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Repercussions of Sustainable Agricultural Productivity, Foreign Direct Investment, Renewable Energy, and Environmental Decay: Recent Evidence from Latin America and the Caribbean

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This research aimed to assess and implement the long- and short-run relationship of agriculture and environmental sustainability with control variables. Purposely, this research consolidated theoretical and conceptual principles to create a systematic structure in agriculture for the development of both sectors, i.e., agricultural and the environment. On this ground statement, this research was motivated to contemplate the relationship between carbon dioxide emission, agricultural production, gross domestic product, renewable energy consumption, and foreign direct investment using annual data series of Latin American and Caribbean countries from 1971 to 2018. Autoregressive distributed lag (ARDL) was used as an econometric methodology to examine the relationship among the variables. Agriculture is the most vulnerable sector in Latin American and Caribbean countries, and the economy is heavily dependent on it. The main results of this research indicated that agriculture and CO_2 emissions were positively related to each other for the long and short run, which means that agricultural activities increased the CO_2 emission levels. At the same time, the control variables showed mixed associations with environmental degradation as gross domestic product (GDP) was positively significant and renewable energy consumption was negatively significant. The error correction (EC_{t-1}) term was negatively significant, confirming the long-run relationship and the speed of adjustment from short- to long-run equilibrium. Agricultural production and GDP led to increments in CO_2 emissions, while renewable energy consumption negatively contributed to toxic emissions. The speed of adjustment in Latin American and Caribbean countries was nippy. It required 2.933 periods for the transformation from the short periodic phase to the long term. A comprehensive approach is the research debate rigorously and holistically based on divergent sectors of an economy and their relationship with environmental sustainability. The econometric method, symbolic system, and conceptual existence were designed originally.

Keywords: sustainable agricultural productivity, foreign direct investment, renewable energy, ARDL approach, environmental sustainability, Latin American and Caribbean region

INTRODUCTION

The Earth's weather undergoes significant alterations as the world's climate alters. An increase in carbon dioxide and other radioactive greenhouse gases in the atmosphere may cause substantial changes in the global climate, leading to devastating repercussions on the world's ecosystems (Warrick, 1988). The amount of carbon dioxide produced in Latin America has increased. According to the Carbon Dioxide Information Analysis Center (CDIAC), Argentina, Brazil, Mexico, and Venezuela make about 90% of the world's carbon dioxide emissions. Among the top 20 nations with the largest CO_2 emissions from fossil fuels, Mexico and Brazil account for 52.7% of the 2007 regional emissions (Marland, 2008).

The climate is directly or indirectly affected by emissions of greenhouse gases, which in turn influence agricultural productivity cycles. The recently released Intergovernmental Panel on Climate Change (IPCC) assessment of global agricultural yield found that climate change poses numerous hazards (Intergovernmental Panel on Climate Change 2019). Global warming and changes in climate are unquestionably affecting agricultural productivity. The atmospheric carbon dioxide rise, climate change, and related precipitation have a deleterious influence on agricultural growth and output. One cannot consider the effect of a single factor on productivity. It is highly difficult to forecast the repercussions of the interactions of carbon dioxide enrichment, temperature rise, rainfall, and soil nutrients on the environment. Carbon dioxide (CO_2) levels in the atmosphere can immediately impact crops and have indirect effects *via* climate change. US-produced crops are crucial to our country's food supply and worldwide distribution. The United States provides almost one-quarter of all worldwide grains, such as rice, wheat, and corn, as the largest supplier. Extreme weather conditions, rising temperatures, and increasing CO_2 levels may influence harvest yields. The effect of a higher temperature on every particular crop depends on the crop's ideal growth and reproduction temperature. Although warming may be beneficial in some regions, some crops will grow better there, or farmers may be able to change to different crops cultivated in warmer regions. If the temperature is too hot, the crop's yield will drop.

Today, the two greatest obstacles of humanity are a lack of economic sustainability and environmental degradation (Aye and Edoja, 2017). Following the Kaya identity, the total CO_2 emissions that contribute to global warming are influenced by foreign direct investment (FDI), renewable energy use, and economic development. As the most important economic development engine, investment and overseas trade have made significant contributions to the rapid rise of the economy. However, there is also evidence that FDI and increased foreign trade contribute to environmental pollution (Ren et al., 2014). The primary mechanism for industrial development and economic progress is FDI. Technological transfer, greater competitiveness, and new jobs will make FDI an obvious choice. However, the existence of FDI in a country is not always without complications. For example, the presence of FDI in the massif will result in the construction of new factories, which may have detrimental environmental consequences.

