MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 35 Issue 2, 2025, Pages: 2127-2131

Economic growth, trade openness, and agricultural production as drivers of greenhouse gas emissions in Vietnam

Le Phuong Nam
Vietnam National University of Agriculture, Hanoi, Vietnam
Email: lephuongnam87@gmail.com

Abstract

This study analysis the relationship between greenhouse gas (GHG) emissions, economic growth, trade openness, and agricultural production in Vietnam from 1986 to 2024. The analysis uses annual data from the World Development Indicators and applies the Autoregressive Distributed Lag method to capture both short-run and long-run effects. The study results show a clear long-term relationship between GHG emissions, GDP per capita, trade openness, and agricultural production. Over the long run, economic growth is associated with higher GHG emissions, suggesting that expanding production and consumption still play a role in environmental quality. Agricultural production also increases emissions in the long term, reflecting the continued reliance on emission-intensive farming practices. Trade openness contributes to higher emissions over time, while its short-run effect on reducing emissions is weak and not statistically significant. Overall, the findings indicate that Vietnam's current growth model remains dependent on resource use and high-emission activities. This points to the need for a gradual shift toward greener growth paths and wider adoption of low-emission practices in agriculture to support long-term emission reduction goals.

Keyword: Carbon emissions; Environmental quality; Economic integration; Agricultural sector

1. Introduction

Global climate change, mainly due to the increase in greenhouse gases, is becoming one of the big challenges to sustainable development (B&Company Inc., 2025; Raihan Asif, 2023). Vietnam is currently the 17th largest country of greenhouse gases in the world and the second largest in the ASEAN region, with emissions reaching approximately 344 Mt-CO2eq in 2022 (B&Company Inc., 2025; Van Pham Dang Tri et al., 2023). As a country with a long coastline, Vietnam is extremely vulnerable to sea level rise and extreme weather events, with estimated economic losses accounting for approximately 3.2% of GDP in 2020 (OECD, 2025; World Bank Group, 2022). Against this matter, at the COP26 conference, Vietnam made a strong commitment to achieving net emissions of "zero" by 2050, to need for low-emission growth (Nguyen Thanh Phuc et al., 2025; Van Pham Dang Tri et al., 2023).

The relationship between economic development and environmental quality is often examined through the environmental Kuznets curve hypothesis, which suggests that pollution rises in the early stages of development and starts to decline once income reaches a certain level (Soumyananda Dinda, 2004). Since the Doi Moi reforms in 1986, Vietnam has experienced a strong economic transformation, moving from a low-income country to a middle-income country (Anh Tu Nguyen et al., 2021). However, this growth lead to higher emissions; between 2000 and 2015, Vietnam's per capita emissions increased steadily (World Bank Group, 2022). Empirical studies on Vietnam report many evidence on the shape of the EKC, including inverted U-shaped, N-shaped, and particularly inverted N-shaped patterns in both the short run and the long run (Anh Tu Nguyen et al., 2021). Beyond GDP growth, trade openness also affects emissions through export–import activities and foreign investment flows. Trade openness allows Vietnam to access cleaner technologies and international environmental standards. On the other hand, under the pollution haven hypothesis, the country faces the risk of receiving energy-intensive industries relocated from developed economies (Le Thi Thanh Mai et al., 2025).

In the GDP structure in Vietnam, agriculture accounts for around 30% of total national greenhouse gas emissions, in there, rice cultivation, livestock production, and fertilizer use are the main sources of methane and nitrous oxide emissions (Dinh Thi Hai Van et al., 2025; Nguyen Thi Kim Phuoc, 2023). Although increases in agricultural value added may help lower emission intensity through practices such as alternate wetting and drying or climate-smart agriculture, the large-scale adoption of these approaches remains limited. Because, key barriers include gaps in infrastructure and low levels of awareness among farmers (B&Company Inc., 2025; Raihan Asif, 2023).

Although many studies have examined the separate effects of economic growth or trade openness, a clear research gap remains in combining GDP growth, trade openness, and agricultural production within a single analytical framework for Vietnam (Nguyen Phuong Thao, 2022; Nguyen Thanh Phuc et al., 2025). Building on this gap, the present study contributes to the empirical literature by examining the joint effects of economic growth, trade openness, and agricultural production on greenhouse gas emissions in Vietnam.

