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Contribution of agriculture subsectors on economic growth in Bangladesh: An application of the ARDL method

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Abstract

As the largest sector in Bangladesh, agriculture and its subsectors have always played a dominant role in accelerating economic growth. The current research was performed to assess the agriculture subsector's contribution to Bangladesh's economic development. To evaluate the effect of agricultural subsectors on economic growth, this study employed the Autoregressive Distributed Lag (ARDL) method and Error Correction Model (ECM)with the historical data collected from the Bangladesh Bureau of Statistics (BBS) and the World Bank (WB). The results of the ARDL bound test confirm that the agricultural subsectors and economic growth have a strong association in the long run. The positive and significant coefficients of the crop, livestock, and fisheries subsectors reveal that these variables have an impact on the economic growth of Bangladesh in both the short and long-run. The findings also showed that the crop subsector has a bidirectional causal connection with economic growth. In addition, the pairs 'economic growth and livestock subsector', and 'economic growth and forestry subsector' showed a unidirectional relationship. Therefore, this study suggests that the development of agricultural subsectors is vital to the economic development of Bangladesh. The agricultural subsectors intensively require more attention and investment from public and private sources in order to steer more economic expansion.

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1. Introduction

Agriculture has been the lifeblood of Bangladesh's economy since its independence in 1971 (Ghose et al., 2014). Agriculture and economic development have a positive association (Xuezhen *et al.*, 2010). Despite the fact that the global economy is mostly based on industrialization, Bangladesh's agricultural sector has long acted as a driving force for the country's continuous growth and development (Helal and Hossain, 2013; Rahaman *et al.*, 2020; Rahman, 2017; Khandker and Koolwal, 2010). Food security, housing, employment, and the quality of life of Bangladesh's large population are allied with the growth of the agriculture sector.

Significant changes have happened in Bangladesh's rural economy as a result of the agricultural sector's expansion and development in recent years. Bangladesh produced 11 million tons of food grains soon after its independence in 1972, yet, this quantity of food was insufficient to support the country's 75 million residents (Kabir et al., 2015). In the country's 48 years of independence, the population has increased by 165 million, and cropland is shrinking one percent per year due to increasing rural housing, urbanization, and industrialization, yet food production has increased more than three and a half times (Rahaman et al., 2021; Islam et al., 2020; Rahman, 2017; Kabir et al., 2015; Habiba et al., 2015; Hasan et al., 2013). Bangladesh now produces 38.74 million tons of food grains; moreover, the country has attained self-sufficiency in cereals, potatoes, and vegetables, while substantial development has been made in pulses, oilseeds, spices, and fruits (BBS, 2020). Consequently, Bangladesh is currently a global leader in cultivating different crops on the same land throughout the year and has gone a long way in producing chicken eggs, milk, and meat. According to the World Bank, agricultural production has been essential in reducing the country's poverty rate (World Bank, 2019a).

Bangladesh is one of the fastest expanding and emerging global economies (World Bank, 2019b; Rahman *et al.*, 2022). Across the last decade, its GDP has grown at a rate of more than 6 percent on average, and in the fiscal year 2018-19, it was the highest at 8.15 percent (BER, 2020; World Bank, 2019b). The GDP of Bangladesh encompasses three broad sectors: agriculture, industry, and service (Figure 1).

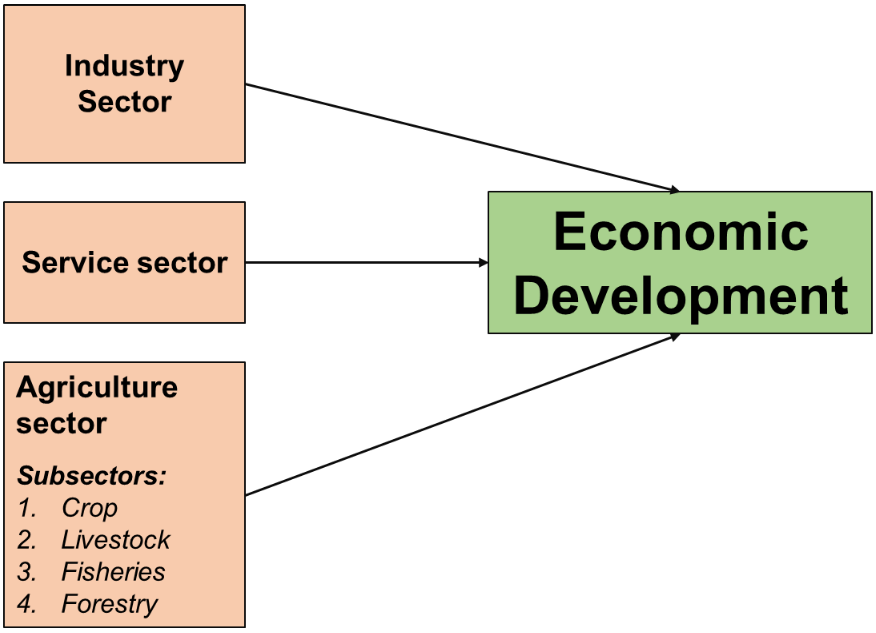

Figure 1. Main sectors of economic development.

In the fiscal year 2018-19, the agriculture, industry, and service sectors each contributed 13.65, 35.00, and 51.35 percent on average, and their growth rate was 3.92, 12.62, and 6.78 percent, respectively (BBS, 2020; BER, 2020). Although the industrial sector has a greater contribution to the economy than the agriculture sector, the agriculture sector is the main driving force and acts as the key to the introduction of the development of the industrial sector in Bangladesh (Rahman, 2017; Uddin, 2015). Even the developed countries, although faster industrial growth and significant contribution to the economy, yet recognize the roots of that growth lie in the agricultural sector that gave rise to the modern economy (Fiszbein, 2022). Figure 2 shows Bangladesh's real GDP and agricultural GDP since its independence. The size of the real GDP increased along with the increase in agricultural GDP. Because, the adoption of modern agricultural technology forms the foundation for long-term agricultural growth (Sarkar *et al.*, 2022). Among the sectors, agriculture is a vital part that employs 40 percent of the workforce and provides a source of income for about 84 percent rural population of the nation (Islam and Musa, 2014; Uddin, 2015; BBS, 2020). The agriculture sub-sectors in Bangladesh are crop, livestock, forestry, and fisheries (Rahman, 2011; BER, 2020). The sectoral share of the sub-sectors, i.e., crops, livestock, forestry, and fisheries, was 7.06, 1.47, 1.62, and 3.49 percent, respectively, in the financial year 2018-19, and their growth rate was 1.96, 3.54, 8.34, and 6.10 percent, respectively (BBS, 2020; BER, 2020).