Meanwhile, numerous plans, such as the Kyoto Protocol and the Paris Agreement, have promoted renewable energy usage as a means of mitigating climate change problems (Nguyen and Kakinaka, 2019). Economic growth and a growing need for energy are increasing, and some of the major fuel sources are coal, oil, and natural gas. Energy use and per capita income are closely linked, which has led to the worsening of the environment (Hasnisah et al., 2019). The associations between environmental quality and economic development have been discussed thoroughly.

The distinctiveness of this research lies in its exploration of the knowledge regarding the agricultural production, renewable energy consumption, economic development, FDI, and environmental sustainability of 18 Latin American and Caribbean (IBRD and IDA) countries (hereafter IBRD and IDA countries). The maximum possible panel data from 1971 to 2018 are approached for analytical purpose. Existing research has mainly focused on renowned developed and developing countries, but the IBRD and IDA countries have not been discussed. After Asia, these regions receive the greatest capital inflows to least developed countries (LDCs), accounting for around 30% of the total FDI inflows to LDCs (UNCTAD, 2011). Emerging countries and developing economies also primarily contributed to environmental degradation. They are also crucial in the discussion to reduce pollution and toxic emissions thoroughly. Primarily, this research focused on measuring the periodic nature of the relationship between variables, whether long run or short run. Secondly, this study determined the sectorial impact on a sustainable environment in line with agriculture. The salient purpose of this research was to urge focusing on significant development sectors such as gross domestic product (GDP), renewable energy consumption (REC), and FDI. The econometric methodology provides ease of measurement, and the autoregressive distributed lag (ARDL) method was selected for the analysis before and after checking the reliability of the time series.

LITERATURE REVIEW

Global warming has become a challenge not only for human survival but also for other habitats. The development and stability of an individual economy are based on trade, investment opportunities, capital flows, and cultural ties (Gyamfi et al., 2021; Murshed et al., 2021; Nathaniel et al., 2021). The agricultural industry produces massive greenhouse gas (GHG) emissions, which significantly contribute to climate change and global warming. Thus, agriculture is both a victim of and a contributor to climate change. Agriculture is a contributor to GHG emissions and is sensitive to GHG release (IPCC 2007). The World Bank (2013) stated that between one-fourth and one-third of the world's total GHG emissions are generated by agriculture, from both on-farm operations, i.e., approximately 10%–12% of global emissions, and land use and land cover changes to cropland, including an additional 12%–20% (Mulatu et al.,

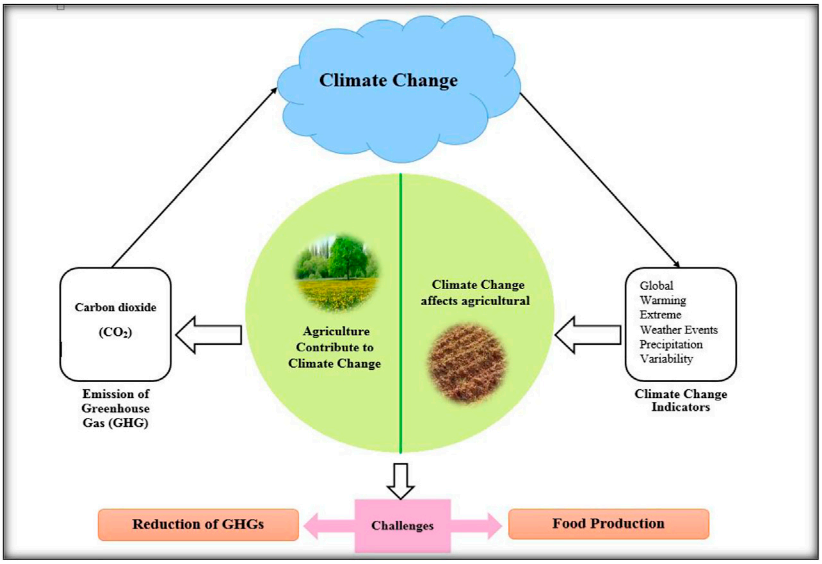

FIGURE 1 | Agricultural productivity and climate change.

2016; Ahmed et al., 2021; Bekun et al., 2021; Chishti et al., 2021). According to Malhi et al. (2021), increased CO_2 levels resulted in improved crop fertilization and decreased energy requirements from heat (Eshete et al., 2020). It was concluded that agricultural activities are a major contributor to GHG emissions (30% overall) because of the use of chemical fertilizers, pesticides, and animal manure. Increased food consumption due to a growing global population, increased demand for dairy and meat products, and the intensification of agricultural processes are expected to contribute to continued increases in this rate.

In contrast, greenhouse gases such as carbon dioxide (CO_2) contribute to climate change and global warming and significantly impact the sustainability of agricultural production systems. This does not yet consider the GHG emissions associated with the use of pesticides, the environmental cost of which is largely unrecognized. **Figure 1** shows the relation between agricultural productivity and climate change.