2. Methodology

2.1. Data

This study uses annual time-series data from the World Development Indicators by the World Bank, the period of time from 1986 to 2024, with 39 observations. The dataset satisfies the condition that the number of observations minus the number of variables exceeds 20, as suggested by Tabachnick et al. (2013) và Pham et al. (2022). Four key variables are included in the analysis: total greenhouse gas emissions (GHG), which represent environmental quality; GDP per capita (GDPPC), used to measure of economic growth; trade openness (TRADE), defined as the ratio of total exports and imports to GDP, which captures the degree of economic integration; and agricultural value added as a share of GDP (AGRI), reflecting the role of agricultural production in the economic structure.

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 35 Issue 2, 2025, Pages: 2127-2131

Table 2.1: Descriptive statistics of variables

Indicators	GHG (Total greenhouse gas emissions (Mt CO_2e))	GDPPC (GDP per capita, calculated at constant USD prices in 2015)	TRADE (Trade openness, measured as total import and export turnover compared to GDP (%)	AGRI (Proportion of value added from agriculture, forestry and fisheries in GDP (%)
Mean	251.80	1818.22	116.39	22.69
Median	225.20	1609.96	124.33	20.41
Standard Deviation	145.89	1010.99	44.18	9.84
Kurtosis	-0.53	-0.77	-0.26	-0.23
Skewness	0.73	0.62	-0.57	0.85
Minimum	85.62	607.59	18.95	11.78
Maximum	584.26	4017.75	186.68	46.30
Number of observations	39	39	39	39

2.2. Autoregressive Distributed Lag Model

The Autoregressive Distributed Lag (ARDL) model consists of two parts: (i) the autoregressive part, in which the dependent variable depends on its own past values, and (ii) the distributed lag part, in which the independent variables affect the dependent variable across multiple lag periods.

The ARDL model was proposed by (Pesaran & Shin, 1999), as shown in Equation (2.1).

$$\mathbf{ARDL\ (q,p)\Delta Y_t = \beta_0 + \underbrace{\sum_{j=1}^{p} \beta_j \Delta Y_{t-j} + \sum_{i=0}^{q} \delta_{1,i}\Delta X_{t-i}}_{Short-term} + \underbrace{\varphi_1 Y_{t-1} + \varphi_2 X_{t-1}}_{Long-term} + \varepsilon_t \quad (Eq. 2.1)}$$

In which, short-term coefficients: β_0; β_j; $\delta_{1,i}$; long-term coefficients: φ_1; φ_2; Error: ε_t

The ARDL model in this study is represented in equation (Eq. 2.2):

$$\text{ARDL: } \Delta \ln GHG_t = \beta_0 + \underbrace{\sum_{j=1}^{p} \beta_j \ln GHG_{t-j} + \sum_{i=0}^{q} \delta_{1,i} \ln GDPPC_{t-i} + \sum_{i=0}^{q} \delta_{2,i} TRADE_{t-i} + \sum_{i=0}^{q} \delta_{3,i} AGRI_{t-i}}_{Short-term} + $$

$$+ \underbrace{\varphi_1 \ln GDPPC_{t-1} + \varphi_2 TRADE_{t-1} + \varphi_3 AGRI_{t-1}}_{Long-term} + \varepsilon_t \quad (Eq. 2.2)$$

The ARDL model has the advantage of allowing variables to have different optimal lag lengths, being suitable for small samples, and handling variables that are stationary at both I(0) and I(1). In addition, this method allows the estimation of both short-run and long-run relationships within a single system of equations. The steps for implementing the ARDL model are as follows: Test the stationarity of the variables using Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) unit root tests to confirm there are no second-order integrated variables (I(2)); The optimal lag length of the model was selected based on information criteria such as the Akaike Information Criterion (AIC) or the Schwarz Information Criterion (SIC). In this study, the EViews software was used to automatically select the optimal lag, following the approach suggested by Nsor-Ambala and Amewu (2023). The ε_t is an IID process with zero mean and constant variance, σ_ε^2. Next, the Bounds test is used to determine the existence of a long-run cointegration relationship between the variables. When cointegration is present, the long-run coefficients are estimated, and an error correction model (ECM) is applied to analyze short-run effects and the speed of adjustment toward long-run equilibrium, where the ECT coefficient must be negative and statistically significant. Finally, model diagnostic and stability tests, including tests for autocorrelation, heteroskedasticity, and the CUSUM and CUSUMSQ tests, are conducted to confirm the reliability of the results.

