRD.FOOD.XD.

FPIBD:

In the basic assumption of the methodology section, this study assumes FPIBD is a function of FCBD, AN2O3BD, and ACH4BD to analyze relationships amongst the variables. Therefore, this study has used multivariate regression that can be represented as follow

$$FPIBD = \beta_0 + \beta_1\ FCBD + \beta_2\ AN_2OBD + \beta_3\ ACH_4BD + €t$$ ………… (1)

In the above equation FPIBD stands for Food Production Index of Bangladesh, FCBD stands for Fertilizer Consumption in Bangladesh, AN2O3BD is Nitrogen trioxide generated from agricultural production and ACH4BD denoted as Methane emission from agricultural production. Hence β0, β1, β2 are coefficient and €t represent the error term in the equation.

After constructing, the basic multivariate equation it is then transformed into a log-linear model by using natural logarithm in the equation. Through the use of natural logarithm, the above multivariate regression equation can be represented as

$$Ln\ FPIBD = \beta_0 + \beta_1\ Ln\ FCBD + \beta_2\ Ln\ AN_2O_3BD + \beta_3\ Ln\ ACH_4BD + €t$$ ………. (2)

Results and discussions

The descriptive statistics of the main variables utilized in the empirical study represented in Table 1.

Table 1. (Descriptive statistics)

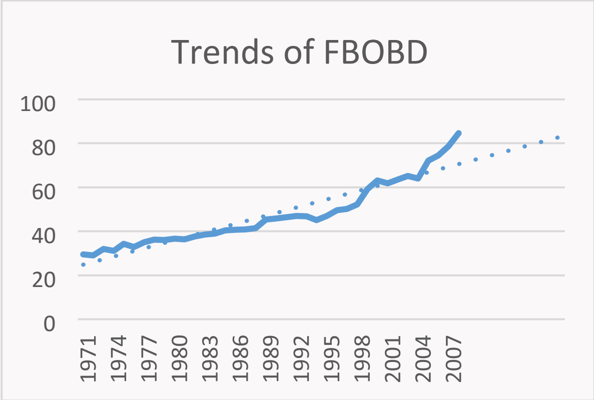
	FPIBD	FCBD	AN2O3BD	ACH4BD
Mean	47.68447	99.68813	12519.24	70499.35
Median	45.28500	96.83634	12205.43	69323.89
Maximum	84.70000	200.0641	18492.52	79843.03
Minimum	29.11000	12.92294	7284.280	63570.05
Std. Dev.	14.52452	60.86520	3732.570	5115.902
Skewness	0.886013	0.168361	0.165047	0.511739
Kurtosis	2.866893	1.652881	1.552314	1.805566
Jarque-Bera	4.999836	3.052842	3.490863	3.917452
Probability	0.082092	0.217312	0.174570	0.141038
Sum	1812.010	3788.149	475731.0	2678975.
Sum Sq. Dev.	7805.587	137069.2	5.15E+08	9.68E+08
Observations	38	38	38	38

The descriptive statistics gives an overall view of the examined variable before movinginto sophesticated diagonisis. In this study, the natur of skewness is observer for each varible. The Food Production of Bangladesh is showed merros normal skewness and platycartic. Also other three independent variable also showed mirors normal skewness and platicartic. Here the paltycartie indicates that the series has lower sample mean and it also implies a flat surface of the sries. In addition, for each and every variable the Jarque-Bera statistics exceed the absolute probability value. Also, this study can not reject the null hipothesis of normal distribution. Therefore, we can say that the series are normaly distributed.

Trends of the variables

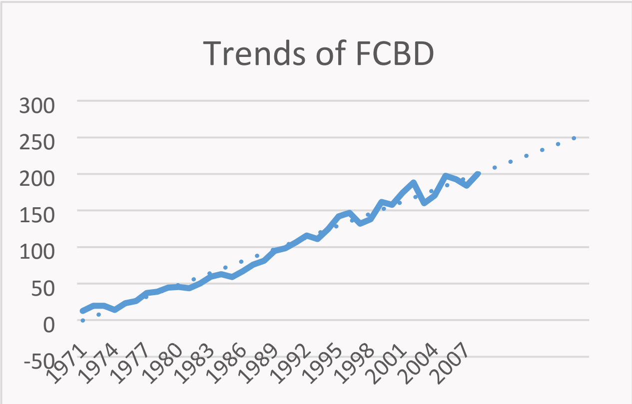
The trends of some variable can represent through graphs and can give a clear perspective about properties of the variable over time change. In this study, the Food Production of Bangladesh witnessed upward sloping intense over time. In addition, the Fertilizer consumption per hector also increased over time. The nitrous oxide generated from the agricultural sector has increasing trends while the Methane emission has downward trends in Bangladesh.

