



## Economic growth, climate change, and agriculture sector: ARDL bounds testing approach for Bangladesh (1971-2020)

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**Abstract:** Agriculture, Food security, Climate change, and food import are vital components of an economy. This article empirically explored the long-run and short-run impact of these variables on the economic development of Bangladesh by employing the ARDL model over the period from 1971 to 2020. The outcome of the F-bounds test confirmed the existence of a no long-run relationship among the variables examined, and hence, the appropriate model is ARDL. The study then analysed the short-run impact of agriculture, food security, food import and climate change on economic growth. The short-run and long-run coefficients revealed a positive and significant impact of the agriculture sectors on economic growth in Bangladesh in the short-run and long-run. Findings further showed that climate change and food security have a positive and insignificant impact on economic development. Food import has a negative and insignificant impact on economic growth in the short-run and an insignificant positive impact in the long-run+. Therefore, the study concludes that Bangladesh should invest in the agriculture sector as an engine of economic growth. Climate change, food security and food imports are essential for Bangladesh's economy.

**Keywords:** agriculture sector, food security, economic growth, climate change, ARDL model bound testing, Bangladesh



## 1. Introduction

According to the UN Committee for Development Policy, Bangladesh developed from a low income to a middle-income country in 2018. This nation was documented as a 'role model of development' worldwide for its presentation over the whole era of UN-supported MDGs between 2000 to 2015. In order to sustain the middle-income status, the country needs to continue its present status on various economic and social criteria until 2024. Bangladesh is placed exceptionally well to achieve the Sustainable Development Goals (SDGs) by 2030. In addition, the economy of Bangladesh is categorised as an emerging market economy (Riaz & Rahman, 2016). It is the 37<sup>th</sup> largest in the world in nominal GDP terms and the 31<sup>st</sup> largest by purchasing power parity (PPP); it is categorised among the eleven developing market middle income economies. In the first quarter of 2019, Bangladesh was the seventh fastest-growing economy, with an 8.3% real GDP annual growth (IMF, 2020). Since 2004, Bangladesh's average GDP growth rate was 4.5%, mainly determined by its exports of ready-made garments and remittances and the domestic agricultural sector.

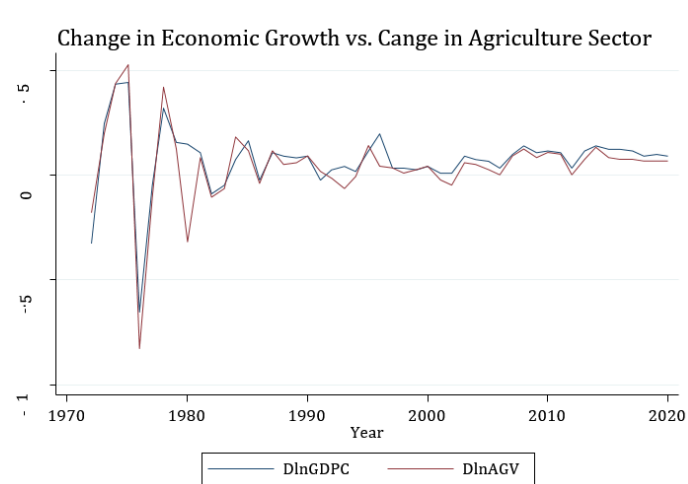
Agriculture is the pillar of Bangladesh's economy, contributing 14.2% of GDP and the major employer employing about 42.7 percent of the workforce. The demonstration of this sector has an overwhelming effect on primary macroeconomic objectives such as agriculture employment for males and females, poverty alleviation, human resources development, food security and other economic, climate change economics and other social forces. Due to many issues, Bangladesh's labour-intensive agriculture has accomplished steady upsurges in food grain production, despite frequently unfavourable weather circumstances. These include better flood control or flood dykes and irrigation facilities, more well-organised use of fertilisers, and better delivery and rural access to credit networks. In 2007 report by World Bank confirmed that the areas in which women's labour force participation has improved the most are in the fields of agriculture, farming, education, health and social work. As of 2014, female participation in the labour force is 58%, and male participation is 82%, as per World Bank data. Population burden continues to place a plain burden on productive capacity and creates a food deficit, especially wheat. Other challenges facing the agricultural sector include environmental issues: insecticides, water management challenges, pollution, and land degradation. Bangladesh is particularly vulnerable to climate change, with extreme weather and temperature changes significantly affecting food production. The vagaries of climate change are a significant concern for government and policymakers, hence the need for policies and strategies to address those concerns.