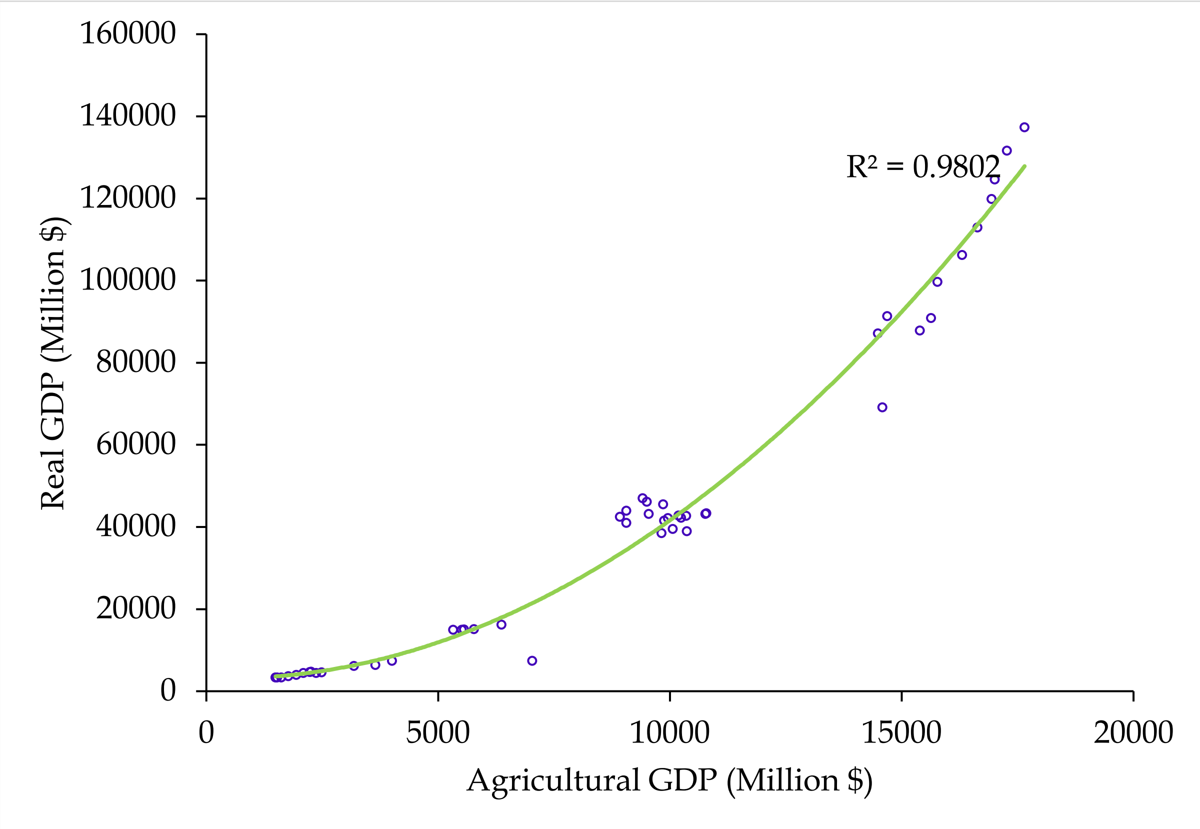

Figure 2. Relationship between Real and Agricultural GDPs of Bangladesh.

Data source: BBS different issues and WB.

Although Bangladesh's agricultural GDP size shows an increasing trend (Figure 2), its total GDP and growth rate share have declined over time (BER, 2020). Even though the government has taken several promising measures for the agriculture sector, it faces some potential challenges. Every year, agriculture in Bangladesh is challenged by problems such as shrinking cropland, climate change, poor management practices, volatile produce prices, and limited research funding (Al Mamun *et al.*, 2021; Islam and Musa, 2014; Kabir *et al*., 2017). The significant impact of agricultural sub-sectors on the economy's growth is a source of much debate in the field of development economics, particularly under the given agricultural productivity challenges (Awokuse and Xie, 2014). Nonetheless, the economic growth of Bangladesh has been consistent over time. Historically, agriculture has been at the heart of Bangladesh's economy, and agriculture's contribution to non-agricultural development has gradually been increasing. Thus, the agriculture sector continues to be an indispensable driver of the country's economic development (Rahman, 2017).

In the progress and economic growth of a country, several earlier studies have identified the agriculture sector's contribution. However, most analysis has failed to independently and adequately explain all details of the agriculture sub-sectors and their importance for certain countries' economies. In the context of Bangladesh, several studies have shown the contribution of agriculture to economic development. The very popular studies in the literature are Islam *et al*. (2020), Helal and Hossain (2013), Rahman (2017), Islam and Musa (2014), Ahmed (2004), and Rahman *et al*. (2011). As the agricultural sector in Bangladesh consists of several sub-sectors, a question arises- does every agricultural subsector equally contribute to economic development? None of the studies in the literature split the agricultural sector's contribution into its sub-sectors. But it is crucial to investigate the sub-sectoral contribution of the agricultural sector to the national economy to formulate effective policy for boosting the contribution of agriculture to economic development. Therefore, this study has been designed to investigate the association of agricultural sub-sectors with the economic development of Bangladesh using advanced econometric techniques. The research has demonstrated the causal relationship between the agricultural sub-sectors and economic development that would provide helpful evidence to develop Bangladesh's agricultural policies. The study used the most up-to-date methods, software, and techniques to assess and interpret these impacts. This study has aimed to provide useful result-based evidence to help the Bangladesh government to concentrate on the agricultural sub-sectors to boost the country's overall economic performance and development. There is no question that further research with new data will be needed in the future.

1.2 Literature review

As an attractive topic, the relationship between economic growth and different sectors has been studied several times and explained by various researchers, which also serves as a source of dispute in the development literature (Nkalu and Edeme, 2019; Islam *et al*., 2020). When scholars discuss a particular country's economic growth, the explanations become more specific, which only match those countries.

Islam *et al*. (2020) have studied, utilizing the ARDL model, the long and short-run effects of agricultural and industry sectors on Bangladesh and India's GDP between 1975 and 2019. For both Bangladesh and India, the F-bounds test verified the existence of a long-run association. In addition, the short-run coefficients also confirmed that the agricultural and industrial sectors have a favorable effect on the economies of both countries. Using VECM, Asim and Akbar (2019) explored the role of sectoral growth interconnections on agricultural production in Pakistan from 1960 to 2016. The findings of the VECM reveal that the manufacturing sector harms agricultural production, while the agricultural output is positively affected by the service sector in the long run.

Michael (2017) investigated the connection and effect of the agriculture and petroleum sector on Nigeria's economic development using the ARDL model. He has shown that the agricultural and oil sectors benefit the economy over the long and short term. While the manufacturing industry, on the other hand, was excluded from the report. Mehrara (2016) evaluated agricultural and industrial exports on 34 developing nations' economic progress from 1970 to 2014. He found that the favorable impact of industrial exports on economic growth was more notable than agricultural exports.

Applying the VECM model from 1980 to 2013, Uddin (2015) analyzes the role of Bangladesh's agricultural, manufacturing, and utility sectors in economic development. Researchers found that economic sectors have a beneficial effect on economic development. However, two-way causalities were found between the agricultural sector and GDP, manufacturing and the agricultural sector, while the services sector and agriculture, and industry and services sectors show one-way causality.

Chebbi (2010) employs Johansen's multivariate method to examine the function of agriculture in Tunisian economic development. According to empirical findings, agriculture tends to play a limited stance as a pushing factor in developing non-agricultural industries in Tunisia in the short run, and its development can only benefit the agribusiness sector.

Xuezhen *et al*. (2010) conducted an econometric model analysis and found that agriculture and economic development have always had a positive relationship from 1952 to 2007. According to the findings, while agriculture's GDP share has been reduced across the period, agriculture's influence on growth remains upward. Trade, exchange rates, components (Finance, Work), and productivity have contributed dramatically to non-agricultural development, and it continues to be a vital controlling force for the economy's growth.

Subramaniam and Reed (2009) determined the value of agricultural inter-sector linkages in Poland and Romania's economic development. The Johansen cointegration test was applied to identify the sectoral association. At the same time, it adopted VECM to justify the relationship between agricultural, manufacturing, utility, and trade industries. The importance of agriculture in the Northern Cyprus economy from 1975 to 2002 is examined by Katircioglu (2006). The study's findings indicate they are in a long-term equilibrium relationship and have two-way causation. Kanwar (2000) uses a vector autoregressive (VAR) method to inspect the interdependence of the Indian economy's various sectors to avoid spurious regressions due to non-stationarity data.

Many of the studies mentioned above have contributed to a better understanding and realization of agriculture's possible contribution to the GDP and a causal relationship between them. Unfortunately, almost no previous studies have identified which agricultural subsector has the most significant impact on economic development. However, as far as the author is aware, there is scarce research on this subject, requiring empirical research to determine the effect of agricultural sub-sectors on Bangladesh's economy.