Figure.1 Trends of Food Production Index of Bangladesh



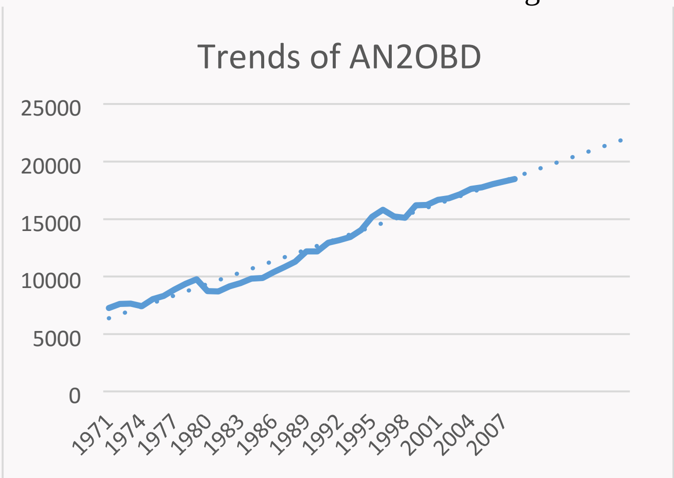
(a)

Figure-2 Trends of Fertilizer Consumption of Bangladesh.



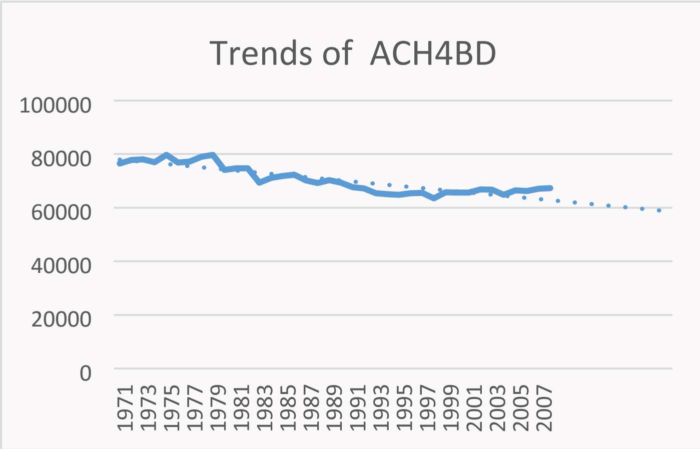
(b)

Figure.3 Trends Nitrous Oxide emission from agriculture of Bangladesh.



(c)

Figure.4 Trends Methane emission from agriculture of Bangladesh.



(d)

Unit root test

Testing the presence of a unit root in the series is the basic requirement for time series regression. The Augmented Dicky Fuller test and Phillips Perron tests were performed in this investigation as an econometric tool. The essential objective is to reject the null hypothesis without altering the data series with test findings. Null hypotheses can be rejected only if the probability value of the studied variable is lower than 5 percent according to the empirical theory.

Table 2. (Augmented Dicky Fuller Test results

Variables	Level (Prob.)		1st difference (Prob.)		
	C	C & T	C	C & T	Conclusion
FPIBD	1.0000	0.9986	0.0001	0.0000	I(1)
FCBD	0.9885	0.2496	0.0000	0.0000	I(1)
AN_2OBD	0.9650	0.3996	0.0000	0.0002	I(1)
ACH_4BD	0.5809	0.9851	0.0000	0.0000	I(1)

***Note:** I(1) indicates rejection of null hypothesis at first difference.

Table 3. (Phillips Perron Test)

Variables	Level (Prob.)		1st difference (Prob.)		
	C	P C & T	C	C & T	Conclusion
FPIBD	1.0000	0.9996	0.0000	0.0000	I (1)
FCBD	0.9858	0.0174	0.0000	0.0000	I (1)
AN_2OBD	0.9701	0.4392	0.0000	0.0001	I(1)
ACH_4BD	0.6836	0.5101	0.0000	0.0000	I(1)