Food availability refers to the physical presence of food at various levels, from household to national level, from own production or through markets (Deitchler et al., 2010). Today, food availability as one pillar of food security in Bangladesh remains a continuing problem. Rice constitutes the main crop in the country, accounting for around 80 per cent of the land area used for agricultural production. Even though rice production has increased substantially, Bangladesh has currently lengthy its ban on non-fragrant rice varieties. The analysis of the most recent 2010 Household Income and Expenditure Survey (HIES) shows that approximately 41 per cent of the population fall below the nutritional requirement of 2,122 kcal. The condition is predominantly upsetting amongst the poorest sections of the society, where around 57 per cent of individuals do not meet their nutritional necessities. Due to poor road networks and high food prices, food accessibility related to physical and financial access is another constraint. At the macroeconomic level, the ILO (LABORSTA) index proposes that between 2002 and 2010, the price of food almost folded. A complementary analysis of the HIES data shows that around 60 per cent of Bangladesh's households spend 75 per cent or more of their total expenditure on food (WDI, 2014).

Economic growth and agriculture growth change over time. The trends show they are generally moving together in the same direction. Figure 1 indicates the stationary change in economic growth versus change in the agriculture sector.

Worldwide, climate change affects agriculture, market, employment livelihoods, infrastructure, economic growth and communities and forces people to evacuate their homes, towns and even countries. In 2016, extreme weather and climate change-related disasters displaced around 23.5 million people.

**Figure 1: Stationary time series graph for the growth of economic growth versus the growth of the agriculture sector in Bangladesh from 1971 to 2020**

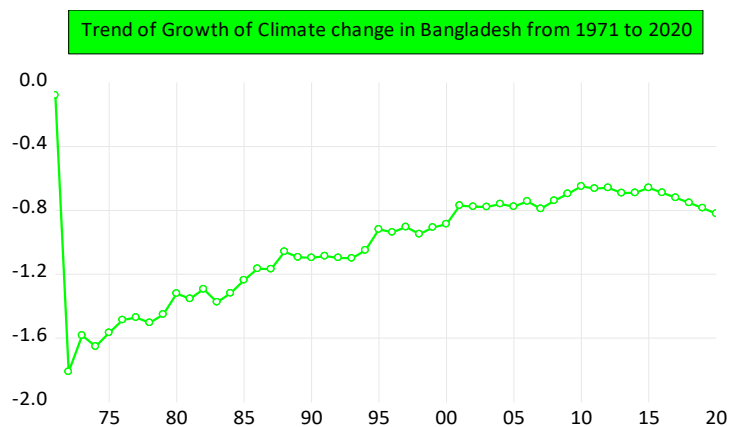


Bangladesh is remarkably vulnerable to climate change due to its low elevation, high population density, inadequate infrastructure facilities, and an economy dependent on agriculture for survival. Due to the country's natural susceptibility to extreme weather events, the people of Bangladesh have always used migration as a coping strategy for climate change. However, as situations strengthen underneath climate change, additional people are being driven from their homes and land by more recurrent and plain hazards. Sea level rise, storms, cyclones, drought, erosion, landslides, flooding and salinisation, displaced many people. Salinisation left 33 million people who rely on such resources vulnerable to health problems such as preeclampsia during pregnancy, acute respiratory infections and skin diseases.

It has been projected that by 2050, one in seven people in Bangladesh will be expatriated or displaced by climate change impact. Further, by 2050, with a predictable 50 cm rise in sea level, Bangladesh might lose nearly 11% of its land, which will upset a projected 15 million of the population living in its low-lying coastal region and 18 million people will be evacuated by sea level rises. Therefore, the research question is 1) The role of food security in increasing agriculture and economic growth; 2) The role of climate adaptation in solving the problems of food import; 3) How the short run ARDL model can solve the dynamic nature of economic growth in Bangladesh by looking at the food security, climate change, agriculture, and food import simultaneously.

Climate change affects the economy of Bangladesh over time. It shows a positive trend from 1971 to 2020, as displayed in figure 2.

**Figure 2: Non-Stationary time series graph for the growth of climate change from 1971 to 2020**



The general research question of the study is to analyse the dynamic nature of the growth of the economy, growth of the agriculture sector, growth of climate change (CO2 emission), growth of food security and growth of food import in Bangladesh both in the short-run and long-run using Autoregressive Distributive Lag Model (ARDL) model.