3. Results and Discussion

3.1. Unit Root test and Cointegration test

The study used two unit root tests, namely the ADF and PP tests, to confirm the stationarity of the data series. The results presented in Table 3.1 show that the variables lnGHG, lnGDPPC, TRADE, and AGRI are non-stationary at level, but become stationary after first difference. Therefore, all variables included in the model are integrated of order one (I(1)). The absence of any variable integrated of order I(2) indicates that the data satisfy the requirements to apply the ARDL approach to analyze both long-run and short-run relationships among the variables in the subsequent analysis.

Table 3.1. Unit Root Test

Null hypothesis (H_0): The variable has a unit root (is non-stationary).

Variable	ADF		PP		Order of Integration (with intercept)
	Level	First Difference	Level	First Difference	
lnGHG	2.1222	−5.2610***	2.0430	−5.1552***	I(1)
lnGDPC	1.2786	−3.7455***	0.8542	−3.5858**	I(1)
TRADE	−1.7457	−5.9535***	−2.2675	−6.2191***	I(1)
AGRI	−3.9556***	−6.8766***	−1.1414	−5.8505***	I(1)

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
The Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) unit root tests are employed.
The test equations include a constant (with intercept).

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 35 Issue 2, 2025, Pages: 2127-2131

In Table 3.2, the bounds test results show that the F-statistic is 9.3156, which is higher than the upper value I(1) at the 1% significance level. This confirms the present a long-run cointegration relationship among the variables in the model. This result provides a basis for further estimation of long-term and short-term coefficients within the ARDL–ECM model framework.

Table 3.2. Bounds Test Estimates

Null hypothesis (H_0): No cointegration exists (at the level form)

F-statistic	Critical values for the Bounds test		
	Significance level	**I(0)**	**I(1)**
9.3156	10%	2.958	4.100
	5%	3.615	4.913
	1%	5.198	6.845

3.2. Short-term and long-term relationships

Short-run relationship: In Table 3.3, the ECM(-1) coefficient has a negative sign (−0.6820) and is statistically significant at 1%, indicating the existence of an error correction mechanism that brings the system back to its long-run equilibrium after short-run shocks. Specifically, about 68.2% of the deviation from long-run equilibrium is corrected within one period, reflecting a quick adjustment process of the model. The variable D(GHG(-1)) has a positive value (0.3328) and is statistically significant at the 1% level, indicating that fluctuations in greenhouse gas emissions in the previous period tend to affect emissions in the next period. For TRADE, the coefficient of D(TRADE) is negative but statistically insignificant, while D(TRADE(-1)) is negative and significant at the 10% level, it meant that trade openness reduces GHG emissions in the short run with a one-period lag, although the magnitude of this effect is limited. The constant (C) is negative and statistically significant, meaning of other underlying factors not explicitly captured in the model that tend to reduce emissions in the short run.

Long-run relationship: In Table 3.3, the lnGDPPC with a coefficient of 1.0601 has a positive effect on greenhouse gas emissions, and is statistically significant at the 1% level. This result indicates that economic growth lead to higher emissions, because of the expansion of production and consumption in the economy. The TRADE variable has also a positive coefficient (0.0005) and is statistically significant at the 10% level, indicating that trade openness increase emissions in the long run, suggesting the presence of a scale effect as economic activity expands through trade. The AGRI variable also shows a positive coefficient (0.0030) and is highly statistically significant at the 1% level, confirming that agricultural activities contribute to GHG emissions in the long term.

Table 3.3: Short-run and long-run ARDL estimation results

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Short-run relationship				
ECM(-1)	-0.6820*	0.1064	-6.4123	0.0000
D(GHG(-1))	0.3328***	0.1141	2.9164	0.0064
D(TRADE)	-0.0002	0.0001	-1.2851	0.2080
D(TRADE(-1))	-0.0003*	0.0002	-1.8794	0.0693
C	-0.8000***	0.1277	-6.2666	0.0000
Long-run relationship				
lnGDPPC	1.0601***	0.0410	25.8361	0.0000
TRADE	0.0005*	0.0002	1.9209	0.0632
AGRI	0.0030***	0.0009	3.2653	0.0025

	Model Diagnostic Tests	
Test	F-Statistic	Giá trị p (Prob.)
Breusch–Godfrey serial correlation test (LM test)	1.5406	0.2325
Breusch–Pagan–Godfrey heteroskedasticity test	1.6699	0.1559

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

3.3. Diagnostic test and model stability

In Table 3.3, the Breusch–Godfrey LM test has a p-value of 0.2325, it mean that the absence of serial autocorrelation. At the same time, the Breusch–Pagan–Godfrey test shows no evidence of heteroskedasticity, with a p-value of 0.1559. These results confirm the reliability of the model results. Based on the CUSUM and CUSUM of Squares tests presented in Figure 3.1, the ARDL–ECM model meets the parameter stability condition at the 5% significance level. Accordingly, both the short-run and long-run estimates are considered reliable, and the model can be used to analyze economic–environmental impacts and derive policy implications.