Over the last few decades, much research has been conducted into the relationship between economic growth and CO_2 emissions. Many countries are confronted with a major challenge: ensuring sustained economic growth while also protecting the environment. The study of Kasperowicz (2015) hypothesized that the long-term relationship between GDP and CO_2 emissions is negative since new low-carbon technologies will allow output levels to be met at lower levels of CO_2 emissions in the long term. However, they also believed that there is a positive link between GDP and CO_2 emissions in the short run since quick production growth could be realized with higher energy use *via* the existing technologies, which would expand the capacity of the economy and CO_2 emissions (Gyamfi et al., 2021; Murshed et al., 2021; Nathaniel et al., 2021). According to the findings, basic equity capital market (ECM) estimations suggested that, in the long run, the GDP-to-CO_2 emissions relationship is negative as new low-carbon technologies will help to achieve the same production levels at lower CO_2 emissions. However, in the short run, the relationship is positive as the quick production boost is made possible through the use of existing energy technologies, which then triggers CO_2 emissions to rise (Kasperowicz, 2015). Multiple studies (Tucker, 1995; Chang, 2010; Fodha and Zaghdoud, 2010; Niu et al., 2011; Shahzad et al., 2021c) have empirically investigated the linear relationship between carbon dioxide emissions and economic growth (GDP). The results of the empirical analysis have shown that a causal relationship exists between carbon emissions, the amount of energy used in producing electricity, coal, and oil, and the nation's GDP (Gyamfi et al., 2021; Murshed et al., 2021; Nathaniel et al., 2021). Meanwhile, the study of Niu et al. revealed that, in contrast to underdeveloped countries with no direct connection between carbon emissions and GDP, the United States showed a strong association between the two.

Of course, like renewables, other forms of energy have their trade-offs and associated debates. Despite the many studies on the relationship between CO_2 emissions and energy consumption, almost all use total energy consumption as a proxy for energy consumption. In contrast, studies that focus on the types of energy consumed are still scarce. Therefore, two categories of energy are used in restricted studies: renewable energy and non-renewable energy. Additionally, this research used panel data methods to evaluate the effects of oil and gas consumption on carbon dioxide emissions in 20 Organization of Islamic Cooperation (OIC) countries. The most important study finding was that, over the long term, increased national productivity causes greater environmental damage than previously thought (Shaari et al., 2020; Shahzad et al., 2021a; Shahzad et al., 2021e). Conventional energy production cannot keep up with the increased demand due to the increasing demand for energy in numerous industrial sectors. In this regard, to reduce dependency and reliance on old sources and improve economic performance, energy from renewable sources has emerged as an option. In other words, researchers have studied the link between economic growth and environmental quality by looking at the effects of non-recycled materials in their empirical studies (Bölük and Mert, 2014; Dogan and Seker, 2016; Irandoust, 2016; Jebli and Ozturk, 2016; Yang et al., 2018; Shahzad et al., 2021b). According to the high, the rising use of RE will decrease CO_2 emissions and enhance the quality of the environment because it cuts down on energy usage. Meanwhile, Bölük and Mert (2014) found that energy derived from renewable sources is the most efficient at reducing emissions by 50% compared to energy obtained from traditional sources (Nathaniel et al., 2021).

The present age is the age of globalization, making the world a borderless territory and enhancing the feasibility of exchanging goods and services. The trending globalization enormously affected the development and growth of the country by considering FDI. With the rapid growth of FDI knowledge, the governments of developed and developing countries have provided an investment-friendly environment. There is limited literature on the relationship between FDI and pollution for Latin America. Most of the publications have focused on finding empirical evidence against or favoring the pollution haven hypothesis (Cole and Ensign, 2005; Barbier and Hultberg, 2007; Waldkirch and Gopinath, 2008; MacDermott, 2009; Staats and Biglaiser, 2012; Shahzad et al., 2020; Naseem et al., 2021). As a result of migration, lower environmental standards have been implemented in countries that have become havens for polluting companies (Copeland and Taylor, 1994). Levinson and Taylor (2008) analyzed how regulatory costs affected trade flows and found that industries with the highest cost increases had the greatest rise in net imports. The study of Shahzad et al. (2021e) discovered that large amounts of foreign capital are critical to industrial adjustment and economic growth in industrial countries. They found that global carbon emissions have decreased in response to emission reduction policies, although such policies have been weakened by carbon leakage. Indeed, one question that arises from the increasing influx of FDI into developing countries is whether it has any environmental impact (Zeng and Eastin, 2012; Mohsin et al., 2020; Naseem et al., 2020). Therefore, research on the effect of FDI on carbon emissions is necessary. Existing literature has not addressed the IBRD and IDA countries mainly; meanwhile, they have the highest contribution to global warming. The deforestation and land utilization activities of these countries have become the reason for the environmental decline. The industrial and residential sectors of IBRD and IDA countries are globally considered environmental decay elements. This research will focus on selected sectors of the economy and their impact on the environment to fill the literature gap and contribute to existing research for the holistic purpose of saving the environment.