## 2. Literature review

The growth of climate change, growth of agriculture and food security and growth of food imports are crucial for the country's economy. In Bangladesh, due to its high population density, around 1 percent of its total arable land is declining every. Therefore, the need to understand the linkages between growth of GDP, growth of agriculture, growth of food security, growth of food import and growth of climate change in Bangladesh from 1971 to 2020. Studies looked at the relationship between economic growth, climate change and other variables relevant to economic growth and other relevant variables using short-run and long-run relationships.

Subramaniam and Reed (2009) studied agricultural inter-sector relationships and their implication for the economic development of Poland and Romania. They adopted a VECM and Johansson Cointegration procedure to assess the relationship between agriculture, manufacturing, service, and trade and identified the long-run and short-run inter-sectorial relationship.

Mougou et al. (2011) divided the relationship between agriculture and non-agricultural sectors in Tunisia. Their results showed that agriculture promotes the long-run growth of other economic sectors, but the short-run impact on other sectors is not significant.

Sarker et al. (2019) found that the maximum level of temperature negatively affects rice production while the minimum level of temperature improves rice production in Bangladesh.

Alam and Sumon (2020) studied the impact of trade openness and climate change on Nigeria's food productivity by using a nonlinear autoregressive distributed lag (NARDL) model and found the presence of asymmetry in the long run, not in the short run. The long-run estimates show that high rainfall variability upsurges food production, but the opposite is the case in the short-run, where the decomposed shocks showed a negative impact.

Nasrullah et al. (2021) applied the <https://journals.sagepub.com/action/doSearch?target=default&ContribAuthorStored=Shuaibu%2C+Mohammed> autoregressive distributed lag (ARDL) model to study the impact of climate change and other factors on rice production in South Korea and whether there exists a long-run equilibrium relationship among variables and the results disclosed that an increase in CO<sub>2</sub> emissions increases rice production by roughly 0.15%.

In his part, Ceessay (2020) studied the impact of flood disasters on GDP growth, be it agriculture and manufacturing sector in the Gambia for the period 1969 to 2016, by applying an Autoregressive Distributed Lag Model (ARDL) and Dynamic ARDL for cointegration and Error Correction Model (ECM) to test the short-run and long-run relationships between the variables. The study's findings suggest that floods positively affect agricultural growth in both the long run and short run.

Ceessay et al. (2021) studied climate change, growth in agriculture value-added, food availability and economic growth nexus in the Gambia: Granger causality and ARDL modelling approach. Their results confirmed that the growth of food imports and agriculture growth hurt GDP growth in the short-run and long-run.

The autoregressive distributed lag (ARDL) model F-bound test, proposed by author Pesaran et al. (2001), allows the determination of whether a long-run relationship exists in the series. The ARDL approach has recently become more known in some empirical studies for exploring the relation of climate change with other agricultural factors in several countries, for example, China (see details Sarkodie et al., 2020), and Europe (see details Acaravci & Ozturk 2010). Because of the difference in the ability to identify long and short-run relationships among time series variables compared to the traditional method. The ARDL bound test for cointegration is used to find the relationship among variables.

Belford et al. (2020) studied the effects of climate change on economic growth and concluded that in Anglophone West African countries, the relationship between the growth rate of GDP and growth rate of the agriculture sector and temperature is negative and statistically harmful significant. In the random effect model for agriculture, the growth rate of rainfall has the uppermost impact on the growth of agriculture in Anglophone West Africa than the impact of temperature on this region.

## 3. Methodology

### Source and description of data

The paper used secondary data from the world development indicator (WDI) from 1971 to 2020. The data covered the information on GDP (current US\$), Agriculture, forestry, and fishing, value added (current US\$), Food production index, CO<sub>2</sub> emissions (kg per 2010 US\$ of GDP), Average precipitation in depth (mm per year), and Human Capital Index (HCI). GDP (current US\$) was considered a proxy of economic growth in Bangladesh. Agriculture, forestry, and fishing, value added

(current US\$) represented the agricultural sector, the Food production index (2014-2016), which is a component of food availability, was also considered a proxy of food security, and Average precipitation in depth (mm per year) and CO<sub>2</sub> emissions (kg per 2010 US\$ of GDP) are considered potential proxies for climate change in Bangladesh. We consider the following model, Economic Growth (GDP or Y as a proxy) as a function of Agriculture, forestry, and fishing, value added (current US\$), Food security (Food production index (2014-2016 as a proxy), Climate change (CO<sub>2</sub> emissions kg per 2010 US\$ of GDP as a proxy), and food import. All the variables are transformed into natural logarithms to help interpret the results as a rate of change or elasticity and control potential heteroskedasticity issues. We use both R, Stata and Eview for data analysis. After importing the data into Stata 16, we declare the dataset as time series data. After importing the data into Eview 11, dated-regular frequency, annual start date, 1971. Finally, we import the data into R-studio.