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 35 Issue 2, 2025, Pages: 2127-2131

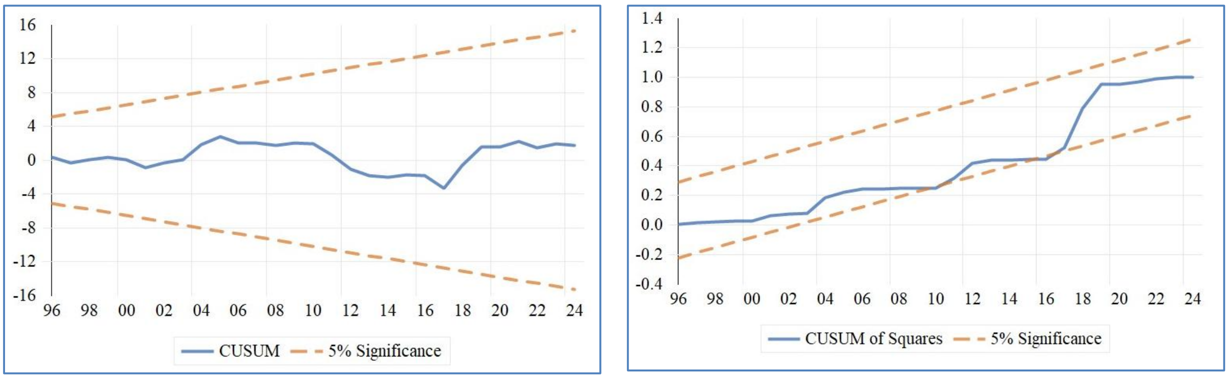

Figure 3.1. CUSUM and CUSUMSQ plots of the ARDL model

3.4. Discussion

Economic growth tends to raise greenhouse gas emissions, which is in line with the findings of Raihan Asif (2023) that per capita GDP moves in the same direction as emissions. This evidence reflects the "scale effect": when the economy expands, it extracts more energy and resources, and emissions increase as a result (Soumyananda Dinda, 2004). In Vietnam, the process of industrialization and modernization have helped the economy grow, but they have also increase per capita emissions upward (World Bank Group, 2022). At the same time, there is little evidence that environmental quality improves as income rises. Clean technologies have not yet reduced environmental pollution (Anh Tu Nguyen et al., 2021). Trade openness is related to increasing greenhouse gas emissions, which is in line with the findings by (Le Thi Thanh Mai et al., 2025) found. The study result showed a positive relationship between the agriculture production and greenhouse gas emissions. In Vietnam, agriculture accounted for approximately 28% of total national emissions in 2014, with rice cultivation is a major source of methane emissions (Dinh Thi Hai Van et al., 2025; Van Pham Dang Tri et al., 2023). These findings suggest that traditional farming practices, excessive use of chemical fertilizers, and inadequate livestock waste management continue to pose major challenges to achieving emission reduction targets.

4. Conclusion and policy implications

This study provides empirical evidence of a long-run cointegration relationship among greenhouse gas emissions, economic growth, trade openness, and agricultural production in Vietnam. The results indicate that, in the long run, economic growth, trade openness, and agricultural production lead to increasing greenhouse gas emissions. In contrast, the emission-reducing effects in the short run remain weak, despite a relatively fast adjustment toward long-run equilibrium.

These findings suggest that Vietnam's current growth pattern continues to exert to increase environmental quality, including within the agricultural sector. Accordingly, policy efforts should prioritize a transition toward a green growth model by improving resource-use efficiency, strengthening environmental standards in trade-related industries, and promoting the adoption of low-emission agricultural practices.

This study is subject to several limitations. First, it relies on time-series data at one country and a linear ARDL framework, which may not fully capture sector-specific dynamics. Second, the lack of detailed emission data for individual agricultural sub-sectors. Finally, the model does not account for potential non-linear effects or explicitly incorporate the roles of technology and institutional factors. These limitations point to important directions for future research.

