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Long and Short-Run Effects of Climate Change on Boro Rice Productivity: An Empirical Evidence from Bangladesh

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Abstract: This study endeavors to examine the effect of climate change on Boro rice productivity in Bangladesh. Unit root, Co-integration and Vector Error Correction Model estimation technique are applied to measure the climate-crop yield interrelation on the basis of country level time series data for the period 1972-2019. Average maximum and minimum temperature, rainfall and humidity are used to attribute variables for climate change. The result of vector error correction model denotes that both in the long-run and short-run, average maximum temperature, average total rainfall and humidity negatively effect on Boro rice productivity in Bangladesh respectively. On the other hand, Average minimum temperature is positively effect on Boro rice productivity in the short-run. Fertilizer and irrigation have positive effect on Boro rice productivity in the short-run respectively. Conversely, labor has robust negative effect on Boro rice productivity in the short-run in Bangladesh agriculture. Policy maker should develop policies to mitigate temperature and introduce heat tolerant rice varieties and adaptation measure to sustain the Boro rice productivity in Bangladesh.

Keywords: Climate Change, Boro Rice Productivity, Temperature, Humidity, Co-Integration, VECM.

1. INTRODUCTION

Climate variability would ominously effects on agricultural efficiency and competence and would lead to serious diverse in agricultural production [1].Furthermore, utmost climatic events, frequency of pests and diseases, soil salinity in coastal areas may be occurred in further adverse impact on agricultural production [2]. In spite of scientific improvement, the agricultural productivity is fully dependent on climatic fundamental determinant whereas rainfall and temperature perform as key phenomenon of agricultural yields by significance

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country food safekeeping [3]. Only in the short-term, the adverse implications of climate change would compensate slightly on increased crop production which is under raised carbon dioxide in the air [4]. In the absence of calculating for CO_2 reproduction, there are predicted that climate variation could make reduce in crops production by seventeen percent for quantity of yields in diverse areas through the universe [5]. Forming on these concerns and sum of study examined the agricultural domestic level current then possible future influences of weather alteration on farming efficiency, farmland values and net farm incomes [6].

Bangladesh is more powerless country's to the unfavorable impacts of climate modification within the world [7]. It is the 6th most climate helpless nation within the world [8]. Climate inconsistency would altogether impacts on rural efficiency and competence and would lead to genuine changes in agrarian generation [9]. Creating countries are more helpless to the unfavorable impacts of climate variety [10]. Subsequently, climate variety is the basic determinant of agrarian efficiency. It is key issues for particularly in with respect to of creating nations like Bangladesh wherever agribusiness is amazingly subordinate on characteristic phenomena in contradiction of the controlled natural condition in developed countries. As Bangladesh could be a creating nation with big population thickness where (20.5%) of its total population lives under insufficiency [11]. Rice is the staple nourishment of our people and developed in this country from time immemorial. It contributes for about 92% of the over-all food grains are made in the country and covers about 77% of agricultural land. Bangladesh is the fourth largest rice producer in the world [12].

Many people in the world eat rice as their main food to survive [13]. Around 3 billion people eat rice every day, which makes it one of the most important foods for humans. Rice is even more important for feeding people than any other crop [14]. In Bangladesh, a lot of people like to eat rice and it is the main food that people eat every day. Many people who live in the countryside grow rice. This is why Bangladesh produces a lot of rice. Bangladesh needs to grow more rice in order to feed more people in the future and deal with changes in the world's climate. If the weather changes and rice production goes down, it would really hurt our ability to keep enough food in the country. So, scientists are trying to figure out how climate change will affect rice farming. They're also looking at how well rice farmers will be able to change their methods to deal with climate change.

But, studies show that farming in poorer countries can be easily affected by the changing climate. Bangladesh is very affected by climate change, but not many studies have looked at how it affects the food grown there [15]. Therefore, the main objective of this study is to explore the effect of climate change on Boro rice productivity in Bangladesh. To identify the climatic factors which are likely to affect Boro rice production using national level time series data over the period from 1972 to 2019.