Therefore, ADF and PP tests were carried out in the data set to determine the unit roots. The dependent variable

Food Production Index of Bangladesh (FPIBD) is nonstationary at I(0) while found stationary at I(1) in both Augmented Dicky-Fuller and Phillips Perron test results. The independent variable Fertilizer Consumption Kilogram per Hector in Bangladesh is non-stationary at I (0) while stationary at I(1) in both Augmented Dicky-Fuller and PP test results. In addition, the independent variable FCBD shows stationarity at the first difference in both ADF and Phillips Perron test results. Differently speaking, if the study prioritizes ADF test results for unit root it can reject the null hypothesis for all three variables. Also, the other two independent variables, nitrous oxide (AN2OBD) and Methane (ACH4BD) emit from the agricultural activity of Bangladesh found non-stationary at I(0) while stationary at I(1). Therefore, the empirical theory suggested by the different scholar's in the field of economics strongly suggests the hypothesis rejection. Hence, this study can further move forward to analyze other diagnostic tests as the first criterion fulfilled in this study.

Table 4. Optimum Lag selection

VAR Lag Order Selection Criteria

Endogenous variables: FPIBD FCBD AN2O3BD ACH4BD

Exogenous variables: C

Date: 07/08/21 Time: 02:52

Sample: 1971 2008

Included observations: 34

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-849.2699	NA	7.39e+16	50.19235	50.37192	50.25359
1	-724.9028	212.1557	1.27e+14	43.81781	44.71567*	44.12401
2	-702.8348	32.45291*	9.28e+13*	43.46087*	45.07702	44.01202*
3	-687.3067	19.18181	1.07e+14	43.48863	45.82306	44.28474
4	-674.8765	12.43014	1.66e+14	43.69862	46.75134	44.73968

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Johanson Co-Integration Test

The result of the Augmented Dicky Fuller test and Phillips Perron test advocated to castoff the null hypothesis of a unit root. Differently speaking the data series is non-stationary at level but then again stationary at order one. Consequently, the presence of co-integration in the data series should identify to construct a strong econometrical outline for the study. The Johanson Cointegration test is used to analyze whether this study can reject the null hypothesis of the co-integration test or not. The optimum lag for the Johanson Co-integration test is 2 according to the lag length structure. The trace statistics and maximum Eigenvalue statistics recommended that there is no co-integration among variables at a 5% level of confidence. That means the null hypothesis in this study of Johanson Co-integration test cannot be rejected according to empirical theory [5]. As a result, it exhibits short-run relationship among variables.

Table 4. Results of Johanson Co-integration test results

Trace Statistic				
Null Hypothesis	Alternative Hypothesis	Trace Statistic	5% Critical	Prob. Value
H_0 r ≤ 0	H_0 > 0	45.40319	47.85613Value	0.0835
H_0 r ≤ 1	H_0 > 1	19.13300	29.79707	0.4834
H_0 r ≤ 2	H_0 > 2	8.024982	15.49471	0.4628
H_0 r ≤ 3	H_0 > 3	0.021290	3.841466	0.8839
Maximum Eigen Statistic				
Null Hypothesis	Alternative Hypothesis	Max-Eigen	5% Critical	Prob. Value
H_0 r ≤ 0	H_0 > 0	26.27019	27.58434	0.0729
H_0 r ≤ 1	H_0 > 1	11.10802	21.13162	0.6365
H_0 r ≤ 2	H_0 > 2	8.003692	14.26460	0.3783
H_0 r ≤ 3	H_0 > 3	0.021290	3.841466	0.8839

***Note:** Trace test and Max Eigen Value test indicates no Co-integration at 5 % level of confidence.

Table 5. Vector Auto Regression Estimation

Vector Autoregression Estimates

Date: 07/08/21 Time: 22:44

Sample (adjusted): 1973 2008

Included observations: 36 after adjustments

Standard errors in ( ) & t-statistics in [ ]