References

Anh Tu Nguyen, Shih-Hao Lu, & Phuc Thanh Thien Nguyen. (2021). Validating and Forecasting Carbon Emissions in the Framework of the Environmental Kuznets Curve: The Case of Vietnam. *Energies*, *14*(11), 3144. https://doi.org/10.3390/en14113144

B&Company Inc. (2025). *Reducing greenhouse gas emissions in agriculture in Vietnam: Emerging technologies*. https://b-company.jp/reducing-greenhouse-gas-emissions-in-agriculture-in-vietnam-emerging-technologies/

Dinh Thi Hai Van, Nguyen Thi Kim Oanh, & Nguyen Thi Bich Yen. (2025). A Survey-Based Emission Inventory of Greenhouse Gases Released from Rice Production on Consolidated Land in the Red River Delta of Vietnam. *Atmosphere*, *16*(7), 794. https://doi.org/10.3390/atmos16070794

Le Thi Thanh Mai, Hoang-Anh Le, & Kim Taegi. (2025). The Effects of Trade Openness on CO2 Emission in Vietnam. *arXiv preprint*. https://arxiv.org/abs/2504.17260

Nguyen Phuong Thao. (2022). Carbon emissions versus value-added in export-driven countries: case of Vietnam. *Journal of Economic Structures*, *11*(1), 12. https://doi.org/10.1186/s40008-022-00272-w

Nguyen Thanh Phuc, Trang Thi Thuy Duong, & Nguyen Tran Thai Ha. (2025). U-shaped Relationship between Financial Development and Greenhouse Gases in Vietnam: ARDL Bound Test Approach [journal article]. *Polish Journal of Environmental Studies*. https://doi.org/10.15244/pjoes/196733

Nguyen Thi Kim Phuoc, L. T. T. L. (2023). Greenhouse gases emission tradeoffs to achieve financial efficiency value from chili and green mustard cultivation in Hon Dat District, Kien Giang Province, Vietnam. *Can Tho*

University Journal of Science, *59*(CĐ Môi trường & Biến đổi khí hậu), 42-53. https://doi.org/10.22144/ctu.jvn.2023.105

Nsor-Ambala, R., & Amewu, G. (2023). Linear and non-linear ARDL estimation of financial innovation and economic growth in Ghana. *Journal of Business and Socio-economic Development*, *3*(1), 36-49. https://doi.org/10.1108/jbsed-09-2021-0128

OECD. (2025). *OECD Economic Surveys: Viet Nam 2025*. https://doi.org/10.1787/fb37254b-en

Pesaran, M. H., & Shin, Y. (1999). An Autoregressive Distributed-Lag Modelling Approach to Cointegration Analysis. In S. Strøm (Ed.), *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium* (pp. 371-413). Cambridge University Press. https://doi.org/DOI: 10.1017/CCOL521633230.011

Pham, M. H., Nguyen, A. T., & Le, P. T. (2022). The relationship between ghg emissions and economic growth in Vietnam. *Science & Technology Development Journal - Economics - Law and Management*. https://doi.org/10.32508/stdjelm.v6i1.802

Raihan Asif. (2023). An econometric evaluation of the effects of economic growth, energy use, and agricultural value added on carbon dioxide emissions in Vietnam. *Asia-Pacific Journal of Regional Science*, 1-32. https://doi.org/10.1007/s41685-023-00278-7

Soumyananda Dinda. (2004). Environmental Kuznets Curve Hypothesis: A Survey. *Ecological Economics*, *49*(4), 431-455. https://doi.org/https://doi.org/10.1016/j.ecolecon.2004.02.011

Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. (2013). *Using multivariate statistics* (Vol. 6). pearson Boston, MA.

Van Pham Dang Tri, Phan Ky Trung, Nguyen Tan Loi, Surajit Ghosh, & Bunyod Holmatov. (2023). *Greenhouse Gas Emission Assessment Methods in the AFOLU, Data Sources and Reporting Processes in Vietnam*. https://mekong.ctu.edu.vn/en/images/hinh_l/14Feb2024_GHG_Emission_Assessment_Methods_Data_Sources_and_Reporting_Processes_in_Vietnam_Revised.pdf

World Bank Group. (2022). *Vietnam Country Climate and Development Report* (CCDR Series, Issue. https://hdl.handle.net/10986/37618