### Economic model

The economic theory proposes models that explain the behaviour of one or more variables, say  $Z_1, Z_2, Z_3, \dots, Z_n$  as a function of some other variables, say  $P_1, P_2, P_3, \dots, P_m$  which are determined outside the model or which are exogenous. Consider the following model, Economic Growth (GDP or Y as a proxy) is a function of Agriculture, forestry, and fishing, value added (current US\$), Food security (Food production index (2014-2016 as a proxy), Climate change (CO<sub>2</sub> emissions kg per 2010 US\$ of GDP as a proxy), and food import.

### Empirical Model

The empirical model used in the study to model the relationship between Economic Growth (GDP), Agriculture, forestry, and fishing value-added, Food security, Climate change and food import is :

$$\ln \text{GDPC}_t = \beta_0 + \beta_1 \ln \text{AGV}_t + \beta_2 \ln \text{CL}_2_t + \beta_3 \ln \text{FPI}_t + \beta_4 \ln \text{FIMP}_t + \varepsilon_t$$

The variables above are abbreviated below.

$\ln \text{GDPC}_t$  = is the growth rate of GDP at time t

$\ln \text{FPI}_t$  = the growth of Food Security (Food production index proxy) at time t

$\ln \text{AGV}_t$  = growth rate of Agriculture at time t

$\ln \text{CL}_2_t$  = growth of CO<sub>2</sub> emission per capita as at time t

$\ln \text{FIMP}_t$  = growth rate of food import at time t  $\varepsilon_t$  = error term at time t

### Method of data analysis

We use unit root tests to test for stationarity of the data, which helps us know which method(s) are appropriate for our analysis. The unit root test below indicates that the data set is stationary at different levels, and therefore the appropriate method is ARDL bound testing for cointegration. This method helps us assess the short-run and long-run relationships among co-integrated time series variables. The F-statistic bound testing results confirmed that our F-statistic is less than the lower bound, i.e. integrated of order zero, I(0) at all the significant levels. Therefore, we cannot reject the null hypothesis. Hence no cointegration exists among the variables, and no long-run relationship exists. Therefore, we estimate the short-run relationship, which is the ARDL model.

### Unit root test

To control for potential spurious regression, we examine the stationarity properties of the variables using ADF and PP tests. In other words, before we performed the ARDL model, we employed the Augmented Dickey-Fuller (ADF) unit root test and Phillips-Perron (PP) unit root test to check the stationarity of variables at the level, I(0) and at the first difference, I(1). First, we run ADF and PP tests at the level and first difference. The Augmented Dickey-Fuller (ADF) test is the most common time series unit root method. Suppose we have a series  $y_t$  for testing unit root. Then, the ADF model tests the unit root as follows;

$$\Delta y_t = \mu + \gamma y_{t-1} + \sum_{i=1}^k \theta_i \Delta y_{t-i} + e_t$$

Where;

$\gamma = (\vartheta - 1)$

$\vartheta$  = is the coefficient of  $y_{t-1}$

$\Delta y_{t-i}$  = is the first difference of  $y_t$  i.e.  $y_t - y_{t-1}$

$\Delta y_{t-i} = y_{t-i} - y_{t-i-1}$

The null hypothesis of ADF is  $\gamma = 0$  versus  $\gamma < 0$ . If we do not reject the null hypothesis, the series is said to be non-stationary or unit root, while if we reject the null hypothesis, the series is said to be stationary, i.e. stationary at the level, I(0) and first differences I(1).

### Phillips-Perron (PP) test

PP tests like the DF or ADF test also test the presence of unit root test in a time series data. The Phillips-Perron test can be specified as follows:

$$\Delta y_t = \gamma y_{t-1} + \theta_i D_{t-i} + e_t$$

Where;

$e_t$  is an integrated of order zero, with mean zero and  $D_{t-i}$  is the deterministic trend component.

The hypothesis is tested for  $\gamma = 0$

$$\Delta y_t = \theta_i D_{t-i} + e_t$$

The difference between the ADF and PP tests is that the PP test is a non-parametric test that mean that it does not needs to specify the form of the serial correlation of the  $\Delta y_t$  under the null hypothesis. The calculation procedure of t-statistics or ratios to get the value of  $\gamma$  becomes different. The PP correct the statistics to consider the autocorrelation and heteroskedasticity problems. The hypothesis testing procedure is similar to ADF test, although the ADF is more reliable than the PP test. This is due to the size of distortion and low test power, making both the tests less useful (Maddala & Kim, 2003). For financial data that has a higher frequency, the PP test is suggested (cite).