The evolution of the model indicators is presented in *Literature review*, then an econometric analysis is performed, and the regression equation parameters are estimated in *Data description and econometric methodology*. The research assumptions are presented and tested next in *Empirical results*. Finally, the conclusions of the paper, i.e., *Discussion*, are summarized by the authors' recommendations, study limitations, and future research implications.

DATA DESCRIPTION AND ECONOMETRIC METHODOLOGY

Data description

This research deals with yearly data series of the CO_2 emissions, agricultural production (AGP), GDP, REC, and FDI of the IBRD and IDA countries. The IBRD and IDA are the International Bank for Reconstruction and Development and the International Development Association, respectively. The analytical data series were extracted from the World Bank (WB) from 1971 to 2018. The official website of the WB provides data at different scales, so the data specifications of this research are presented in **Table 1**.

Econometric model

The linear logarithmic form of the main model examining the relationship between CO_2, AGP, GDP, REC, and FDI is presented below.

$$CO_{2t} = \alpha_0 + \alpha_1 AGP_t + \alpha_2 GDP_t + \alpha_3 REC_t + \alpha_4 FDI_t + \varepsilon_t \quad (1)$$

In **Eq. 1**, CO_{2t} is representative of the environment concerning time. The constant term is represented as a coefficient with specific independent variables. The term is archetypal of regression error. The variables in uppercase are shown the series in their natural log. The assumption of the main model is that the increasing trend in independent variables will lead to an increase in environmental degradation or an increase in CO_2 emissions. In **Figure 2**, the complete flowchart of the econometric methodology used in this research article is presented.

The bounds testing model

Equation 1 presents a long-run relationship according to the advanced econometric approach, which should incorporate the short-run dynamic adjustment. As a solution to that issue, Engle and Granger (1987) presented an error correction model. The error correction model is given below.

$$\begin{aligned}\Delta CO_{2t} = \beta_0 &+ \sum\nolimits_{i=1}^{m} \beta_{1i} \Delta CO_{2t-i} + \sum\nolimits_{i=0}^{m} \beta_{2i} \Delta AGP_{t-i} \\ &+ \sum\nolimits_{i=0}^{m} \beta_{3i} \Delta GDP_{t-i} + \sum\nolimits_{i=0}^{m} \beta_{4i} \Delta REC_{t-i} \\ &+ \sum\nolimits_{i=0}^{m} \beta_{5i} \Delta FDI_{t-i} + \gamma \varepsilon_{t-1} + \mu_t \end{aligned} \quad (2)$$

In **Eq. 2**, is the change in the variables, is the speed of adjustment parameter from short- to long-run equilibrium, and is an error correction term for one lagged period. The error correction term is estimated from **Eq. 1** residual. The econometric method of Engle and Granger is required for establishing cointegration that the variables integrated of order one, $I(1)$, and the error term integrated of order zero, $I(0)$. The bounds test for cointegration check is divided into three parts, cointegration, inclusive, and no cointegration, which denote exceeding F-statistics than the upper bound, equal or in between the upper and lower bounds, and below

TABLE 1 | Descriptions of the variables used in the model.

Symbol	Explanation	Source
CO_2	CO_2 emissions (metric tons per capita)	World Bank
AGP	Agriculture, forestry, and fishing, value added (% of GDP)	World Bank
GDP	GDP (current US$)	World Bank
REC	Renewable energy proportion (% of total energy supply)	CEPALSTAT/IEA statistics
FDI	Foreign direct investment, net inflows (% of GDP)	World Bank

AGP, *agricultural production;* GDP, *gross domestic product;* REC, *renewable energy consumption;* FDI, *foreign direct investment;* IEA, *International Energy Agency.*