2. Methodology

2.1 Data

We used time series data from 1972 to 2019 to achieve the study objective. Data on the real GDP of Bangladesh, crop sector GDP, animal and livestock sector GDP, forestry sector GDP, and Fisheries sector GDP are obtained from the various issue of the Bangladesh Bureau of Statistics (BBS) and World Bank (WB). For ease of comparison with other assessments, all data was measured in US dollars.

As a representation of economic growth, the nominal GDP was deflated to convert into real GDP, while agriculture sub-sectors such as crops, animal and livestock, fisheries, and forestry were used as explanatory variables in this study. Thus, the variable real GDP, crop, animal and livestock, forestry, and fisheries sector GDP are denoted as RGDP, Crop, Liv, For, and Fish, respectively. Table I summarizes the data description and statistical properties of the considered variables, and Figure 3 depicts the trend lines of the time series variables.

Table I. Data description and statistical properties of the time series variables.

	RGDP	Crop	Liv	For	Fish
Mean	72597.37	5746.68	1078.09	968.73	1946.50
Median	54130.72	5555.06	1231.14	764.45	2093.87
Maximum	209974.40	22131.88	4405.88	7295.33	7648.59
Minimum	21475.76	1148.16	154.79	76.68	96.4169
SD	50559.34	3633.54	786.46	1138.36	1641.49
Sum	3484674	275840.60	51748.45	46499.32	93432.41
Observations	48	48	48	48	48

Note: RGDP = Real gross domestic product; Liv. = Animal and livestock; For. = Forestry; Fish = Fisheries. Author's computation.

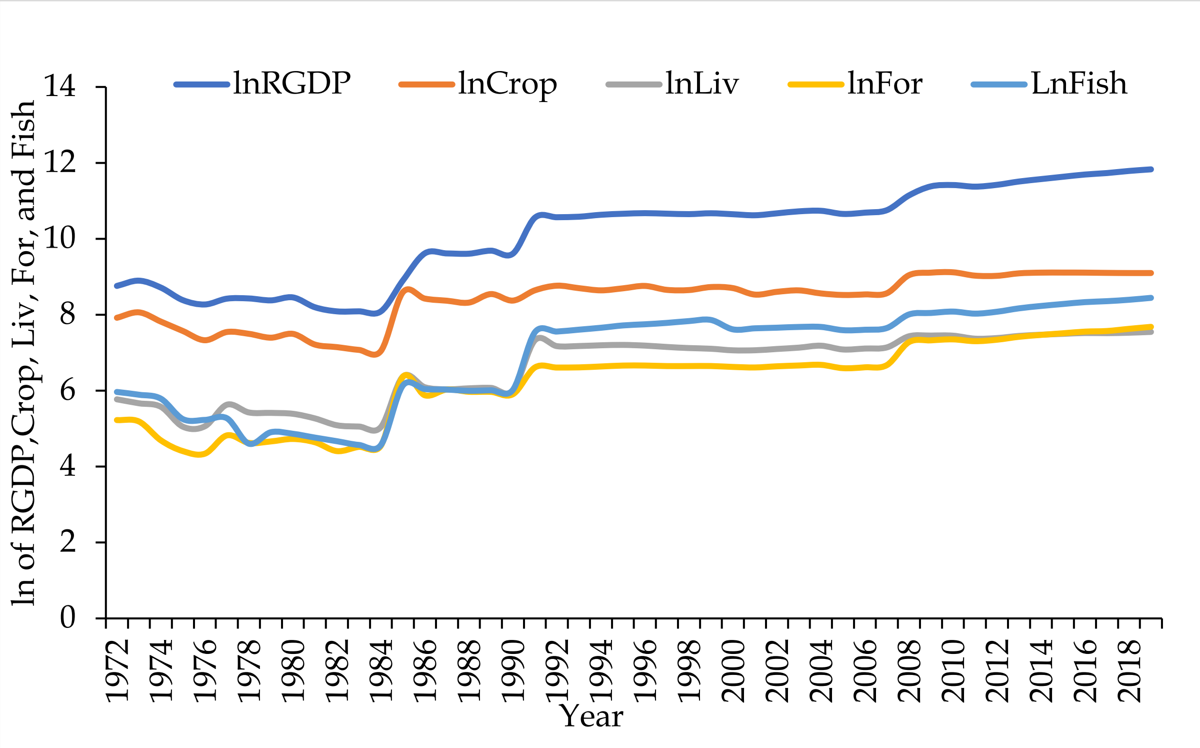

Figure 3. Trend of the natural logarithm of the considered times series variables.
Data source: BBS.

2.2 Empirical methodology

2.2.1 Stationary test

Since the stationarity structure of the data sets the estimate procedure, the first phase in the time series analysis is to check for data stationarity (Nelson and Plosser, 1982). Therefore, before dealing with the final modeling, all variables used in this analysis are checked for stationarity. To examine the type of data stationarity, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests can be used (Dickey and Fuller, 1979; Phillips and Perron, 1988).

Also, the ADF test is the most popular method for testing unit roots (Shrestha and Bhatta, 2018). The following ADF model equation can be used to measure the unit root of a series.

$$\Delta y_t = \alpha + \delta y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t \; \dots\dots\dots\dots\dots\dots (1)$$

where, $\delta = \sigma - 1$, $\sigma =$ coefficient of y_{t-1}, $\Delta =$ difference operator, $\Delta y_t =$ first difference of y_t The test hypotheses are $H_0 : \delta = 0$, and $H_1 : \delta < 0$.

Where, $H_0 : \delta = 0$ of ADF states that the non-stationary nature of the variable means it has a unit root; on the other hand $H_1 : \delta < 0$ indicates that no unit root in the data.

The PP test is expressed as follows

$$\Delta y_t = \theta y_{t-1} + \gamma_i D_{t-i} + \varepsilon_t \dots\dots\dots\dots\dots\dots (2)$$

Where the hypothesis is tested for $\theta = 0$, D_{t-i} is the coefficient of deterministic trend. ε_t is a I(0) with zero mean.

The Likelihood Ratio Test Statistics (LR), Akaike Information Criterion (AIC) (Akaike, 1974), Final Prediction Error (FPE), Hennan-Quinn Information Criterion (HQ) (Hannan and Quinn, 1979), and Schwarz Information Criterion (SIC) (Schwarz, 1978), were used to select the maximum lag lengths.

2.2.2 ARDL Model specification

The primary objective of this study is to examine how different agricultural sub-sectors in Bangladesh contribute to the country's gross domestic product. The model was developed using the Autoregressive Distributive Lag (ARDL) econometric strategy to determine the role and relationship between the study's variables. The analysis employed the Ordinary Least Square (OLS) method to measure the parameters in a multiple linear regression mode. This relationship can be expressed as a log-log empirical model with the following form

$$lnRGDP_t = \alpha_0 + \alpha_1 lnCrop_t + \alpha_2 lnLiv_t + \alpha_3 lnFor_t + \alpha_4 lnFish_t + \varepsilon_t \; \dots\dots\dots\dots\dots\dots (3)$$

Where ln stands for the natural logarithm; $RGDP_t$ denotes the real GDP at time t; $Crop_t$ crops at time t, Liv_t denotes animal and livestock at time t, For_t denotes forestry at time t, $Fish_t$ denotes fisheries at time t, ε_t is a standard error term.

The paper follows Hossain (2021), Chandio *et al.* (2019), Nwani *et al.* (2016), and Hossain and Hasanuzzaman (2013) to determine the long and short-run relationships and interlinkage among the interest variables. This paper uses Pesaran *et al.* (2001) ARDL method to conduct bound and cointegration tests. The ARDL method is a statistically reliable method for assessing associations in small samples, while Engle and Granger's (1987) and Johansen and Juselius's (1990) techniques need larger samples for meaningful findings (Ghatak and Siddiki, 2001; Pahlavani, 2005). Furthermore, it is essential for all the variables used in the model to be integrated in the same order in conventional methods, while ARDL can work irrespective of their order, i.e., integrated at I(0), I(1), or a mixture of both orders (Pesaran *et al.*, 2001).