### ARDL model specification

We use the autoregressive distributive lag model (ARDL) bounds testing method for cointegration to estimate the short-run and long-run relationship between economic growth and specified control variables. We used the ARDL bound testing approaches as developed by Pesaran et al.(2001), which, unlike the other methods, can determine the effects of lag on the variables for more extended periods. The ARDL bounds testing approach for cointegration reflects the descriptive regression and produces unbiased long-term and practical t-statistics values (Harris et al., 2003). The ARDL bounds testing approach for cointegration is a better analysis method and produces improved and unbiased results (Haug, 2002; Alimi, 2014). The ARDL model is formulated below, where the dependent variable is Gross Domestic Product (GDPC), and the independent variables are the agriculture sector, climate change, food security and food imports.

### Hypothesis testing

Pesaran et al. (2001) propose testing  $H_0 = \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5$  which means that we cannot reject the absence of cointegration against the alternative hypothesis,  $H_A = \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5$  which implies that the hypothesis of such a relationship cannot be rejected. We will do the two-step procedures the ARDL model relies on from this hypothesis. First, to do the F-bound testing for cointegration, compare the F-statistic with the upper bounds  $I(1)$  and lower bounds,  $I(0)$ , at 1%,5%,2.5% and 10% of significances. Second, we will determine whether to run either ARDL short-run or ARDL long-run contain error correction model (ECM). These all depend on whether F-statistic is greater or lesser than the upper or lower bound.

### ARDL model:

Dependent variable: lnGDPC; Independent variable: lnAGV, lnCL2, lnFPI, and lnFIMP

$$\begin{aligned} \Delta \ln \text{GDPC} = & \alpha_0 + \sum_{i=1}^p \alpha_i \Delta \ln \text{GDPC}_{t-1} + \sum_{i=m}^p \beta_{1i} \Delta \ln \text{AGV}_{t-1} + \sum_{i=n}^p \beta_{2i} \Delta \ln \text{CL2}_{t-1} + \sum_{i=0}^p \beta_{3i} \Delta \ln \text{FPI}_{t-1} \\ & + \sum_{i=0}^p \beta_{4i} \Delta \ln \text{FIMP}_{t-1} + \lambda_1 \ln \text{GDPC}_{t-1} + \lambda_2 \ln \text{AGV}_{t-1} + \lambda_3 \ln \text{CL2}_{t-1} + \lambda_4 \ln \text{FPI}_{t-1} \\ & + \lambda_5 \ln \text{FIMP}_{t-1} + \epsilon_t \end{aligned}$$

Where lnGDPC is the log of the GDP, an AGV is the log agriculture sector, lnCL2 is the log of climate change, lnFPI is the log of food security, and lnFIMP is the log of food import. The  $\alpha_i, \beta_1, \beta_2, \beta_3,$  and  $\beta_4$  are the coefficients that measure the short-run relationship while  $\lambda_1, \lambda_2, \lambda_3, \lambda_4,$  and  $\lambda_5$  are the coefficients that measure the long run relationship.  $\alpha_0$  is the intercept terms of the model and  $\epsilon_t$  is the error terms.

$\Delta$  is the first difference operator of the variables. To test for cointegration, we use the bounded test Pesaran and Shin proposed (1999) and Pesaran et al. 2001. Following the ARDL model, the F-bounds test (Pesaran et al. 2001) was conducted to check the long-run association among the variables. If F-statistics exceed the critical value of upper bound (UB),  $I(1)$  at a 1%, 2.5%, 5%, and 10% level of significance, we conclude that there is cointegration. That is, there is a long-run relationship. We reject the null hypothesis and estimate the long-run model, which is the error correction model. Otherwise, if F-statistic is lower than  $I(0)$ , the critical value of the lower bound (LB), we conclude that

there is no cointegration. There is no long-run relationship, so we accept the null and estimate the short-run model, which is the ARDL model. Stata 16 and E-views 11 Software were used for data analyses.

#### 4. Results and discussion

The data generated for this study was made by authors' from the world development indicator (WDI). The periods covered from 1971 to 2020. The variables included are GDP (current US\$)-GDPC as a proxy for economic growth, Agriculture sector as a proxy for Agriculture, forestry, and fishing, value added (current US\$)-AGV, Food imports (% of merchandise imports)-FIMp, CO2 emissions (metric tons per capita)-CL2, and Food production index (2014-2016 = 100)-FPI.