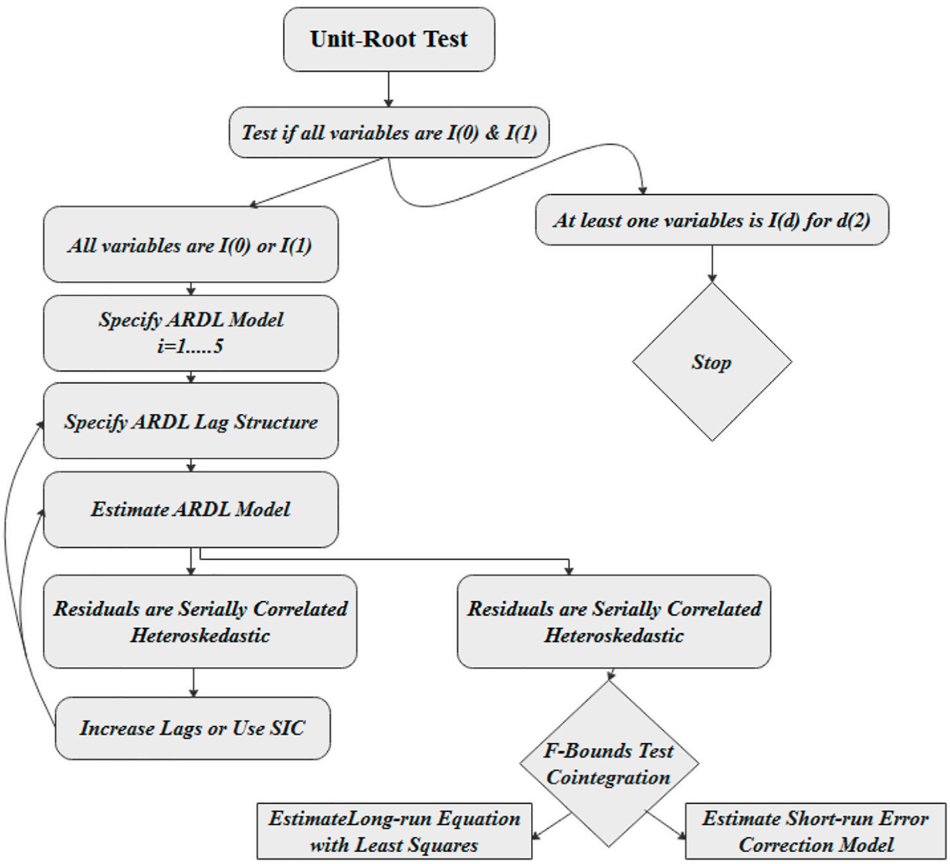

FIGURE 2 | Flowchart of the econometric methodology.

the lower bound, respectively. If any data series are not stationary, we used the cointegration method proposed by Pesaran et al. (2001) and Engle and Granger (2001). The more advanced econometric approach is known as the autoregressive distribution lag (ARDL).

Autoregressive distribution lag

The ARDL combines the two steps of Engle and Granger (1987) into one by replacing the term in **Eq. 2** with its equivalent form from **Eq. 1**. In **Eq. 3**, the term is substituted by a linear combination of lagged variables. The ARDL model measures two sets of critical values. This econometric approach accurately measures the significance level with or without trend for a small sample between 30 and 80 annotations.

The following **Eq. 3** is a combination of the short- and long-run models. The coefficients from to are representative of the short-run model, while the are inferred to estimate the long-run relationships that are normalized on.

$$\Delta CO_{2t} = \beta_0 + \sum_{i=1}^{m} \beta_{1i}\Delta CO_{2t-i} + \sum_{i=0}^{m} \beta_{2i}\Delta AGP_{t-i} + \sum_{i=0}^{m} \beta_{3i}\Delta GDP_{t-i} + \sum_{i=0}^{m} \beta_{4i}\Delta REC_{t-i} + \sum_{i=0}^{m} \beta_{5i}\Delta FDI_{t-i} + \beta_6 CO_{2t} + \beta_7 AGP_t + \beta_8 GDP_t + \beta_9 REC_t + \beta_{10} FDI_t + \mu_t \quad (3)$$

Equation 3 above was further transformed as:

TABLE 2 | Unit root test using the augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests.

Variables	ADF (constant)		PP (constant)		Interpretation
	Level	First difference	Level	First difference	
CO_2	−2.0691	−6.6456*	−2.0794	−6.6448*	*I*(1)
AGP	−1.4280	−7.5350*	−1.6768	−7.8381*	*I*(1)
GDP	2.9107	−4.3669*	−0.3805	−5.5924*	*I*(1)
REC	−2.3346	−3.8158*	−2.9638**	−5.0047*	*I*(0)
FDI	−1.2047	−8.6442*	−1.0327	−8.6573*	*I*(1)

AGP, *agricultural production;* GDP, *gross domestic product;* REC, *renewable energy consumption;* FDI, *foreign direct investment.*
, **, and * represent the 1%, 5%, and 10% levels of significance, respectively.*

$$\Delta CO_{2t} = \beta_0 + \sum_{i=1}^{m} \beta_{1i}\Delta CO_{2t-i} + \sum_{i=0}^{m} \beta_{2i}\Delta AGP_{t-i} + \sum_{i=0}^{m} \beta_{3i}\Delta GDP_{t-i} + \sum_{i=0}^{m} \beta_{4i}\Delta REC_{t-i} + \sum_{i=0}^{m} \beta_{5i}\Delta FDI_{t-i} + \lambda EC_{t-1} + \mu_t \quad (4)$$