The first step of the ARDL testing process is the bound test, which compares the estimated F-statistic to the tabulated value. The bound test hypotheses are as follows:

H_0: The variables are not cointegrated.
($\delta_1 = \delta_2 = \delta_3 \dots\dots\dots = 0$)
H_1: The variables are cointegrated.
($\delta_1 \neq \delta_2 \neq \delta_3 \dots\dots\dots \neq 0$)

Three possible outcomes may be deduced from this. First, if the measured F-statistics is greater than the tabulated value, the null hypothesis (H_0) is rejected; nevertheless, it is not rejected if the estimated F-statistic is less than the tabulated value. Finally, if the value of the F-statistic falls between these two limits, the findings are ambiguous. This paper's ARDL framework is as follows

$$\Delta lnRGDP_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1t}\Delta lnRGDP_{t-i} + \sum_{i=1}^{p} \alpha_{2t}\Delta lnCrop_{t-i} + \sum_{i=1}^{p} \alpha_{3t}\Delta lnLiv_{t-i} + \sum_{i=1}^{p} \alpha_{4t}\Delta lnFor_{t-i} + \sum_{i=1}^{p} \alpha_{5t}\Delta lnFish_{t-i} + \alpha_6 lnRGDP_{t-1} + \alpha_7 lnCrop_{t-1} + \alpha_8 lnLiv_{t-1} + \alpha_9 lnFor_{t-1} + \alpha_{10} lnFish_{t-1} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where, Δ represents the lag operator, p is the optimal lag lengths, $\alpha_1 \ldots \alpha_5$ and $\alpha_6 \ldots \alpha_{10}$ are the short-run and long-run dynamic coefficients and ε_t is the standard random error term.

The ARDL bound test has the advantage that if some cointegrating vector is detected, the cointegrating vector of the ARDL model is re-parameterized to an Error Correction Model (ECM). According to Nkoro and Uko (2016), the cointegrating vector of the ARDL model comprises a single model with long-run multipliers as well as short-run dynamics of the variables. The F-statistic has been used to recognize the long-run association as it exceeded the critical value bound. The existence of cointegration implies that causality among the variables exists at least in one direction (Tursoy and Faisal, 2016). The causality between real GDP and agriculture sub-sectors determines using the ECM Granger causality method (1987). The mutual causality of short-run relationships was checked in this analysis to see whether the variables were jointly significant. In the form of this analysis, a general specification of the causality test is as follows:

$$\Delta lnRGDP_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1t}\Delta lnRGDP_{t-i} + \sum_{i=1}^{p} \alpha_{2t}\Delta lnCrop_{t-i} + \sum_{i=1}^{p} \alpha_{3t}\Delta lnLiv_{t-i} + \sum_{i=1}^{p} \alpha_{4t}\Delta lnFor_{t-i} + \sum_{i=1}^{p} \alpha_{5t}\Delta lnFish_{t-i} + \delta ECT_{t-1} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where, ECT is the error correction term.

Several diagnostic and model stability tests are performed to ensure the precision and reliability of the ARDL model assessment. In addition, the Cumulative Sum (CUSUM) and Cumulative Sum of Squares (CUSUMQ) measures proposed by Brown *et al*. (1975) were used to evaluate the model's stability.

3. Results and Discussion

3.1 Unit root test

Prior to testing for cointegration, the variables' integration order and data stationarity must be determined. The ARDL bound test method's most critical statement is that the data must be integrated at I(0), I(1), or mutually cointegrated; otherwise, the ARDL F-test findings become unjustifiable (Pesaran *et al*., 2001). Both the ADF and PP unit root tests were recommended by Enders (1995). Therefore, we used ADF and PP to evaluate stationarity in this analysis (Table II). The unit root test results show that all the research variables are stationary at I(1). Therefore, the ARDL-bound cointegration approach is the best choice for this analysis.

Table II. Results of ADF and PP unit root test.

Variables	ADF I(0)		ADF I(1)		PP I(0)		PP I(1)	
	I	IT	I	IT	I	IT	I	IT
lnRGDP	-1.055	-3.87**	-10.328***	-10.231***	-1.081	-3.903**	-13.895***	-15.103***
lnCrop	-1.340	-3.956**	-10.378***	-10.294***	-1.469	-3.985**	-14.728***	-17.455***
lnLiv	-1.346	-3.421**	-10.241***	-5.532***	-1.274	-3.375	-13.295***	-18.980***
lnFor	-1.275	-4.598**	-7.610***	-7.586***	-1.240	-4.692***	-19.662***	-26.356***
lnFish	-1.028	-3.512**	-10.106***	-4.818***	-0.972	-3.497**	-11.974***	-11.999***

'**' and '***' indicate significant at 5 and 1 percent level, respectively. Note: 'I(0)' is for 'Level', 'I(1)' is for 'First difference', 'I' is for 'Intercept', and 'IT' is for 'Intercept and trend'.

3.2 Lag length selection criteria

After testing the time series' stationary level, selecting a suitable lag period is crucial before using the ARDL bound test. Table III presents lag order selection criteria for the ARDL model. We use the LR, FPE, AIC, SIC, and HQ parameters to determine the acceptable lag time. Since the AIC criteria produce reliable results and outperform the SIC and HQ, the lag length was chosen based on AIC in this study, and the optimum lag length is 1. Additionally, the polynomial graph was used to validate the optimum lag order (Figure 4). All the blue colored dots in this graph are bounded in the circle, meaning that estimations would be useful in achieving fruitful outcomes at lag 1.

Table III. Criteria for the selection of optimum lag order.

Lag	LogL	LR	FPE	AIC	SIC	HQ
0	-51.848	NA	9.12e-06	2.584	2.787	2.659
1	56.325	186.845*	2.10e-07*	-1.197*	0.020*	-0.745*
2	78.755	33.645	2.47e-07	-1.080	1.150	-0.253
3	94.185	19.638	4.30e-07	-0.6455	2.599	0.558
4	115.188	21.958	6.60e-07	-0.463	3.795	1.116

Notes : *Indicates lag order selected by the criterion.

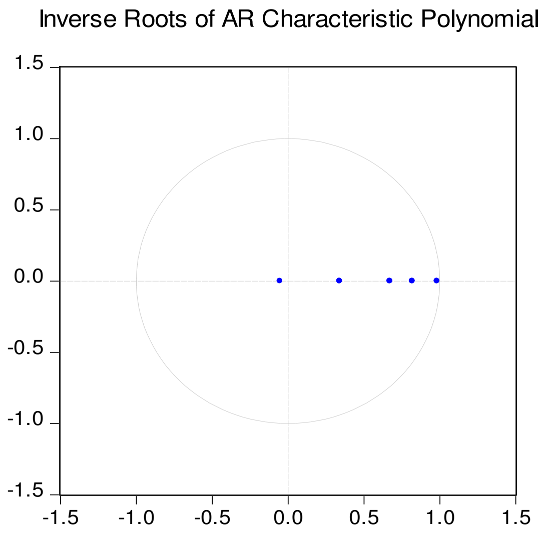

Figure 4. Optimum lag order selection criteria in a polynomial graph using a VAR model

3.3 Bounds test of Co-integration

Table IV summarizes ARDL bounds testing outcomes. The F statistics (9.817) is greater than the upper critical limit (4.37) at a 1 percent significance level, indicating that the null hypothesis of non-cointegration can be rejected. These findings suggest a long-run relationship between agriculture sub-sectors and economic growth in Bangladesh.