			AN2OBD	ACH4BD
FPIBD(-1)	0.932244	-0.010101	3.244873	82.55534
	(0.18948)	(0.60482)	(38.9635)	(184.814)
	[4.92011]	[-0.01670]	[0.08328]	[0.44669]
FPIBD(-2)	0.430818	2.389906	43.48492	84.33322
	(0.20442)	(0.65254)	(42.0375)	(199.395)
	[2.10747]	[3.66248]	[1.03443]	[0.42295]
FCBD(-1)	-0.055026	-0.135555	-5.788381	-11.85164
	(0.05338)	(0.17041)	(10.9779)	(52.0713)
	[-1.03074]	[-0.79548]	[-0.52727]	[-0.22760]
FCBD(-2)	-0.200044	-0.774646	-5.068933	-63.77773
	(0.05669)	(0.18097)	(11.6586)	(55.2997)
	[-3.52845]	[-4.28045]	[-0.43478]	[-1.15331]
AN2O3BD(-1)	0.000858	0.013214	0.944144	-0.278829
	(0.00111)	(0.00355)	(0.22846)	(1.08366)
	[0.77222]	[3.72607]	[4.13258]	[-0.25730]

AN2O3BD(-2)	0.001834	0.004959	-0.068596	0.612756
	(0.00113)	(0.00362)	(0.23339)	(1.10704)
	[1.61622]	[1.36883]	[-0.29391]	[0.55351]
ACH4BD(-1)	-0.000170	-0.002940	-0.091289	0.590684
	(0.00022)	(0.00071)	(0.04591)	(0.21775)
	[-0.75945]	[-4.12571]	[-1.98856]	[2.71270]
ACH4BD(-2)	-0.000231	-0.001040	-0.027204	0.088047
	(0.00026)	(0.00083)	(0.05375)	(0.25495)
	[-0.88225]	[-1.24658]	[-0.50613]	[0.34535]
C	4.536808	136.9635	9096.869	17773.44
	(15.0661)	(48.0921)	(3098.17)	(14695.4)
	[0.30113]	[2.84794]	[2.93621]	[1.20945]
R-squared	0.986307	0.991913	0.991097	0.894018
Adj. R-squared	0.982250	0.989517	0.988459	0.862616
Sum sq. resids	97.15422	989.9369	4108374.	92432560
S.E. equation	1.896920	6.055108	390.0795	1850.251
F-statistic	243.0970	413.9615	375.7026	28.47012
Log likelihood	-68.95184	-110.7360	-260.6921	-316.7343
Akaike AIC	4.330658	6.651999	14.98290	18.09635
Schwarz SC	4.726537	7.047879	15.37878	18.49223
Mean dependent	48.70361	104.3135	12800.14	70125.96
S.D. dependent	14.23783	59.13928	3631.016	4991.867
Determinant resid covariance (dof adj.)				

Determinant resid covariance	9.51E+12
Log likelihood	-742.2327
Akaike information criterion	43.23515
Schwarz criterion	44.81867
Number of coefficients	36

Table 6. Variance Decomposition of FPIBD

Period	S.E.	FPIBD	FCBD	AN2OBD	ACH4BD
1	1.896920	100.0000	0.000000	0.000000	0.000000
2	2.596993	98.50272	0.149609	0.347887	0.999784
3	3.818555	90.21701	4.109597	2.567639	3.105758
4	4.902318	91.06750	4.301182	2.428348	2.202970
5	5.665801	92.38837	3.702108	2.138709	1.770817
6	6.542779	91.98028	3.854813	2.354790	1.810119
7	7.590640	91.64738	4.167300	2.524147	1.661176
8	8.575294	92.10374	4.032621	2.440214	1.423426
9	9.577039	92.26520	3.979329	2.442169	1.313299
10	10.72729	92.12071	4.109344	2.523956	1.245985

Note* Cholesky Ordering: FPIBD FCBD AN2O ACH4BD

Table 7. Variance Decomposition of FCBD

Period	S.E.	FPIBD	FCBD	AN2OBD	ACH4BD
1	6.055108	3.425618	96.57438	0.000000	0.000000
2	8.432054	4.596919	60.51150	6.373106	28.51848
3	10.89083	11.16612	36.35959	9.992357	42.48194
4	11.76901	12.10704	35.34833	8.560140	43.98449
5	12.92868	10.07925	34.65764	7.171504	48.09160
6	14.36538	9.638928	28.35014	6.335468	55.67546
7	15.45708	11.60320	24.93035	5.565285	57.90116
8	16.31044	11.37596	24.18304	5.029184	59.41182
9	17.32744	11.29530	22.09454	4.501610	62.10854
10	18.41942	12.90828	19.74652	4.111714	63.23349