Review of Literature

There's a developing body of literature in current years a long time that has watched the impact of climate alter on agrarian efficiency. The specialized community has long contended that changes in climatic factors such as temperature and precipitation altogether effect on crops

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yields. The study of climate alter impacts on Bangladesh farming has accomplished later consideration, due to the share of Bangladesh's agricultural sector.

Sarker et al. [16] clarified a study to illustrate the effect of climate variety on Aman rice efficiency in Bangladesh. Econometric show as well as Ricardian, relapse and Fair pope generation work are utilized within the think about. The paper appears that most extreme temperature performs a critical positive and negative part on the Aman rice efficiency. The think about express that climate variety would upgrade the differences of Boro rice. The research's result fair illustrates the negative and positive affect of climate variety in Bangladesh.

Paul et al. [17] outlined a report endeavor to display the effect of climate variety on agrarian cultivate and nourishment security, nourishment trading and nourishment bringing in nations, Nursery gas surge and adjustment. The research's result illustrates the negative affect of climate alter on rural divisions and human movement. The research's result adjusted illustrate the negative affect of climate alter on agrarian segments, human activity and helpless nourishment security without being numerical result.

Zahi and Zhuang [18] explored study to appear the effect of climate variety on rural yielding and the financial suggestion on Southeast Asian states. Ricardian and CGE demonstrate as well as basic Factual econometric instruments are utilized in this ponder. The researcher's result fair appears the more negative impact of climate variety on specific nations than other Asian nations but it isn't evaluated.

Akram and Hamid [19] found a study to appear the impact of climate effect on financial development, negative relationship with GDP and agrarian efficiency, industrialization, underprivileged human advancement record, and outflow of nursery gas as well as administrations divisions. Econometric time arrangement demonstrate as well as basic insights devices utilized in this consider. The research's finding fair appears the negative affect of climate alter but it isn't evaluated.

Conversely, very insufficient studies have been done in Bangladesh to examine the outline and trend of rainfall, temperature, relative humidity, heat budget and energy balance on several ecosystem, and meteorological application on Boro rice production. Therefore, a small studies have been done to demonstrate the association between climate change and Boro rice productivity in Bangladesh.

2. ECONOMETRIC METHODOLOGY

2.1 Data description

Country level yield data of key nourishment crops Boro rice yield within the length 1972–2019 are collected from distinctive yearbook of agrarian measurements in Bangladesh. . Yield data are taken as the financial year premise, such as 1971–1972, 1972–1973, etc. At that point, these monetary year information are changed over to annually information, for case, 1971–1972 is

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considered as 1972. Aggregate level month to month information on climatic parameters for all (35) the climate stations are got from the Bangladesh Meteorological Division [20], for the comparative time period which covers the entire nation. These year-wise month to month information are at that point changed to regular information agreeing to the developing period of the crops. Boro rice efficiency length of developing period December-May, climatic factors have been characterized for this add up to time period. The previous year (1971) and next year (1972) climate data are merged for 1972's yield. Data are also collected from Department of Agricultural Extension [21], Ministry of Agriculture, Bangladesh Economic Review [22], World Development Indicator [23], and World Bank [28].

2.2 Unit Root

The unit root is a type of non-stationary series that is different from a random walk model. We test for a problem called "unit root" using the Augmented Dickey-Fuller and Phillips-Perron tests. If a variable doesn't change much, we say it's "stationary." If it's stationary without changing at all, we call it "integrated of order zero," and if it only becomes stationary after we take away the first difference [24]. The study used a test called ADF and another called PP on a set of data without making any changes to it. If we find that a group of numbers have a starting point with only one root, we use tests called ADF and PP on the first difference of those numbers.

ADF test is applied by the following equations

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + u_t \qquad (1)$$

Where β is the intercept (constant), β_2 is the coefficient of time trend t, α and δ are the parameter where, γ=p-1, Δ Y is the first difference of Y series, p is the number of lagged first differenced term, and u_t is the error term.