Table IV. Results of ARDL bound cointegration test.

Variable		**lnRGDP**
Optimal lag structure		(1, 1, 1, 0, 1)
F-statistics		9.817***
Critical values (percent)		1
	Lower Bound	3.29
	Upper Bound	4.37
Critical values (percent)		5
	Lower Bound	2.56
	Upper Bound	3.49

***Indicates significant at 1 percent level.

3.4 Estimation of long-run and short-run coefficients

The long and short-run coefficients of the ARDL model and the error correction expression must be validated after establishing the long-run relationship. We computed long and short-run coefficients using equations 4 and 5. Tables V and VI display the computed long and short-run outcomes, and the importance of agriculture sub-sectors to Bangladesh's economic development.

With the exception of forestry, all explanatory variables had a positive and statistically significant long-run influence on Bangladesh's real GDP, as demonstrated in Table 5. In the long run, the crop sub-sector positively and significantly impacts GDP. It means that a one percent rise in the crops sub-sector would result in a 0.63 percent increase in economic growth. This is consistent with the findings of Chongela (2015) and Jobarteh and Selemani (2020). Similarly, the sub-sector of livestock and fisheries has a long-run positive and significant association with Bangladesh's economic growth. Also, a one percent increase in the livestock and fisheries sub-sectors would increase economic growth by 0.37 and 0.23 percent, respectively. In the long run, the forestry sector, on the other hand, was negatively and statistically insignificant to economic development. This means in the long-run the forestry sector has no major impact on economic growth. This verdict is consistent with Jobarteh and Selemani's (2020) findings. Therefore, the agriculture sub-sectors are contributing greatly to increased economic development since the government of Bangladesh has granted the agriculture sector priority. These sub-sectors benefited from the implementation and distribution of modern and suitable agricultural innovations and varieties, as well as the advancement of secure processing infrastructure, irrigation facilities, mechanization, agricultural incentives, rehabilitation assistance in natural disasters, and easy marketing of agricultural products. The respective ministry also implements successful policies and strategies, such as agriculture advancement and farmer capacity growth. Furthermore, by offering subsidies, producers and farm owners are able to buy inputs and feeds at a low cost. These two initiatives significantly impact the development of Bangladesh's agricultural sub-sectors and the country's overall economic growth.

The short-run ARDL error correction model is depicted in Table VI. According to the results, the agriculture, livestock, and fisheries subsectors positively and significantly impact Bangladesh's economic development. It means that a one percent increase in the crop, livestock, and fisheries subsector rises economic growth by 0.65, 0.31, and 0.18 percent, respectively. On the other hand, using a one-period lagged error term (ECT-1) to capture short-run dynamics is a standout feature of this model. The lag error expression is the residual of the cointegrating vector between the model's economic growth and agriculture sub-sectors. After an economic shock, the estimated coefficient of the ECT reveals how rapidly the economy will become reappearance to equilibrium in the long run. The results show the coefficient of ECT is − 0.066, which is negative and highly significant at 1 percent. It suggests that 6.65 percent of imbalances from the prior shock will adjust in the long run. It shows that any prior model error will be corrected during this time frame. In this scenario, the results suggest that the transition pace is sluggish, and it can take some time to recover from a short-run shock to a long-run balance. The R^2 and adjusted R^2 values were 99.62 and 99.21 percent, respectively, indicating the well-fitted model. The estimated F statistic is 25.326.

Table V. Long-run estimation of the ARDL model.

Dependent variable: lnRGDP				
ARDL (1, 1, 1,0, 1)				
Model selection method: AIC				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	***P*-value**
lnCrop	0.629***	0.047	13.219	0.000
lnLiv	0.371***	0.049	7.620	0.000
lnFor	-0.158	0.475	-0.332	0.741
lnFish	0.234***	0.046	5.061	0.000
C	0.017***	0.004	3.873	0.001

***Denotes significant at 1 percent.

Table VI. Short-run estimation of the ARDL model.

Dependent variable: ΔlnRGDP				
ARDL (1, 1, 1, 0, 1)				
Model selection method: AIC				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	***P*-value**
ΔlnCrop	0.654***	0.032	20.611	0.000
ΔlnLiv	0.312***	0.070	4.435	0.0001
ΔlnFish	0.178***	0.060	2.965	0.005
ECM (-1)	-0.066***	0.022	-3.016	0.004
F-statistics		25.326*** (0.000)		
R-squared		0.993		
Adjusted R-squared		0.992		
Durbin-Watson stat.		1.796		

***Denotes significant at 1 percent. Note: Δ is the first difference operator.

A model stability test was performed using the diagnostic tests presented in Table VII. The results demonstrate that all diagnostic checks passed the specified ARDL model with no model misspecification. Furthermore, CUSUM and CUSUMSQ stability tests have also been performed to check the short and long-run parameters. The diagrams for both tests are within critical limits and significant at a 5 percent level, as shown in Figure 5, which implies that the long and short-run precision of parameters affects the economic growth of Bangladesh during the period 1972–2019. Table VIII shows Q-Stat is statistically insignificant, which implies no autocorrelation or partial correlation in the ARDL model.

Table VII. Model diagnostic test results.

Diagnostic tests:	**F statistics (*P*-value)**
χ^2Normal	2.346 (0.246)
χ^2Breusch-Godfrey Serial Correlation LM Test	1.408 (0.228)
χ^2Heteroskedasticity Test: Breusch-Pagan-Godfrey	0.550 (0.892)
χ^2Ramsey RESET Test	0.471 (0.499)

Note: *P*-value in the parentheses.

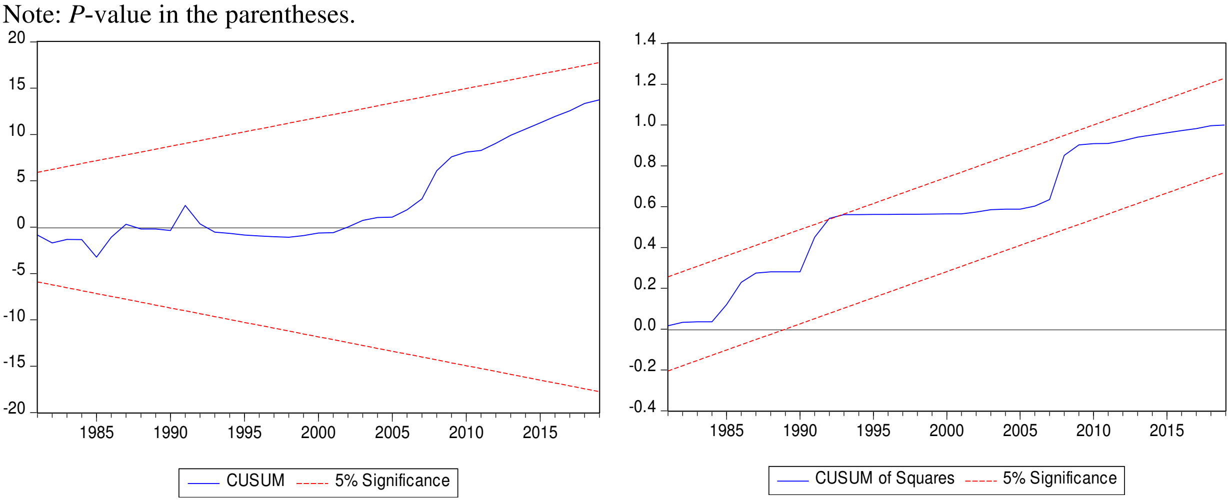

Figure 5. CUSUM test and CUSUM of Squares test

Table VIII. The correlogram statistics of the estimated model.