In **Eq. 4**, the one period lagged error correction term and is the parametric coefficient of the EC term (Pesaran et al., 2001; Shahzad et al., 2021d; Zhang et al., 2021). The negative sign with the EC term represents the speed of adjustment and confirms the cointegration among the selected variables. Generally, the cointegration approach of Pesaran et al. (2001) is used to attain the results accurance than other single cointegration procedures. The ARDL bounds test is used in the analytical process due to its authenticity and accuracy for cointegration. An extra *F*-test was included in the ARDL bounds test on the lagged levels of the independent variables. This cointegration method is comparatively better than the other methods in three divergent aspects: 1) there is no need for same order integration of variables; thus, the integration of the underlying variables at *I*(1), *I*(0), or mixed has no issue running the bounds cointegration test; 2) the small and finite data can be accurately analyzed using the ARDL cointegration approach; and 3) the unbiased estimation of the long-run model can be assured by applying the ARLD technique. This model is also beneficial in terms of forecasting and disentangling the long-run relationships from the short-run dynamics. Furthermore, the series bound does not affect the accuracy of the results under this econometric model by automatic fixation.

EMPIRICAL RESULTS

The results of the augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests are contained in **Table 2**. These stationarity tests have confirmed the significance of the series at constant and first difference. The mixture of the series integration levels is in support of the application of ARDL for further analysis. Except for renewable energy consumption, all variables were integrated at first difference with a 1% significance level. The renewable energy consumption results were integrated at first difference under the stationarity tests and a level under the Phillips–Perron test at 1% significance level.

The results of lag length selection are presented in **Table 3**. Lag length selection does not have hard and fast rules. As per the dependence of the regressed variables on the predictor variable or the regressor, lag 1 was automatically selected. The analytical data deal with series analysis, so selection criteria were also exercised to include lags in the model. The log-likelihood had the highest value (−366.7609) at first lag, while the final prediction error (FPE; 47.16959), Akaike information criterion (AIC; 18.03459), Schwarz criterion (SC; 19.25108), and Hannan–Quinn (HQ; 18.48572) showed the lowest values with a 1% significance level.

The results of the bounds test are displayed in **Table 4**, which presented the periodic relationship of the variables. Spurious results were avoided by the mixture integration level of the results of the ADF and PP tests. The *F*-statistics (5.6821) and *t*-statistics (−4.4987) of bounds were higher than the tabulated values (5.06 and −4.60) with the same lag selection order. The significance of the *F*-statistics and *t*-statistics at the 1% level confirmed the long-run relationship among the variables. It failed to reject the alternative hypothesis that cointegration exists in the data series.

The short-run ARDL model is implied to check the short-term relationship among selected variables (Mohsin et al., 2020; Naseem et al., 2020). The results are presented in **Table 5** showing the automatic different lag selection for the variables. Except for GDP, the rest of the variables were checked at the difference of 1. CO_2 emissions and renewable energy consumption showed a 1% significance level with a negative sign, while all the other variables at a whole different level showed 1% and 5% significance, except for FDI. As per the assumption of Engle and Granger (2001), the EC term was negatively significant at a 1% level with a value of −0.3710. The short-run error correction was 37.10%, which was unhurried and required 2.933 periods to move from short- to long-run equilibrium. The significance of the *F*-statistics at the 1% level has confirmed the fitness of the model.

The long-run ARDL model estimation results are contained in **Table 6** which revealed that agriculture and GDP positively affect CO_2 emissions. Agricultural consumptions are prodigious emitters of ammonia (NH_3), but crop processing is involved in other emissions. Therefore, farming activities and GDP were both declared as CO_2 emission enhancers. On the other hand, renewable energy consumption is negatively affected by CO_2 emissions (Ahmed and Shimada, 2019; Koengkan and Fuinhas, 2020; Shahzad et al., 2022). Renewable energy is leading as an environment-friendly energy production and consumption source. The analytical process also confirmed the fundamental

TABLE 3 | Optimal lag length selection based on the Akaike information criterion (AIC) for the cointegration test.

Lag	Log*L*	LR	FPE	AIC	SC	HQ
0	−535.1928	NA	31,725.36	24.55422	24.75697	24.62941
1	−366.7609	290.9278*	47.16959*	18.03459*	19.25108*	18.48572*
2	−358.4519	12.46353	105.4261	18.79327	21.02350	19.62035
3	−342.0521	20.87247	175.7631	19.18419	22.42817	20.38721
4	−306.5483	37.11763	139.6434	18.70674	22.96446	20.28571

LR, *likelihood ratio;* FPE, *final prediction error;* SC, *Schwarz criterion;* HQ, *Hannan–Quinn.*
, **, and * represent the 1%, 5%, and 10% levels of significance, respectively.*

TABLE 4 | Bounds test results.