Phillips Perron (PP) test equation

$$\Delta Y_t = \alpha + \beta t + \gamma \Delta Y_{t-1} + \varepsilon_t \qquad (2)$$

Where,

α= is a constant
β =is the coefficient of time trend t
γ =is the parameter, and
ε= is the error term

2.3 Model Specification

This study wants to find out how the amount of Boro rice grown is affected by the weather and other things like labor, fertilizer, and irrigation. They will look at things like temperature, rainfall, and humidity to see if climate change could impact how much rice is grown. The VECM is based on a theory called the Granger Causality Theorem [25]. This theory says that if two variables are linked, there is a cause-and-effect relationship between them. The VECM helps us study this relationship over a long period of time and see how the variables change in the short term. Vector Error Correction Model (VECM) is employed to explore the long run

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causality, short run dynamics, and short run to long run dynamic adjustment of a system of cointegrated variables.

For the case of our 8 variable, the VECM is identified as:

$$\Delta LYIELD_t = \alpha_0 + \alpha_1 \; ECT_{t-1} + \sum_{i=1}^{n} \beta_1 \, \Delta LYIELD_{t-1} + \sum_{i=1}^{n} \delta_1 \; \Delta LMAXT_{t-1} + \sum_{i=1}^{n} \lambda_1 \; \Delta LMINIT_{t-1} + \sum_{i=1}^{n} \sigma_1 \, \Delta LRAIN_{t-1} + \sum_{i=1}^{n} \mu_1 \, \Delta LHUMI_{t-1} + \sum_{i=1}^{n} \pi_1 + \sum_{i=1}^{n} \varphi_1 \; \Delta LLABOR_{t-1} + \sum_{i=1}^{n} \eta_1 \, \Delta LFERTI_{t-1} + \sum_{i=1}^{n} \kappa_1 \, \Delta LIRRI_{t-1} + + \varepsilon_t \quad (3)$$

$$ECTt_{-1} = LYIELDt_{-1} - \gamma_0 - \gamma_1 \, LMAXT_{t-1} - \gamma_2 \, LMINIT_{t-1} - \gamma_3 \, LRAIN_{t-1} - \gamma_4 \, LHUMI_{t-1} - - \gamma_5 LLABOR_{t-1} - \gamma_6 \; LFERTI_{t-1} - \gamma_7 \; LIRRI_{t-1} \quad (4)$$

The error correction term (ECT) indicates that last period deviation from long-run equilibrium effect the short-run dynamics of the dependent variable. Consequently, the coefficient of ECT, α_1 is the speed of adjustment, for the reason that it calculate the speed at which yield return to the equilibrium after a change in explanatory variables.

Where,

$\alpha_{1=}$ adjustment parameter
e=base of natural logarithm
u_t= error term
$\beta_{0=}$ Intercept
β_1 to $\beta_{10=}$ the coefficient parameters to be estimated
t= is the time (i.e., year).

3. RESULTS DISCUSSION

This research looks at information that was gathered to figure out how the changing climate is affecting the amount of Boro rice grown in Bangladesh and how that affects the country's economy. Climate change affects how much it rains over a long time, how hot or cold it gets, and how much moisture is in the air. The study looks at information about when things happened and uses that information to learn more. So, we're going to look at how climate change affects the amount of Boro rice we can grow using a special method called a Vector Error Correction Model. Before we use the Vector Error Correction Model, we check if the data has certain properties called "unit root" and "cointegration". To define the stationarity of each variables, the unit root test and co-integration test is employed for defining the presence of long-run relationships among variables.

3.1 Descriptive statistics

Narrative statistics of the log value of the variables in the model which exhibits in the table 1. The result exposes that maximum and minimum value of Boro LYIELD are 7.43 and 6.59 with 0.25 standard deviations. The largest mean value of irrigation is 10.97 and a standard deviation of about 1.15, the lowest men value of labor is 1.87 with a standard deviation is 0.58.It can be

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exhibited that LYIELD and LMINIT variables shown positive Skewness, while LMAXT, LRAIN, LHUMIDITY, LLABOR, LFERTI and LIRRI are negatively skewed. The excess kurtosis (kurtosis-3) of average minimum temperature and land are greater than zero (positive) which denotes that this distribution are leptokurtic (peaked curve).