Table 1 and Table 2 report the unit root test results for ADF and PP tests, respectively. It shows that, for Bangladesh, all the variables are stationary at the first difference, whereas variables are integrated of a different order at the level form. For example, in the ADF test, lnGDPC is not stationary at the level but stationary at the first difference. Likewise, lnFIMp is stationary at both the level and first difference. For the PP test, only the growth of the agriculture sector is not stationary at the level, but other variables are stationary at the level and first differences. We used this commands in Stata for the difference;  $gen DlnGDPC=lnGDPC[_n]-lnGDPC[_n-1]$ . None of the variables for any country is integrated at the second difference. Hence, the ARDL model is appropriate.

**Table 1: ADF test for Bangladesh**

Variables	Level.ADF	Remarks	$\Delta$ .ADF	Remarks
lnGDPC	-0.464	Not Stationary	-8.189***	Stationary
lnAGV	-0.764	Not stationary	-8.921***	Stationary
lnCL2,	-2.232	Not stationary	-6.086***	Stationary
lnFPI	0.297	Not stationary	-5.154***	Stationary
lnFIMp	-5.301***	Stationary	-5.372***	Stationary

\*\* and \*\*\* denote significant at 5%, and 1% level of significance respectively

Source: Authors' calculation using Stata 16.

Notes: Level ADF and  $\Delta$ .ADF denote the level and first difference of the augmented Dickey-Fuller unit root test; \*\* and \*\*\* denote rejection of the null hypothesis of no unit root at 5% and 1% significance level, respectively.

**Table 2: PP test for Bangladesh**

Variables	Level PP	Remarks	$\Delta$ .PP	Remarks
lnGDPC	0.151***	Stationary	-7.391***	Stationary
lnAGV	-0.525	Not Stationary	-7.401***	Stationary
lnCL2	-3.762***	stationary	-38.734***	Stationary
lnFPI	0.403***	stationary	-9.216***	Stationary
lnFIMp	-7.869***	stationary	-7.732***	Stationary

\*\* and \*\*\* denote significance at 5%, and 1% levels of significance, respectively

Source: Authors' calculation using Stata for window

Notes: Where Level PP and  $\Delta$ .PP denote the level, and first difference of the Phillips-Perron unit root test; \*\* and \*\*\* denote rejection of the null hypothesis of no unit root at 5% and 1% significance level, respectively.

#### ARDL estimation

After meeting the condition of strict first-difference stationary in the ADF and PP test above for the dependent variable (lnGDPC), we determine the optimal lag for the proposed model. The lag length is selected using the minimum values of selection-order criteria, which is -11.5402\* in our model, and it falls under the Akaike information criterion (AIC). Therefore, the optimal lag for the model is 2 using the AIC. Using the optimal lag selected, we test the Pesaran, Shin, and Smith (PSS) bounds test below. Hence, the results in Tables 1 and 2 above show a combination of  $I(0)$  and  $I(1)$  of the regressors in the models. Hence, using the ARDL and ECM approaches is appropriate to analyse our model. This is confirmed in the study (Shrestha & Chowdhury, 2005).

Table 3 reveals the outcome of the F-bounds statistic test. It showed no long-run relationship between economic growth, agriculture value-added, climate change, food security and food import for Bangladesh. The calculated F- statistic is lower than the lower bound at all the significance levels, and therefore no long-run cointegration relationship exists; the short-run ARDL model is more applicable for the analysis.

**Table 3: Results of F- Bounds test**

Country	F- Statistics	Level of Significance	Low Bound,I(0)	Upper Bound,I(1)	Long-run relationship
Bangladesh	1.658	10%	2.45	3.52	Absent
		5%	2.86	4.01	(no-co-
		2.5%	3.25	4.49	integration
		1%	3.74	5.06	exist)

Source: Author's calculation using Stata 16 for Windows

\*, \*\*, \*\*\* denote significant at 10%, 5%, and 1% level of significance respectively

Table 4 shows the short-run and long-run coefficient estimates of the ARDL model. It shows that, in the short-run, a change in the growth of agriculture, forestry, and fisheries value-added has a positive and highly significant impact on economic growth in Bangladesh. A 1% increase in the growth of agriculture value-added leads to a 0.5024951% increase in GDP growth rate. The study further revealed that change in the growth of food imports has a negative and insignificant impact on economic growth in Bangladesh. The change in the growth of climate change has a positive and insignificant impact on the change in the growth of the economy of Bangladesh. So policymakers in Bangladesh should improve the agriculture sector for sustainable development. The coefficient of error correction term is -0.6358994, which is insignificant, denoting that at approximately 63% speed of adjustment, the dependent variable lnGDPC returns to equilibrium after a change in lnAGV lnCL2 and lnFIMP.