Note* Cholesky Ordering: FPIBD FCBD AN2O ACH4BD

Table 8. Variance Decomposition of AN2O

Period	S.E.	FPIBD	FCBD	AN2OBD	ACH4BD
1	390.0795	1.395630	32.49840	66.10597	0.000000
2	515.0458	0.845558	32.97559	58.80921	7.369634
3	601.2237	0.679632	30.57560	48.56855	20.17621
4	677.4613	0.540524	29.98265	38.91961	30.55721
5	758.2903	0.509425	28.15282	31.16465	40.17310
6	836.3879	0.421022	25.46621	25.67633	48.43644
7	906.5236	0.387999	23.69007	21.85970	54.06222
8	973.0229	0.343256	22.51720	18.97748	58.16207
9	1037.402	0.330484	21.26330	16.69518	61.71104
10	1097.478	0.393246	20.16262	14.91748	64.52665

Note* Cholesky Ordering: FPIBD FCBD AN2O ACH4BD

Table 9. Variance Decomposition ACH4BD

Period	S.E.	FPIBD	FCBD	AN2OBD	ACH4BD
1	1850.251	15.77159	1.331486	14.37269	68.52423
2	2182.749	18.66534	2.360774	12.55676	66.41713
3	2531.999	24.81028	5.814510	11.47149	57.90372
4	2865.229	30.29426	7.477400	9.699850	52.52849
5	3125.559	33.36271	8.047842	8.428569	50.16088
6	3384.811	36.63039	9.120544	7.608764	46.64030
7	3679.829	40.33557	10.08560	6.855610	42.72322
8	3964.035	43.45204	10.45463	6.167473	39.92586
9	4243.738	46.27790	10.78070	5.656383	37.28502
10	4552.710	49.24705	11.15311	5.251107	34.34873

Note* Cholesky Ordering: FPIBD FCBD AN2O ACH4BD

Explanation of VAR outcomes

According to the VAR estimate, FPIBD's one- or two-period lag is substantially endogenous or has a significant impact on its current value. According to the estimations, one- and two-period lag values of FPIBD can raise FPIBD by 93% and 43%, respectively, ceteris paribus. FCBD, AN2OBD, and ACH4BD, on the other hand, are highly exogenous and have only a little effect on the FPIBD. FPIBD's two-period lag has a significant impact on FCBD, with a 238 percent rise in FCBD. Furthermore, the one-period lagged value of AN2OBD has a little effect on FCBD, increasing it by just 1%, and ceteris paribus, the AN2OBD is substantially impacted by its one-period lagged value. By its one-period delayed value, it suggests a 94 percent raise. As a response, the one-period lagged value of ACH4BD seems to have a substantial impact on the present value of ACH4BD, implying that the one-period lagged value of ACH4BD displays a 59 percent rise in the present value of ACH4BD.

Major Findings

Several relevant characteristics of the investigated variable were discovered in this study. The VAR estimate reveals important results that might unfold in the near future. The FPIBD is the dependent variable, and the goal of this study was to discover various key features that may infiltrate the current situation. This research also looks at other relevant elements that have a major impact on Bangladesh's food production. The VAR estimate result, which was backed up by Variance Decomposition diagnosis, revealed several aspects of the variables' important characteristics. FPIBD was shown to have high endogeneity in this study, implying that its lagged value has a strong influence. The VAR forecasted that the one- and two-period lags of FPIBD would boost Bangladesh's food production by 93 percent and 43 percent, respectively. This research also revealed that the study's independent variables had no significant impact on Bangladesh's food production. FPIBD, on the other hand, has a minor impact on fertilizer usage. It means that if Bangladesh's food production increases by a certain amount in the preceding era, fertilizer use in agricultural output will be influenced quite minimally. Bangladesh's fertilizer use has a close relationship with its lagged value. As a result of the effect of two periods lagged by FPIBD, VAR estimate projected a 238 percent increase in fertilizer consumption. The prior value of the AN2OBD and ACH4BD has a big impact on them. The current value of AN2OBD can be influenced by a one-period delayed rise in AN2OBD, according to this study, and the anticipated change can be estimated by a 94 percent increase in AN2OBD. As a consequence, the one-period lag of ACH4BD can raise ACH4BD by 59 percent in the current period.