Table 1: Descriptive statistics of the data series for the period of 1972-2019

Measures	**LYIELD**	**LMAXT**	**LMINIT**	**LRAIN**	**LHUMI**	**LLABOR**	**LFERTI**	**LIRRI**
Mean	7.04	3.39	2.79	6.14	4.31	1.87	3.83	10.97
Median	6.97	3.39	2.76	6.11	4.32	1.97	4.07	11.02
Maximum	7.43	3.43	3.02	6.70	4.35	2.53	4.86	12.81
Minimum	6.59	3.35	2.71	5.36	4.23	0.79	2.24	7.91
Std.Dev.	0.25	0.01	0.07	0.27	0.02	0.58	0.74	1.15
Skewness	0.06	-0.01	1.47	-0.13	-0.76	-0.46	-0.41	-0.76
Kurtosis	1.76	2.84	4.05	2.79	2.80	1.68	1.92	3.06
Jarque Bera	3.08	0.05	19.44	0.21	4.67	5.15	3.68	4.61

3.2 Stationarity and Unit Root Test

Looking for unit roots is important to figure out how integrated the variables are and avoid getting false results. We use a test called the Augmented Dickey Fuller (ADF) to see if there is a stable pattern in each set of data over time. The ADF test checks if the data series keeps changing (unit root) or is steady (stationary). The null hypothesis is that it's changing and the alternative hypothesis is that it's steady. The table 2 shows the results of the ADF test, which were done with and without trend. The numbers that are measured constantly change and are not reliable, but if we look at how they change over time, they become stable. The ADF and PP unit-root tests showed that the results were not consistent at first. But after making a change to the variables, all of them were consistent and steady. Subsequently, the results of ADF and PP unit-root tests are found to be non-stationary at level while, after first difference all the variables are stationary in the model.

Table 2**:** Augmented Dickey-Fuller (ADF) & Phillips-Perron (PP) Unit Root Test

Variable	**Augmented Dickey-Fuller (ADF)**		**Phillips-Perron (PP)**	
	At level	**At first difference**	**At level**	**At first difference**
LBORO	-3.513075	-3.510740**	-3.508508	-3.510740***
LMAXT	--3.508508	-3.513075***	-3.508508	-3.510740***
LMINIT	-3.508508	-3.510740***	-3.508508	-3.510740***
LRAIN	-3.508508	-3.513075***	-3.508508	-3.510740***
LHUMI	-3.510740	-3.510740***	-2.925169	-3.510740***
LLABOR	-3.508508	-3.510740***	-2.925169	-3.510740***
LFERTI	-3.508508	-3.513075***	-3.508508	-2.926622***

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LIRRI	-3.508508	-1.948140***	-2.925169	-2.926622***

Note: MacKinnon (1996) one-sided p-values (at 1%, 5% & 10% level is -3.605, -2.936& -2.606 respectively) is used.
Source: Authors own estimation based on BMD, BBS and DAE.

3.3 Optimal Lag Length Selection Criteria for the Model

After unit root test, the ideal lags for the VECM show are found within the taking after step. The ideal lags are discovered based on the VAR choice criteria for requesting lags.

Table 3**:** VAR Lag order selection criteria for Boro yield model

Endogenous variables: LYIELD LMAXT LMINIT LRAIN LHUMI LLABOR LFERTI LIRRI						
Exogenous variables: C						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	438.2743	NA	6.84e-19	-19.12330	-18.80212	-19.00357
1	659.6964	354.2754*	6.54e-22*	-26.11984	-23.22918*	-25.04223*
2	722.3944	78.02417	9.09e-22	-26.06197	-20.60184	-24.02649

Note: * indicates lag order selected by the criterion

The ideal lags are fundamental to check cointegration among factors, and table 3 depicts the criteria of VAR lag determination. It is appeared that the concluding forecast blunder (FPE) and Hannan-Quinn data criteria (HQ) chosen two slacks, so two lags are connected within the current multivariate demonstrate for experimental examination.