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th>Lags</th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>P-value</th></tr>
<tr><td>. | . |</td><td>. |*. |</td><td>1</td><td>0.024</td><td>0.087</td><td>0.4439</td><td>0.114</td></tr>
<tr><td>. |*. |</td><td>. |*. |</td><td>2</td><td>0.074</td><td>0.154</td><td>1.7449</td><td>0.171</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>3</td><td>-0.111</td><td>-0.031</td><td>1.4389</td><td>0.208</td></tr>
<tr><td>. |*. |</td><td>. |*. |</td><td>4</td><td>0.210</td><td>0.178</td><td>5.1970</td><td>0.140</td></tr>
<tr><td>. | . |</td><td>. |*. |</td><td>5</td><td>-0.042</td><td>0.096</td><td>6.4075</td><td>0.197</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>6</td><td>-0.048</td><td>-0.012</td><td>7.1215</td><td>0.261</td></tr>
<tr><td>. |*. |</td><td>. |*. |</td><td>7</td><td>0.145</td><td>0.106</td><td>7.5521</td><td>0.252</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>8</td><td>-0.063</td><td>0.011</td><td>10.776</td><td>0.308</td></tr>
<tr><td>. | . |</td><td>.*| . |</td><td>9</td><td>-0.031</td><td>-0.091</td><td>10.839</td><td>0.381</td></tr>
<tr><td>. | . |</td><td>.*| . |</td><td>10</td><td>-0.020</td><td>-0.098</td><td>11.868</td><td>0.458</td></tr>
<tr><td>. | . |</td><td>.*| . |</td><td>11</td><td>0.013</td><td>-0.102</td><td>11.880</td><td>0.536</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>12</td><td>0.020</td><td>-0.043</td><td>12.909</td><td>0.609</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>13</td><td>-0.086</td><td>-0.069</td><td>12.464</td><td>0.639</td></tr>
<tr><td>. | . |</td><td>.*| . |</td><td>14</td><td>-0.023</td><td>-0.137</td><td>13.506</td><td>0.702</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>15</td><td>0.023</td><td>-0.050</td><td>13.548</td><td>0.758</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>16</td><td>-0.068</td><td>-0.052</td><td>13.934</td><td>0.788</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>17</td><td>-0.110</td><td>-0.175</td><td>14.975</td><td>0.778</td></tr>
<tr><td>. | . |</td><td>.*| . |</td><td>18</td><td>0.024</td><td>-0.082</td><td>14.025</td><td>0.822</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>19</td><td>-0.014</td><td>-0.028</td><td>15.044</td><td>0.860</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>20</td><td>-0.047</td><td>-0.006</td><td>15.254</td><td>0.885</td></tr>
</table>

Table IX represents the pairwise Granger causality test results. The relationship between the variables included in the model may be unidirectional, bidirectional, or no connection. The pairwise Granger causality test results indicate that Bangladesh's crop sector and economic growth are bidirectionally linked. This means that any shifts in the crop sector and economic growth would affect each other in the short run. The causal relationship, on the other hand, is unidirectional: from economic growth to livestock subsector, fisheries to economic growth, economic growth to forestry subsector, livestock to crop subsector, forestry to crop subsector, fisheries to crop subsector, livestock to forestry subsector, and fisheries to forestry subsector (Figure 6). The findings suggest that any change in Bangladesh's economic growth would directly impact the livestock and forestry sub-sectors. Whereas, any changes in the livestock, forestry, and fisheries sub-sectors would have an effect on the country's crop subsector. Furthermore, any livestock and fisheries sub-sectors reforms would affect Bangladesh's forestry sector.

Table IX. Pairwise Granger causality test results.

Null Hypothesis	**F-Statistic**	***P*-value**	**Explanations**
ΔlnCrop ≠> ΔlnRGDP	9.465***	0.004	lnCrop and lnRGDP causing each
ΔlnRGDP ≠> ΔlnCrop	9.740***	0.003	other
ΔlnLiv ≠> ΔlnRGDP	1.408	0.242	lnLiv not causing lnRGDP
ΔlnRGDP ≠> ΔlnLiv	3.486*	0.069	lnRGDP causing lnLiv
ΔlnFor ≠> ΔlnRGDP	0.015	0.903	lnFor not causing lnRGDP
ΔlnRGDP ≠> ΔlnFor	8.550***	0.005	lnRGDP causing lnFor
ΔlnFish ≠> ΔlnRGDP	1.036**	0.031	lnFish causing lnRGDP
ΔlnRGDP ≠> ΔlnFish	2.016	0.163	lnRGDP not causing lnFish
ΔlnLiv ≠> ΔlnCrop	3.677*	0.062	lnLiv causing lnCrop
ΔlnCrop ≠> ΔlnLiv	0.419	0.520	lnCrop not causing lnLiv
ΔlnFor ≠> ΔlnCrop	5.026**	0.030	lnFor causing lnCrop
ΔlnCrop ≠> ΔlnFor	0.007	0.934	lnCrop not causing lnFor
ΔlnFish ≠> ΔlnCrop	4.006*	0.051	lnFish causing lnCrop
ΔlnCrop ≠> ΔlnFish	1.217	0.276	lnCrop not causing lnFish
ΔlnFor ≠> ΔlnLiv	1.485	0.229	lnFor not causing lnLiv
ΔlnLiv ≠> ΔlnFor	3.114*	0.085	lnLiv causing lnFor
ΔlnFish ≠> ΔlnLiv	0.514	0.477	lnFish not causing lnLiv
ΔlnLiv ≠> ΔlnFish	0.133	0.717	lnLiv not causing lnFish
ΔlnFish ≠> ΔlnFor	2.928*	0.094	lnFish causing lnFor
ΔlnFor ≠> ΔlnFish	0.722	0.400	lnFor not causing lnFish

*, ** and *** denote significance at 10, 5, and 1 percent.

Note: Δ is the first difference operator. The null hypothesis of the granger causality is represented by $A \neq> B$. It means A does not granger causes B. For example, 'ΔlnCrop ≠> ΔlnRGDP' means ΔlnCrop does not granger causes ΔlnRGDP.

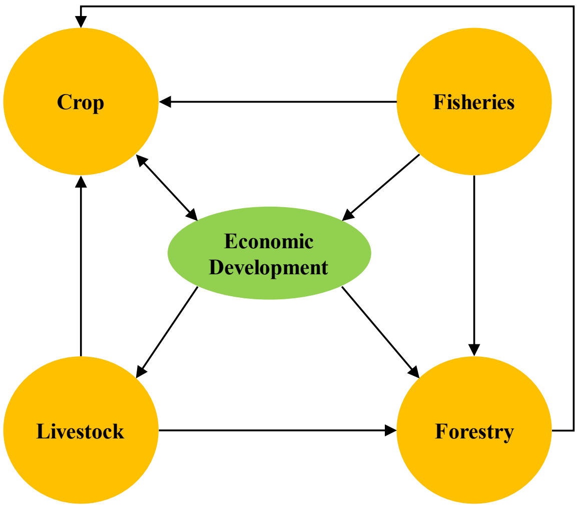

Figure 6. Graphical representation for channelizing the agricultural subsectors and economic development. (Note: Double and single arrows indicate a bidirectional and unidirectional relationship, respectively.)

4. Conclusion

This article examines the relationship between agricultural sub-sectors and Bangladesh's economic development using time series data spanning the period 1972 to 2019. It also revealed the cause of the causal association of agriculture sub-sectors. To detect association existence, a long-run cointegrating ARDL bound testing and ECM technique was employed. The research investigated covariates like the crop, animal and livestock, forestry, and fisheries subsector in the GDP. The integration order of the research variables is evaluated using ADF and PP unit root measures. We observed the long-run association among the research variable, as the measured F-statistics in bound testing was greater than the upper bound and significant at one percent level. The results further pointed out that Bangladesh's forestry subsector has no jurisdiction over long-run economic development. While in the short run, the crop, livestock, and fisheries sub-sector raise economic growth. A pairwise Granger causality test was also used to determine the structure of the relationship. The findings show that economic growth and the crop subsector have a bidirectional relationship. At the same time, unidirectional relationships for economic growth and livestock subsector, fisheries and economic growth, economic growth and forestry subsector, livestock and crop subsector, forestry and crop subsector, fisheries and crop subsector, livestock and forestry subsector, and fisheries and forestry subsector were also observed.