Explanation of Increasing FPIBD and previus year impact

Despite the econometric explanation, this study fells to generalized the results to understand the findings more clearly. It is observed that the previous production, consumption, and emission are heavily or weakly interdependent to each other. The previous production of food in Bangladesh was observed to have a strong impact on the current period's production of food. The growing food demand in the local and international markets may have a crucial impact on food production. Also, intensive practice in farming may influence escalating food production. Above all, the food production of Bangladesh is observed to be running concisely without affecting the environment.

Explanation of FCBD and previus year impact

The fertilizer consumption is heavily influence by previous year food production. The growing food production has a direct impact on increasing fertilizer consumption. Hence, the previous year fertilizer consumption also have impact on current fertilizer usage.

Explanation of AN2OBD and previus year impact

The nitrous oxide emission in Bangladesh is not significant compare to the increasing fertilizer usage in agricultural production. The nitrous oxide emission examined in this study is mainly focused on agricultural nitrous oxide emission. Consequently, the previous nitrous oxide emission has a serious impact on the current period. It can be generalized by the increasing use of nitrogen sources in agricultural cultivation.

Explanation of ACH4BD and previus year impact

The methane emission from agriculture does not have a significant effect on food production or fertilizer consumption in Bangladesh. But it is observed that the previous period methane emission has some impact on current methane emission. The increasing production and processing of food products somehow have some interconnection for this case.

Policy recommendations

Based on the findings of this study, it is to be suggested that the food production of Bangladesh is observed to be sustainable and the agricultural production can be increased to its optimal. The environmental degradation specifically by agricultural production is not significant. Though the chemical fertilizer and pesticide usage increased over time the examined emission factor still running at a significant level. The usage of fertilizer and emission of nitrous oxide and methane does not strongly interconnected. Hence, the regulatory authority should focus on other sources that can significantly boost up the examined emission factor analyzed in this study. This study, therefore, found some specific and crucial findings which can support the following policies.

1. Capital-intensive farming is increasing and authorities should keep up the momentum by expanding research and technological support to the farmers.
2. Government expenditure on infrastructural development in agriculture must increase.
3. The price of fertilizer should cut off to lower cultivation costs.
4. FDI in agriculture production can be increased to boost up agricultural export.
5. Non-collateral and collateral-based agricultural credit schemes must boost up through government and private financial institutions.
6. Commercial organic fertilizer production and distribution should boot up to lower the consumption of chemical fertilizer and pesticides.
7.

Conclusion

The objective of this study was to find out the impacts of fertilizer usage, emission of nitrous oxide and methane on the overall food production of Bangladesh. The study therefore analyzed different outcomes of econometric model to state the accurate findings of the prior diagonostics. This study followed all the emperical procedures in the following estimations to strongly state the problem and findings. As the data used in this study are time series data therefore this study firstly analyzed the unit root in the series. Secondly, this study analyzed the lag length stucture to find out the optimam lag for the estimation of Johanson Cointegration test. The johanson Co-integration test could not find any co-integration amongst the variables and move forward to analyze short run associations through Unrestricted Vector Auto regression approach.

References

[1] A Latif Shah, M. S. R. M. A. A., 2008. OUTLOOK FOR FERTILIZER CONSUMPTION AND FOOD. *BANGLADESH JOURNAL OF AGRICULTURE AND ENVIRONMENT,* Volume 4.

[2] Abbas Ali Chandio, Y. J. A. R. R. D., 2018. The linkage between fertilizer consumption and rice production: Empirical evidence from Pakistan. *Aimspress,* 28 August .p. 295–305.

[3] Anon., 2014. Reviewing the status of agricultural production in Bangladesh from a food security perspective. *researchgate,* January .

[4] Bidhan Bhuson Roy, R. B. C. A. R. B. S. R. S. M. P. N. M. M. S., 2019. Unravelling the anthropogenic pathways of phosphorus in the food production and consumption system of Bangladesh through the lens of substance flow analysis. *Journal of industrial Economy* , 30 July .

[5] Erik Hjalmarsson, P. Ö., 2007. *Testing for Cointegration Using the,* s.l.: International Monetary Fund.

[6]FAO Feed Resource Group, n.d. *Livestock - a driving force for food security and sustainable development.* s.l.:FAO Animal Production and Health Division.