3.4 Result of co-integration test

This study conducts co-integration test in order to identify the existence of long run association among variables comprised in the model. Johansen test for co-integration is employed for this study. Consequently, all the level variables are non-stationary and stationary at fist difference.

Table 4: Unrestricted cointegration rank test (Trace) for Boro rice yield model

Hypothesized No.of CE(s)	**Eigenvalue**	**Trace Statistic**	**Critical Value(at 0.05 level)**	**Probability**
None *	0.893686	407.9144	285.1425	0.0000
At most 1 *	0.798758	304.8121	239.2354	0.0000
At most 2 *	0.690322	231.0628	197.3709	0.0003
At most 3 *	0.630350	177.1407	159.5297	0.0038
At most 4	0.481024	94.96470	95.75366	0.0566
At most 5	0.444132	64.79342	69.81889	0.1179

Note: Trace test indicates 4 cointegrating eqn(s) at the 0.05 level

Null hypothesis of long run association between the independent and dependent variables are verified against the alternative hypothesis by the Johansen tests. Consequently, the null

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hypothesis is rejected and it could be concluded that there happen a long run association among the variables.

The Johansen test have two procedures: the trace test and the maximum eigenvalue test. It is taken the trace teat. The result of trace test (table 4) shows that the δ_{trace} value for r =0 is 407.9144 which surpasses its critical value of 285.1425 at 5% level (p-value 0 < 0.05).So we can reject the null hypothesis of none cointegration equations at 5% significance level. The same way null hypothesis for $r \leq 1$ (at most 1 cointegration equations), $r \leq 2$ (at most 2 cointegration equations), and $r \leq 3$ (at most 3 cointegration equations) can be rejected. But $r \leq 4$, the δ_{trace} value is 94.96470 which is less than its critical value of 95.75366 at 5% level (and also p-value 0.0566 > 0.05) meaning that we cannot reject null hypothesis of existing at most five cointegration equations.

3.5 Result of Vector Error Correction Model (VECM)

The presence of cointegration vectors between variables recommend a long term association among the variables under forecast. In order to know the long-run and short-run association between the variables, the vector error correction model (VECM) is chosen. The output of vector error correction model which can be explained as follows:

$$ECT_{t-1} = 1.0000\ LYIELD_{t-1} - 4.781LMAXT_{t-1} - 0.173LMINIT_{t-1} - 0.575LRAIN_{t-1} - 0.395LHUMI_{t-1} + 0.722LLABOR_{t-1} + 0.497LFERTI_{t-1} - 0.252LIRRI_{t-1} + 17.02426 \quad (5)$$

Where ECT Error Correction Term. The long- run equation) can be formed as follows:

$$LYIELD_{t-1} = 4.78151LMAXT_{t-1} + 0.17379LMINIT_{t-1} + 0.57562LRAIN_{t-1} + 0.39520LHUMI_{t-1} - 0.72273LLABOR_{t-1} - 0.49758LFERTI_{t-1} + 0.25244LIRRI_{t-1} - 17.02426 \quad (6)$$

1% rise in maximum and minimum temperature, rainfall, humidity and irrigation leads to 4.78, 0.173, 0.57, 0.39 and 0.25 unit enhance in Boro rice yield in Bangladesh respectively. Similarly, 1% increase in labor and irrigation will reduce Boro rice yield by 0.72 and 0.49 unit correspondingly.

3.6 VECM Coefficient with P-Value of the model

The Johansen co-integration examination result showings that there happens a long-run affiliation among factors. The blunder redress picture of the VAR demonstrate is evaluated as a taking after step after evaluation of the long-run coefficients. The VECM appears that the long-run and short-run affiliation between climate alter and Boro rice efficiency in Bangladesh.