Furthermore, in the long-run coefficient, the change in the growth of the agriculture sector has a positive and highly significant impact on the change in the growth of the economy of Bangladesh. 1% increases the growth of the agriculture sector and increases economic growth by 1.09%.

The change in the growth of climate change, the growth of food security, and the growth of food imports are positive but statistically insignificantly impact changes in the economic growth of Bangladesh. As indicated, these variables may have significant impacts on the economic growth of Bangladesh, such as climate change; if a good climate change policy is formulated, food security if the excellent food security policy is formulated and food export rises and food import reduces. Furthermore, both these sectors are equally vital to gaining economic advancement; hence, these findings reveal the effectiveness of Bangladesh's agriculture and food security.

**Table 4: Results of short-run and long-run estimates for Bangladesh dependent Variable, lnGDPC**

Short-run Coefficients				
Variables	Coeff.	Std.E	T-ratios	P-value
DlnAGV,	.5024951***	(.107904)	4.66	0.000
DlnFIMP	-.0817922	(.0608327)	-1.34	0.187
DlnCL2	.0130696	(.250172)	0.05	0.959
ECT(-1)/cons	-.6358994	(1.080749)	-0.59	0.560
Long-run coefficients				
Variables	Coeff.	Std.E	T-ratios	P-value
lnAGV,	1.090387	(.2565498)	4.25	0.000***
lnCL2,	.4412457	(.4033295)	1.09	0.281
lnFPI	.5698093	(.5287842)	1.08	0.288
lnFIMP	.045412	(.1816234)	0.25	0.804

\*\*\* denotes significant at a 1% level of significance

Source: Authors' calculation using Stata 16.

Table 5 depicts the results of residuals diagnostics tests. The outcome reveals that residuals of each model for Bangladesh are normally distributed, and No Serial Correlation is present. For Jarque- Bera test for normality tests of the errors, the critical probability is significant because the p-value is greater than the 0.05 level of significance, i.e. 0.400>0.05. The lnGDPC, lnAGV, lnCL2, lnFPI, and lnFIMP follow normal and lognormal laws for the period going from 1971 to 2020. Moreover, for Serial Correlation LM Test-Breusch-Godfrey test indicated that the model is free from serial correlation.

**Table 5: Residuals diagnostics tests**

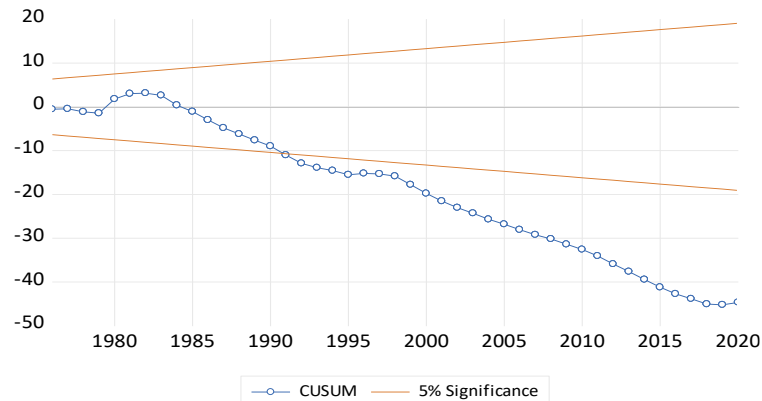
Tests	Bangladesh	Remarks
Jarque- Bera test normality test	0.400220	Significant or normally distributed
Serial Correlation LM Test-Breusch-Godfrey test	0.0000	No Serial Correlation is present

E-View and Stata

Tests of CUSUM, CUSUM of squares and recursive residuals.