Test statistic	Value	Significance level	*I*(0)	*I*(1)
F-bounds test				
F-statistic	5.6821*	10%	2.45	3.52
Lag selection order	[1,0,0,0,0]	5%	2.86	4.01
		2.50%	3.25	4.49
		1%	3.74	5.06
T-bounds test				
t-statistic	−4.4987*	10%	−2.57	−3.66
Lag selection order	[1,0,0,0,0]	5%	−2.86	−3.99
		2.50%	−3.13	−4.26
		1%	−3.43	−4.60

, **, and * represent the 1%, 5%, and 10% levels of significance, respectively.*

TABLE 5 | Estimated short-run coefficients based on Akaike information criterion (AIC).

Variables	Coefficient	SE	*t*-Statistic	Probability
ECM regression: Case 3: unrestricted constant and no trend				
C	1.3196*	0.4121	3.2017	0.0026
D[CO_2(−1)]	−0.3710*	0.0824	−4.4987	0.0001
D(AGP)	0.0316*	0.0109	2.8865	0.0062
D(GDP)	2.72E−05*	8.33E−06	3.2663	0.0022
D(REC)	−0.0329**	0.0125	−2.6170	0.0124
D(FDI)	0.0099	0.0211	0.4680	0.6422
CointEq (−1)	−0.3710*	0.0664	−5.5841	0.0000
F-statistic		31.18247*		

SE, *standard error;* ECM, *equity capital market.*
, **, and * represent the 1%, 5%, and 10% levels of significance, respectively.*

TABLE 6 | Estimated long run coefficients based on Akaike information criterion (AIC).

Variables	Coefficient	SE	*t*-Statistic	Probability
Levels equation: Case 3: unrestricted constant and no trend				
AGP	0.0854**	0.0346	2.4672	0.0179
GDP	7.34E−05*	1.76E−05	4.1681	0.0002
REC	−0.0887**	0.0333	−2.6585	0.0111
FDI	0.0267	0.0583	0.4574	0.6497

SE, *standard error;* AGP, *agricultural production;* GDP, *gross domestic product;* REC, *renewable energy consumption;* FDI, *foreign direct investment.*
, **, and * represent the 1%, 5%, and 10% levels of significance, respectively.*

purpose of renewable energy: it mitigates CO_2 emissions and boosts the environment's quality. FDI behaved insignificantly toward CO_2 emissions. FDI develops the financial position of an individual country, which helps augment the quality of the environment. Especially in this age, if any government wants to obtain international support in national projects and attract FDI, it would first focus on environmental quality. To attain ecological sustainability and reduce global warming, developed IBRD and IDA countries provide financial support to developing countries for environmental quality in individual sectorial growth. The analytical presentation of this research also confirmed that agriculture and GDP positively contribute to CO_2 emissions, while renewable energy is negatively subsidized (Rehman et al., 2019; Sharma et al., 2021).

The results of the post-diagnostic tests are accessible in **Table 7**. The stability and normality tests included serial correlation (Breusch–Godfrey Lagrange multiplier, LM), heteroscedasticity [(Breusch–Pagan–Godfrey and autoaggresive conditional heteroskedasticity (ARCH)], residual normality (Jarque–Bera), and model correction (Ramsey regression equation specification error test, RESET) tests. All variables were free from serial correlation and heteroscedasticity and the model was correctly specified. The normality test was significant, and the value for Jarque–Bera was greater than 3, which means the residuals were abnormally distributed (Mohsin et al., 2021; Sarfraz et al., 2021). The residual distribution had a minor effect on the accuracy of the results when the data series covered an immense data span.

DISCUSSION

The rapid increase of global warming is accelerating the disappearance of snow covers and causing a rise in sea levels, which is an alarming worldwide environment (Adebayo et al., 2021; Ahmed et al., 2021; Baloch et al., 2021). The IBRD and IDA regions also contribute *via* precipitation patterns, the quick melting of the Andean tropical glaciers, and the unpredictable intensive weather-changing events in these areas. Greenhouse gases are a uniparous force behind the climatic changes and rising trend of global warming. Greenhouse gases, especially CO_2, are driven by human activities, and consequently, the whole planet is facing the damages. This research aimed at studying specific

TABLE 7 | Diagnostic statistics.