The study's findings demonstrate that agricultural sub-sectors significantly and robustly impact Bangladesh's economic development. However, the contribution of subsectors is not the same. The contribution of the crop sub-sector is the most, followed by livestock and fisheries. There still have scope to enlarge the contribution of agricultural sub-sectors to the economy. The agro-processing sector is still underdeveloped. The government should emphasize developing the agro-processing sector through a public-private partnership to enhance the agricultural sector's contribution to the economy. Location-specific country investment plans (CIP) should be formulated, and based on that plan annual budget should be allocated. Moreover, an initiative can be taken to reduce production costs and increase productivity in the agricultural sub-sectors. Research and development (R&D) should be prioritized in order to advance a country's degree of technological input, innovation ability, sustainable development potential, comprehensive technological strength, and competitiveness. More specifically, the adoption of high-yielding varieties and/or breeds, and enlarging mechanized cultivation would increase the economic return from agriculture.

5. Reference

Ahmed, R. (2004) "Rice Economy of Bangladesh: Progress and Prospects" Economic and Political Weekly, 39(36), 4043-4052. Retrieved April 15, 2021, from http://www.jstor.org/stable/4415505.

Akaike, H. (1974) "A new look at the statistical model identification" *IEEE transactions on automatic control*, *19*(6), 716-723. https://doi.org/10.1109/TAC.1974.1100705.

Al Mamun, M.A., Nihad, S.A.I., Sarkar, M.A.R., Aziz, M.A., Qayum, M.A., Ahmed, R., ... and Kabir, M.S. (2021) "Growth and trend analysis of area, production and yield of rice: A scenario of rice security in Bangladesh" *PloS one*, 16(12), e0261128.

Asim, H. and M. Akbar (2019) "Sectoral growth linkages of agricultural sector: Implications for food security in Pakistan" *Agricultural Economics*, *65*(6), 278-288. https://doi.org/10.17221/314/2017-AGRICECON.

Awokuse, T.O. and R. Xie (2014) "Does agriculture really matter for economic growth in developing countries?" *Canadian Journal of Agricultural Economics*, *63*(1), 77-99. DOI: 10.1111/cjag.12038.

BBS (Bangladesh Bureau of Statistics) (2020) "Statistical Yearbook of Bangladesh 2019" Statistics and Informatics Division, BBS, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

BER (Bangladesh Economic Review) (2020) "Bangladesh Economic Review 2020" Finance Division, Ministry of Finance, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh. October 2020 www.mof.gov.bd.

Brown, R.L., J. Durbin and J.M. Evans (1975) "Techniques for testing the constancy of regression relationships over time" *Journal of the Royal Statistical Society: Series B (Methodological)*, *37*(2), 149-163. https://doi.org/10.1111/j.2517-6161.1975.tb01532.x.

Chandio, A.A., Y. Jiang and A. Rehman (2019) "Using the ARDL-ECM approach to investigate the nexus between support price and wheat production" *Journal of Asian Business and Economic Studies,* 26(1), 139-152. https://doi.org/10.1108/JABES-10-2018-0084.

Chebbi, H.E. (2010) "Agriculture and economic growth in Tunisia" China agricultural Economic review. Vol. 2 No. 1,pp. 63-78. https://doi.org/10.1108/17561371011017504.

Chongela, J. (2015) "Contribution of agriculture sector to the Tanzanian economy" *American Journal of Research Communication*, *3*(7), 57-70.

Dickey, D.A. and W.A. Fuller (1979) "Distribution of the estimators for autoregressive time series with a unit root" *Journal of the American statistical association*, *74*(366a), 427-431. https://doi.org/10.1080/01621459.1979.10482531.

Enders, W. (1995) "*Applied Econometric Time Series"* 3e, New York: John Wiley & Sons Inc.

Engle, R.F. and C.W. Granger (1987) "Co-integration and error correction: representation, estimation, and testing" *Econometrica: journal of the Econometric Society*, 251-276. https://doi.org/10.2307/1913236.

Fiszbein, M. (2022) “Agricultural Diversity, Structural Change, and Long-Run Development: Evidence from the United States” American Economic Journal: Macroeconomics, 14(2), 1-43. https://doi.org/10.1257/mac.20190285

Ghatak, S. and J.U. Siddiki (2001) “The use of the ARDL approach in estimating virtual exchange rates in India” *Journal of Applied statistics*, *28*(5), 573-583. https://doi.org/10.1080/02664760120047906.

Ghose, B., B. Razib and G. Sharmistha (2014) “Reviewing the status of agricultural production in Bangladesh from a food security perspective” *Russian journal of agricultural and socio-economic sciences*, *25*(1). https://doi.org/10.18551/rjoas.2014-01.04.

Habiba U., M.A. Abedin and R. Shaw (2015) “Introduction and overview of food security and risk reduction issues” In *Food Security and Risk Reduction in Bangladesh* (pp. 1-17). Springer, Tokyo. https://doi.org/10.1007/978-4-431-55411-0_1.

Hannan, E.J. and B.G. Quinn (1979) “The determination of the order of an autoregression” *Journal of the Royal Statistical Society: Series B (Methodological)*, *41*(2), 190-195. https://doi.org/10.1111/j.2517-6161.1979.tb01072.x.

Hasan, M.N., M.S. Hossain, M.R. Islam, M.A. Bari, D. Karim and M.Z. Rahman (2013) “Trends in the availability of agricultural land in Bangladesh” Soil Resource Development Institute (SERDI), Ministry of Agriculture, Bangladesh, Dhaka. Available from URL: http://www. nfpcsp. org/agridrupal/sites/default/files/Trends-in-the-availability-ofagricultural-land-in-Bangladesh-SRDI-Supported-by-NFPCSP-FAO. Pdf.

Helal, M. and M.A. Hossain (2013) “Four decades of economic development of Bangladesh: An assessment” *Journal of the Asiatic Society of Bangladesh (Hum.)*, *58*(2), 335-362.

Hossain, A.N. and S. Hasanuzzaman (2013) “Remittances and investment nexus in Bangladesh: an ARDL bounds testing approach” International Review of Economics, 60(4), 387-407. https://doi.org/10.1007/s12232-012-0170-0.

Hossain, M.R. (2021) “Inward foreign direct investment in Bangladesh: Do we need to rethink about some of the macro-level quantitative determinants?” *SN Business & Economics*, *1*(3), 1-23. https://doi.org/10.1007/s43546-021-00050-z.

Islam, M.A., M.S. Rahaman, M.A.R. Sarkar and M.C. Rahman (2020) “A Time Series Analysis for Supply Response Scenario of Food Grains in Bangladesh: The Quest of Structural Changes” *Journal of Agriculture, Food and Environment (JAFE)| ISSN (Online Version): 2708-5694*, *1*(3), 6-13. http://doi.org/10.47440/JAFE.2020.1302.

Islam, M.S. and M. Musa (2014) “Development of Agriculture Sector in Bangladesh: A Comparative Analysis” Al-Barkaat Journal of Finance & Management, 6(2), 1-11. DOI:10.5958/2229-4503.2014.00001.0.

Islam, M., M. Hasif, N.S. Ema and H. Jahan (2020) “Role of Agriculture and Manufacturing Sectors in the Economic Growth of Bangladesh and India: An ARDL Approach” *Romanian Economic Journal*, *23*(78), 82-92.