[7] FAO, 2010. *Nurtition Country Profile, Bangladesh,* s.l.: Agriculture and consumer protection Department. [8]Fasih uddin Mahtab, Z. K., 2021. Population and Agricultural Land Use: Towards a Sustainable Food Production System in Bangladesh. *JSTOR,* 22 June, Volume 21, pp. 50-55.

[9] GRÓFOVÁ Š, J. V., 2010. BANGLADESH – POPULATION INCREASE, FOOD SHORTAGE. *AGRICULTURA TROPICA ET SUBTROPICA,* Volume 43 .

[10] Hossain, M., 2010. *19th World Congress of Soil Science.* Brisbane, Australia, s.n.

[11] K M Atikur Rahman, D. Z., 2018. Effects of Fertilizer Broadcasting on the Excessive Use of Inorganic Fertilizers and Environmental Sustainability. *Sustainability,* March.Volume 10.

[12] K. M. Atikur Rahman, F. G. D. Z., 2017. AGRICULTURAL CONSUMPTION CULTURE AND
ECOLOGICAL. *Asian Development Policy Review,* Volume 5, pp. 243-252.

[13] M. Hashem Pesaran, Y. S., 1997. *An Autoregressive Distributed Lag Modelling.* England, Department of Applied Economics, University of Cambridge.

[14] M. Mizanur Rahman, K. N. M. M. A. N. S. M. M. K. U. K. A. M. R. M. A. K. A., 2020. Effect of Long-Term Pesticides and Chemical Fertilizers Application on the Microbial Community Specifically Anammox and Denitrifying Bacteria in Rice Field Soil of Jhenaidah and Kushtia District, Bangladesh. *Bull Environ Contam Toxicol,* May .p. 828–833.

[15] M.N.Alam, M. C. ,. M. K. S. G. H. B. D. C., 1998. Radioactivity in chemical fertilizers used in Bangladesh,. *sciencedirect,* 25 June, Volume 48, pp. 1165-1168.

[16] MA Ali, M. F. M. H. A. u. K., 2012. Influence of Soil Amendments on Mitigating Methane Emissions and Sustaining Rice Productivity in Paddy Soil Ecosystems of Bangladesh. *Journal of Environmental Science and Natural Resources,* pp. 179-185.

[17] Mala Rani Das, M. A. H., 2020. Impact of Agricultural Loan Disbursement and Chemical Fertilizer Use on the Rice Production in Bangladesh. *Bangladesh Journal of Public Administration*, August.Volume 27.

[18] Md. SaifulIslam, M. K. M.-A.-M. M. R., 2015. The concentration, source and potential human health risk of heavy metals in the commonly consumed foods in Bangladesh. *ScienceDirect*, December , Volume 122, pp. 462-469. [19] Nayana Sharma, R. S., 2017. Effects of Chemical Fertilizers and Pesticides on Human Health. *International Journal of Agriculture, Environment and Biotechnology*, 10 November.

[20] Rahman, M. K. A. &. B. S., 2021. Effect of Pesticides and Chemical Fertilizers on the Nitrogen Cycle and Functional Microbial Communities in Paddy Soils: Bangladesh. *Bulletin of Environmental Contamination and Toxicology*, 01 February.p. 243–249.

[21] Shah-Al Emran, T. J. K. V. K. M. Y. A. C. M. P., 2019. Agronomic, economic, and environmental performance of nitrogen rates and source in Bangladesh's coastal rice agroecosystems. *Field Crops Research*, Volume 241. [22] TahanaTasmeea, B. B. R. B. M. M. M., 2021. Urban metabolism of phosphorus in the food productionconsumption system of Bangladesh. *Journal of Environmental Management*, 15 August .Volume 292.

[23] Wassmanna, R. et al., 2019. Introducing a new tool for greenhouse gas calculation tailored for cropland: rationale,operational framework and potential application. *Carbon Management*, pp. 79-92.

[24] Yam Kanta Gaihre, U. S. S. M. I. A. H. M. I. M. A. S. J. S. A. S., 2015. Impacts of urea deep placement on nitrous oxide and nitric oxide emissions from rice fields in Bangladesh. *Geoderma*, December , Volume 259-260, pp. 370379.

Appendix

Abbreviations

- ADF (Augmented Dicky Fuller test)
- PP (Phillips Perron test)
- OLS (Ordinary Least Square)
- ARDL (Auto Regressive Distributed Lag Model)
- I(0)- Stationary at level
- I(1)- Stationary at first difference **Description of Variables**

1. **FPIBD (Food Production Index of Bangladesh)**

Food production index covers food crops that are considered edible and that contain nutrients. Coffee and tea are excluded because, although edible, they have no nutritive value.