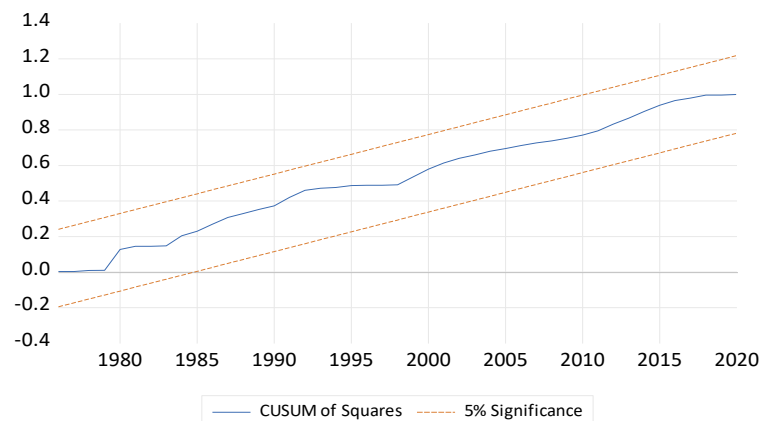
Figures 3, 4 and 5 show the outcome of The CUSUM test, CUSUM of squares test and recursive residuals test. The parameters of regression models for Bangladesh have a breakpoint. CUSUM test (figure 3) illuminates the cumulative sum quickly bypassing the corridor, or the test statistic is outside the corridor, indicating structural stability. On the contrary, the CUSUM of squares test (figure 4) shows the movement of the parameters inside the corridor; it is the same for the recursive residual test (figure 5). We, therefore, conclude that the existence of breakpoints.

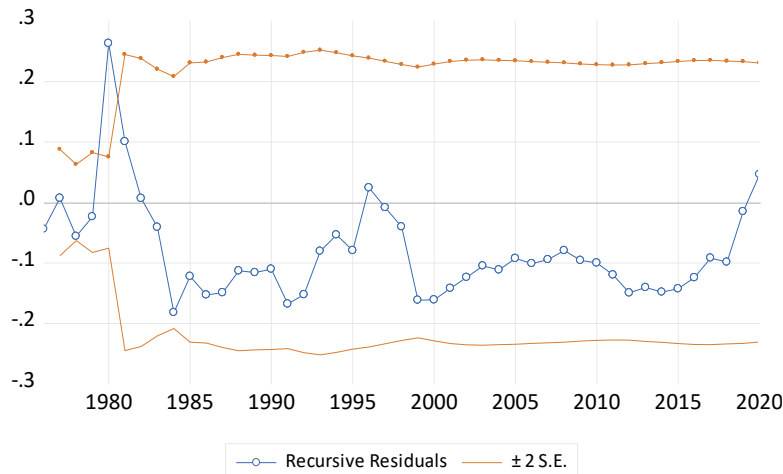
**Figure 3: The CUSUM test as a stability test for Bangladesh from 1971 to 2020**



Source: Drawn by the authors using research data, 2021 using Eview 11.

**Figure 4: CUSUM Squares**



**Figure 5: Recursive Residual test for Bangladesh from 1971 to 2020**

Source: Drawn by the authors using research data, 2021 using EView 11.

## 5. Conclusion

This paper inquired about the impact of the growth of agriculture, growth of climate change, growth of food security, and growth of food import on the economy of Bangladesh from 1971 to 2020. Augmented Dickey-Fuller unit root test and Phillips- Perron unit root test ascertained that all the variables were stationary at the first and mixed at the level, but none of the variables was stationary at the second difference. After running the ARDL model, the F-bounds test illuminated that in Bangladesh, the economic growth, the agriculture sector, food security, climate change and food import are not co-integrated, and we do not reject the null hypothesis because the F-statistic is lower than all the lower bound critical values,  $I(0)$ . Therefore, we used the short-run model, which is the ARDL model.

Hence, ARDL is more applicable for the analysis. In Bangladesh, the agriculture sector and climate change positively impacted economic development, while food imports showed a negative sign. Moreover, in Bangladesh, the agriculture sector proved to produce a highly intense positive long-run impact on economic growth, given a slightly more potent influence on food security and climate change. Confirmed in the paper by (de Janvry & Sadoulet, 2006). Contrarily, food import illustrated an insignificant long-run force on economic development, whereas the agriculture sector proved to be the accelerator of economic growth. It can be summarised that the agriculture sector and climate change contributed to the economic development of Bangladesh in both the short-run and the long-run. In contrast, food imports solely drove the economy of Bangladesh, as food security's influence on economic growth proved inconsistent because it is insignificant both in the short-run and in the long-run. Hence, Long-run development projects should be taken by Bangladesh's government to tackle the oddities of food import, climate change, and food security. Agricultural budgetary expansion, advanced technologies for adaptation and mitigation for climate change, food prices to be stable, proper irrigation facilities for food security, distribution of fertiliser for agriculture development, and awareness of eating what grow programs should be implemented. Also, the Bangladesh government should provide equal importance to budget and development projects for the agriculture sector and climate change financing, the author recommended.

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## Data availability statement

The data is available at [World Development Indicators | DataBank \(worldbank.org\)](https://data.worldbank.org/)

## Conflicts of interest

The authors declare no conflict of interest.

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