The primary lines of the table 5, the mistake rectification coefficient (ECTt-1) is negative and factually noteworthy at 10% noteworthy level. The coefficient of blunder redress ought to be negative and significant to alter balance within the long-run. The ECT coefficient recommends

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that the speed of alteration of any short-run disequilibrium towards the long-run balance is 8.55 % each year. The coefficient of blunder adjustment term of surrender is 0.085522. Inferring that, around 8.55% of disequilibrium redressed each year by the change in yield .The clarification is that the previous period's deviation from long-run balance is adjusted within the current period as an alteration speed of 8.55%.

Table 5 indicates that average temperature have strongly noteworthy negative association with Boro rice yield in the long-run. This suggests as 1% increase in maximum temperature would indicate to debility in Boro rice yield 8.86% in the long-run. On the other hand, 1% rise in average minimum temperature would clues to increase in Boro rice efficiency by 21.28%. The impact of mean rainfall is set up to be negative and statistically significant. Its coefficient indicates that 1% increase in mean rainfall would indicate to decrease Boro yield by 4.76% per acre. The coefficient of mean humidity is negative and it significant.

Table 5: VECM coefficient with P-Value of the model

Dependent Variable: D(LYIELD)					
Method: Least Squares (Gauss-Newton / Marquardt steps)					
	Coefficient		**Std. Error**	**t-Statistic**	**Probability**
ECT	C(1)	-0.085522	0.049826	-1.716403	0.0955*
D(LYIELD(-1))	C(2)	-0.078780	0.167244	-0.471045	0.6407
D(LMAXT(-1))	C(3)	-0.886938	0.476014	-1.863259	0.0713*
D(LMINIT(-1))	C(4)	0.212808	0.228783	0.930175	0.3590
D(LRAIN(-1))	C(5)	-0.047662	0.025007	-1.905959	0.0654*
D(LHUMI(-1))	C(6)	-0.267296	0.507413	-0.526781	0.6019
D(LLABOR(-1))	C(8)	-0.253720	0.113593	-2.233592	0.0324**
D(LFERTI(-1))	C(10)	0.155867	0.106039	1.469904	0.1511
D(LIRRI(-1))	C(11)	0.021224	0.037553	0.565176	0.5758
C	C(13)	0.011063	0.010091	1.096367	0.2809
R-squared		0.427988	Akaike info criterion		-3.208581
Adjusted R-squared		0.219984	Schwarz criterion		-2.691791
F-statistic		2.057596	Hannan-Quinn criter.		-3.014988
Prob(F-statistic)		0.040220	Durbin-Watson stat		1.849672

Labor of Boro season have negative and significant association with Boro rice yield at 5% significance level. The result indicates that 1% increase in seasonal labor on an average will decrease the yield of Boro by 0.25% kg (kilogram) per acre. Furthermore, the significance of agricultural labor coefficient mark to the ineffectiveness of excessive labor force in the

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agricultural sector in Bangladesh. This result is consistent with the findings of Janjua et al. (2014) and Mahrous (2018).

The coefficient of Fertilizer consumption positively related with Boro rice yield and statistically insignificant. It indicates that 1% rise in fertilizer consumption will leads to enhance Boro rice by 0.15% kg (kilogram) per acre. Fertilizer plays dual effect. At first they rise the land fertility and secondly increase the growth of plants. In the log-run fertilizers would increase the land fertility causing to rise the agricultural production. The coefficient of irrigation positively related with Boro yield and it is not significant which indicates that 1% increase in irrigation will lead to 0.02% rise in Boro rice productivity in the short-run.

The p-value of R-square in Boro yield model is 0.427988 which is 42.79% variation in Boro yield can be illustrated by explanatory variables together. The probability of Boro yield model, F-statistic is 0.040220 which is less than 5% significant respectively. Which means that expletory variables can jointly effect on Boro rice yield. Consequently, it can be summarized that the model has a very good fit.