2. **FCBD (Fertilizer Consumption Kilogram per Hector of Bangladesh)**

Fertilizer consumption measures the quantity of plant nutrients used per unit of arable land. Fertilizer products cover nitrogenous, potash, and phosphate fertilizers (including ground rock phosphate). Traditional nutrients--animal and plant manures--are not included. For the purpose of data dissemination, FAO has adopted the concept of a calendar year (January to December). Some countries compile fertilizer data on a calendar year basis, while others are on a split-year basis. Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded.

3. **AN2O3 (Nitrogen Tri Oxide emission thousand metric tons of CO2 equivalent from agriculture in Bangladesh)**

Agricultural nitrous oxide emissions are emissions produced through fertilizer use (synthetic and animal manure), animal waste management, agricultural waste burning (no energy, on-site), and savanna burning.

ACH4BD (Agricultural methane emissions (thousand metric tons of CO2 equivalent of Bangladesh).

Description of the Data

This study collected time-series data from World Development Indicator published by World Bank. The dependent variable is Food Production Index is used as a proxy variable for the food production of Bangladesh. The food production index covers food crops that are considered edible and that contain nutrients. Coffee and tea has excluded because, although edible, they have no nutritive value. Nitrous oxide is the independent variable in this study and only covers the portion of nitrous oxide emission generated from agricultural activity. Nitrous oxide has measured in thousand metric tons of CO2 equivalent. In addition, methane generated from the agricultural activity have used as an independent variable, which is measured in thousand metric tons of CO2 equivalent. This study used data of the following variable from the period of 1971 to 2008.

WebAddress: https://data.worldbank.org/indicator/AG.PRD.FOOD.XD

Table: 1. Yearly data of FPIBD, FCBD, AN2O3 and ACH4 of Bangladesh

Year	FPIBD	FCBD	AN2O3BD	ACH4BD
1971	29.57	12.92294	7284.27956	76564.16875
1972	29.11	19.93934	7641.55363	77876.61634
1973	32.09	19.93352	7656.83477	78122.99786
1974	31.19	14.13985	7454.71074	77092.51451

1990	45.92	98.73329	12216.25277	69366.25187
1991	46.4	107.0218	12962.47423	67762.30712
1992	46.97	116.0137	13168.58517	67309.73732
1993	46.86	111.1666	13465.37018	65460.55275
1994	45.11	124.8058	14079.73004	65087.90022

1975	34.35	23.55741	8062.60214	79843.02586
1976	32.94	26.63088	8330.53979	76920.39782
1977	35.08	37.33753	8900.13255	77250.10513
1978	36.31	39.03671	9385.43166	79121.85497
1979	36.08	44.67592	9775.11375	79763.25771
1980	36.65	45.68446	8748.14265	74167.38316
1981	36.4	43.91569	8715.35953	74789.30592
1982	37.72	50.66773	9161.58717	74782.82239
1983	38.66	59.78964	9455.56637	69385.38951
1984	39	63.33707	9842.38096	71248.61881
1985	40.41	59.07802	9906.38356	71899.92196
1986	40.81	67.30226	10391.84294	72440.67358
1987	40.87	76.42523	10830.05863	70306.01859
1988	41.54	81.41638	11315.05146	69281.52919
1989	45.46	94.93939	12194.60826	70355.95664
2008	84.7	200.0641	18492.52126	67372.9542
1995	47.09	142.1942	15211.74836	64844.43933
1996	49.62	147.2448	15830.97522	65461.49577
1997	50.22	132.205	15234.26242	65620.88926
1998	52.22	138.4552	15125.80675	63570.04702
1999	59.24	161.8895	16216.5371	65794.57087
2000	63.16	158.1075	16242.42644	65729.30455
2001	61.83	174.5903	16678.21539	65752.84162
2002	63.61	188.6392	16832.52595	66865.49612
2003	65.27	160.2669	17165.78915	66844.65129
2004	64.11	170.6714	17639.7197	64924.54015
2005	72.18	197.7487	17775.8097	66530.31062
2006	74.49	193.1901	18061.54798	66366.0111
2007	78.77	184.4111	18278.51549	67098.48929