Diagnostic statistics test	*F*-statistic	*p*-value	Results
Breusch–Godfrey LM	0.4297	0.6537	No problem of serial correlations
ARCH	2.8018	0.1013	No problem of heteroscedasticity
Ramsey RESET test	0.6323	0.4312	Model is specified correctly
Jarque–Bera	84.4875*	0.0000	Estimated residuals are not normal

LM, *Lagrange multiplier;* RESET, *regression equation specification error test;* ARCH, *autoaggresive conditional heteroskedasticity.*
, **, and * represent the 1%, 5%, and 10% levels of significance, respectively.*

economic drivers concerning time and measuring their impact on environmental harms, either mitigating or boosting them up. The main results of this research indicated that agriculture and CO_2 emission are positively related to each other for the long and short run, which confirmed the upward contribution behavior of the agriculture sector in the CO_2 emissions graph. At the same time, the control variables were positively and negatively associated with environmental degradation. The error correction (EC_{t-1}) term was negatively significant, confirming the long-run relationship and speed of adjustment from short- to long-run equilibrium (Gyamfi et al., 2021; Murshed et al., 2021). Renewable energy consumption leads to reductions in CO_2 emissions, while agriculture and GDP positively contribute to toxic emissions. The negative contribution of renewable energy consumption in environmental degradation was very apparent. Global awareness about eco-friendly developments in IBRD and IDA countries is contributing to efforts to mitigate CO_2 emissions from deforestation and the consumption energy of sources. The speed of adjustment in IBRD and IDA countries was nippy. It required only 1.33 periods for the transformation from the short periodic phase to the long term. The research findings indicated the two leading sectors, i.e., GDP and FDI, as environmentally damaging, which pointed out that the unambiguous economic efficient system with positive climate change will exceed the action cost. This research also declared the economy's positive contributors and eco-friendly sectors, such as renewable energy consumption and production (Ahmed et al., 2021; Bekun et al., 2021; Chishti et al., 2021; Paramati et al., 2022). This research suggests that state handlers should focus on eco-friendly sectors to enhance the financial position of their countries and sort out the problems and uncertainties of other sectors. The global needs at present are rapid changes for the environment, which can be attained by avoiding GHG concentration sectors for triggering the enormous and irreversible eco-damages. Domestic policies and their implications on environmental sustainability are the most important things (Nathaniel et al., 2021). The governments and civil societies of the IBRD and IDA regions should be knowledgeable in managing the potential costs of environmental sustainability with economic development in a global context.

CONCLUSION AND POLICY RECOMMENDATION

The World Bank (WB) collaborates by including new states for development purposes every year to attain specific goals. The IBRD and IDA have offered different types of projects and loans to enhance the quality of the environment. To achieve environmental sustainability goals, the WB promotes and assists middle-income countries. Global warming and intensive weather conditions make the world realize the importance of a sustainable environment and ecological habitats. The president of the WB, Jim Yong Kim, conversed about the development of IBRD and IDA countries. These countries must adopt green productive technologies and enhance the effective structure to reduce poverty, improve the quality of education, and promote critical advancement in environmental quality. This research demonstrated that the Latin American and Caribbean (IBRD and IDA) region's ecological sustainability is affected by AGP, GDP, REC, and FDI for the short and long run. The analytical portion of this research has approached the maximum possible data sample from 1971 to 2020. The data series was extracted from the official website of the WB.

This research revealed a positive long-run relationship between CO_2 emissions and GDP and REC, while a negative relationship with AGP and FDI. The short-run behavior and the nature of the relationship between the dependent and independent variables are unpredictable. Sometimes, individual countries are focused on the environment and critically inspect some sectors. Hence, they work on the environment, but sometimes ignore it; this is why the positive and negative signs are not sustainable. The error correction (EC_{t-1}) fulfills the basic assumptions of a negative sign, which confirmed the long-run relationship among the variables and also declared the period of adjustment speed. The adjustment speed of the variables from short- to long-run equilibrium was 37.10%, and required 2.933 periods, which is a decently fast adjustment speed. The post-diagnostic tests confirmed the accuracy of the results and the fitness of the model. This research guides researchers, policymakers, governments, and environmentalists in reducing toxic emissions from specific sectors in order to enrich the quality of the environment. The WB has offered financial and technical assistance to developing and developed countries to better the environment, enhance the quality of life, standard of education, and health and to reduce poverty by increasing production resources. The WB also assists global countries by providing advice, designed policies, platform for research and analysis, and sustainable technological development. Environmental sustainability is the need of the present day. If global countries do not work on it now, may be shortly, there will be no pure air available for breathing and running normal life.

In this research, the most significant constraint was the limited data period due to the unavailability of data. Divergent environmental factors would have to be left out due to data discretion. In this research, only the ARDL cointegration approach was used for analytical purposes. Researchers can extend the econometric methods by applying different cointegration methods and comparing them in future research. Some websites such as CEPALSTAT provide expected figures until the year 2100, which can visualize the current and future environmental sustainability. The predicted data can also help divide the research into three periods, i.e., pre-industrial development, industrial development, and expected future post-industrial stage.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, Further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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