3.7 Result of residual diagnostic test

This consider performs a few diagnostic checks in arrange to test the goodness of- fit of the model. It is utilized typicality test, autocorrelation or serial relationship test and hetoroskedticity test for this reason. Table 6 exhibits that p-value of Jarque-Bera is 0.337575 that's more than 5% noteworthiness level. Thus, we cannot cast-off the null hypothesis which denotes the residual is normally distributed. The p-vale serial relationship and Autocorrelation test and hetoroskedticity test can't dismiss the invalid hypothesis implying that there's no serial relationship or hetoroskedticity within the show. Subsequently, apply of the VECM is free from autocorrelation, typicality and hetoroskedticity issue in this study.

Table 6: Diagnostic test result
Note: All the test of P-value is greater than 5% significant level

Jarque-Bera test	2.112
Probability(Jarque-Bera test)	0.337575
Breusch-Godfrey Serial Correlation LM Test(P-Value)	0.4738
Hetoroskedticity test	0.5244

3.8 Granger causality test

This study applies Granger causality check to know the causal course between the factors. Granger causality test is utilized to characterize the causal linkages between the most climate changes recognized factors (temperature and humidity) and Boro yield in Bangladesh. The null hypothesis of the causality check does not granger causality between climates alter factors and Boro rice yield.

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Table 7: VEC Granger causality test

Null Hypothesis:	Chi-^{2}	P-value	Decision
D(LMAXT)does not Granger Cause D(LYIELD)	3.922352	0.0475**	Rejected at 5%
D(LYIELD) does not Granger Cause D(LMAXT)	5.866112	0.0153**	Rejected at 5%
D(LHUMI) does not Granger Cause D(LYIELD)	6.232703	0.0124**	Rejected at 5%
D(LYIELD) does not Granger Cause D(LHUMI)	2.809598	0.0936*	Rejected at 10%

Note: ***, ** and * indicates the significance level at 1%, 5%, and 10% respectively.

Table 7 reveals that in the case of MAXT↔YIELD, we can cast-off null hypothesis that maximum temperature does not Granger Cause modification in YIELD as the p-value is fewer than 5% (0.047). Equally, the converse null hypothesis that YIELD does not Granger causality alteration in maximum temperature is excluded as p-value is less than 0.05 < (0.015). This result expresses that there occurs a bidirectional short-run Granger causality successively from maximum temperature to Boro YIELD. Likewise mean humidity have a bidirectional short-run Granger causality successively from average humidity to Boro YIELD.

4. CONCLUSION

This study analyzes the impact of climate alter on Boro rice yield in Bangladesh utilizing time arrangement information for the period 1972-2019 utilizing Co-integration and Vector Error Correction Model which are connected to fulfill this objective. Result of the vector Error Correction Model shows that both within the long-run and short-run, climate alter have strong impacts on Boro rice efficiency in Bangladesh. For the Boro rice, maximum temperature and precipitation are found to be negative and factually noteworthy. Normal least temperature is positive and factually critical influencing Boro rice generation. In resistance, normal greatest temperature have an unfavorable impact on Boro rice yield. For the R^2 and F-values of the models have found measurably noteworthy and comes about of in general goodness of fit are steady with comes about of Lobell [27]. When temperature go past the upper restrain or falls underneath the extend or stickiness crossed the upper constrain at that point trim generation changes radically. Moreover, over the top precipitation may make water logging condition and flooding that moreover annihilates the trim generation. Existing the tall helplessness of rice yields to climate alter in Bangladesh, distinctive adjustment techniques ought to be embraced to compensate the antagonistic impacts of climate change. It could be a genuine concern since it antagonistically impact on agriculture which is a critical division within the nation. Thus, the concerned specialist ought to take reasonable approaches to battle against the climate alter impacts on Boro rice generation to guarantee nourishment security for the ever expanding populace of the nation through applying economical agrarian development. In this manner, future investigate in this field ought to center on territorial particular information investigation to capture the territorial varieties of climate alter and to get a more comprehensive situation of climate changes and their impact on rice yield in Bangladesh.

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