Jobarteh, F. and M. Selemani (2020) “Assessing the Effect of Agriculture Sub-sectors on the Gambia's Economic Growth Using Time Series Econometric Models” International Journal of Agricultural Economics, 5(4), 142. https://doi.org/10.11648/j.ijae.20200504.17.

Johansen, S. and K. Juselius (1990) "Maximum likelihood estimation and inference on cointegration –with applications to the demand for money" Oxford Bulletin of Economics and Statistics, Vol. 52 No. 2, pp. 169-210, doi: 10.1111/j.1468-0084.1990.mp52002003.x.

Kabir, MJ., M. Alauddin and S. Crimp (2017) "Farm-level adaptation to climate change in Western Bangladesh: An analysis of adaptation dynamics" profitability and risks. *Land use policy*, *64*, 212-224. https://doi.org/10.1016/j.landusepol.2017.02.026.

Kabir, M.S., M.U. Salam, A. Chowdhury, N.M.F. Rahman, K.M. Iftekharuddaula, M.S. Rahman, M.H. Rashid, S.S. Dipti, S. Islam, M.A. Latif, A.K.M. Islam, M.M. Hossain, B. Nessa, T.H. Ansari, M.A. Ali and J.K. Biswas (2015) "Rice vision for Bangladesh: 2050 and beyond" Bangladesh Rice Journal, 19(2), 1-18. https://doi.org/10.3329/brj.v19i2.28160.

Kanwar, S. (2000) "Does the dog wag the tail or the tail the dog? Cointegration of Indian agriculture with non-agriculture" Journal of Policy Modeling, Vol. 22 No. 5, pp. 533-56. https://doi.org/10.1016/S0161-8938(97)00161-0.

Katircioglu, S.T. (2006) "Causality between agriculture and economic growth in a small nation under political isolation: A case from North Cyprus" *International Journal of Social Economics*. Vol. 33 No. 4, pp. 331-343. https://doi.org/ 10.1108/03068290610651643.

Khandker, S.R. and G.B. Koolwal (2010) "How Infrastructure and Financial Institutions Affect Rural Income and Poverty: Evidence from Bangladesh" The Journal of Development Studies, 46:6, 1109-1137, DOI: 10.1080/00220380903108330.

Mehrara, M. and J. Baghbanpour (2016) "The contribution of industry and agriculture exports to economic growth: the case of developing countries" *World Scientific News*, (46), 100-111.

Michael, O.A. (2017) "Long and Short Run Dynamics of Agricultural and Petroleum Sectors in the Economic Growth of Nigeria" Romanian Economic Journal, 20(64).

Mohanty, R.K. and N.R. Bhanumurthy (2019) "Analyzing the Dynamic Relationships between Physical Infrastructure, Financial Development and Economic Growth in India" *Asian Economic Journal*, *33*(4), 381-403. https://doi.org/10.1111/asej.12190.

Nelson, C.R. and C.R. Plosser (1982) "Trends and random walks in macroeconmic time series: some evidence and implications" *Journal of monetary economics*, *10*(2), 139-162. https://doi.org/10.1016/0304-3932(82)90012-5.

Nkalu, C.N. and R.K. Edeme (2019) "Environmental hazards and life expectancy in Africa: evidence from GARCH model" SAGE Open, 9(1), 2158244019830500. https://doi.org/10.1177/2158244019830500.

Nkoro, E. and A.K. Uko (2016) "Autoregressive Distributed Lag (ARDL) cointegration technique: application and interpretation" *Journal of Statistical and Econometric methods*, *5*(4), 63-91.

Nwani, C., E. Iheanacho and C. Okogbue (2016) "Oil price and the development of financial intermediation in developing oil-exporting countries: Evidence from Nigeria" *Cogent Economics & Finance*, *4*(1), 1185237. https://doi.org/10.1080/23322039.2016.1185237.

Pahlavani, M. (2005) “Sources of Economic Growth in Iran: A Cointegration Analysis in the Presence of Structural Breaks, 1960-2003” *Applied Econometrics and International Development*, *5*(4).

Pesaran, M.H., Y. Shin and R.J. Smith (2001) “Bounds testing approaches to the analysis of level relationships” *Journal of Applied Econometrics*, *16*(3), 289–326. https://doi.org/10.1002/jae.616.

Phillips, P.C. and P. Perron (1988) “Testing for a unit root in time series regression” *Biometrika*, *75*(2), 335-346. https://doi.org/10.1093/biomet/75.2.335.

Rahman, M. C., Pede, V. O., & Balié, J. (2022) “Welfare impact of asymmetric price transmission on rice consumers in Bangladesh” *Review of Development Economics,* 26(3), 1600-1617. DOI: 10.1111/rode.12882

Rahaman, M.S., M.J. Kabir, M.C. Rahman, M.A.R. Sarkar, M.A. Islam, M.A. Salam, M.I. Omar, M.S. Islam and M.A.B. Siddique (2020) “Adoption determinants and constraint of BRRI released Aman rice varieties: Evidence from Mymensingh District” Journal of Bioscience and Agriculture Research, 25(01), 2085-2097. https://doi.org/10.18801/jbar.250120.255.

Rahaman, M.S., S. Haque, M.A.R. Sarkar, M.C. Rahman, M.S. Reza, M.A. Islam and M.A. B. Siddique (2021) “A cost efficiency analysis of boro rice production in Dinajpur district of Bangladesh” Fundamental and Applied Agriculture 6(1): 67–77. doi: 10.5455/faa.137178.

Rahman, M.M., M.S. Rahman and W.U. Hai-Bing (2011) “Time series analysis of causal relationship among GDP, agricultural, industrial and service sector growth in Bangladesh” *China-USA Business Review*, *10*(1).

Rahman, M.T. (2017) “Role of agriculture in Bangladesh economy: uncovering the problems and challenges” *International Journal of Business and Management Invention*, *6*(7).

Sarkar, M.A.R., Rahman, M.C., Rahaman, M.S., Sarker, M.R., Islam, M.A., Balie, J., and Kabir, M. S. (2022) “Adoption Determinants of Exotic Rice Cultivars in Bangladesh” *Frontiers in Sustainable Food Systems*, 6:813933. doi: 10.3389/fsufs.2022.813933

Schwarz, G. (1978) “Estimating the dimension of a model” *Annals of statistics*, *6*(2), 461-464. https://doi.org/10.1214/aos/1176344136.

Shrestha, M.B. and G.R. Bhatta (2018) “Selecting appropriate methodological framework for time series data analysis” The Journal of Finance and Data Science, 4(2), 71-89. https://doi.org/10.1016/j.jfds.2017.11.001.

Subramaniam, V. and M.R. Reed (2009) “Agricultural inter-sectoral linkages and its contribution to economic growth in the transition countries (No. 1005-2016-79162)” https://doi.org/10.22004/ag.econ.51586.

Tursoy, T. and F. Faisal (2016) “Causality between stock price and GDP in Turkey: an ARDL bounds testing approach” *Romanian Statistical Review*, *64*(4), 3-19.

Uddin, M.M.M. (2015) “Causal relationship between agriculture, industry and services sector for GDP growth in Bangladesh: An econometric investigation” *Journal of Poverty, Investment and Development*, *8*.

World Bank. (2019a) “Bangladesh poverty assessment: facing old and new frontiers in poverty reduction” The World Bank 1818 H Street NW, Washington, DC 20433 Telephone: 202-473-1000; Internet: www.worldbank.org

World Bank. (2019b) “*Bangladesh Development Update: Towards Regulatory Predictability*”, The World Bank Office, Agargaon, Sher-e-Bangla Nagar, Dhaka – 1207, Bangladesh. www.worldbank.org/bd

Xuezhen, W., W. Shilei and G. Feng (2010) “The relationship between economic growth and agricultural growth: The case of China” In *2010 International Conference on E-Business and E-Government* (pp. 5315-5318). IEEE. https://doi.org/10.1109/ICEE.2010.1330.