

Dynamic Analysis of The Relationship Between Renewable Energy and Environmental Sustainability in Algeria During the Period 2005-2020

- Econometric Study Using VAR Model -

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Submission date : 19/12/2024 Acceptance date: 23/11/2025 Published date : 31/01/2026

Abstract:

This study explores the relationship between renewable energy exploitation, represented by renewable energy production capacity, and environmental sustainability, represented by greenhouse gas emissions in Algeria, using the Vector Autoregression (VAR) model for the period from 2005 to 2020. The research aims to assess the impact of renewable energy exploitation on reducing greenhouse gas emissions, with a particular focus on statistical tests and model dynamics. The results indicate that greenhouse gas emissions are primarily influenced by their past values, while the relationship with renewable energy exploitation remains weak, as the findings show that renewable energy exploitation does not have a direct impact on greenhouse gas emissions in Algeria.

Keywords: renewable energy, environmental sustainability, greenhouse gas emissions, Vector Autoregression (VAR) model.

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1 INTRODUCTION:

Environmental sustainability is a critical global priority, driven by challenges such as climate change, resource depletion, and ecological degradation. Achieving sustainability requires innovative energy solutions that balance environmental preservation with economic growth and social development. Renewable energy sources, including solar, wind, and hydropower, offer effective alternatives to fossil fuels, playing a key role in reducing greenhouse gas emissions, combating pollution, and mitigating the impacts of global warming.

In Algeria, renewable energy presents a significant opportunity due to the country's vast solar potential, favorable wind conditions, and strategic geographical position. These resources offer a pathway to diversify the energy mix, reduce dependence on fossil fuels, and align with international agreements like the Paris Agreement "L'Accord de Paris". Despite these advantages, Algeria faces challenges such as high initial costs, technological limitations, and regulatory barriers that hinder widespread adoption of renewable energy solutions.

This research addresses the key question: **How does the utilization of renewable energy influence environmental sustainability in Algeria?**

It is hypothesized that expanding renewable energy production capacity may contribute to improving environmental sustainability by reducing greenhouse gas emissions. It is further hypothesized that a relationship exists between renewable energy exploitation and environmental outcomes, with increased renewable energy capacity potentially helping to decrease environmental degradation, particularly through lower emissions.

1.1 Research Focus:

The focus of this study is to analyze the connection between renewable energy exploitation and environmental sustainability, specifically its impact on greenhouse gas emissions. By utilizing the Vector Autoregression (VAR) model, the study explores how variations in renewable energy production affect environmental indicators. Additionally, it aims to provide insights into how enhancing renewable energy capacity can foster better environmental outcomes in Algeria.

1.2 Study Approach:

A descriptive-analytical methodology is employed to assess the theoretical aspects of renewable energy and environmental sustainability. The research also integrates an econometric approach, using the VAR model to analyze the dynamic relationship between renewable energy exploitation and environmental sustainability over the period from 2005 to 2020.

2 Renewable Energy and Environmental Sustainability:

2.1 Renewable Energy:

2.1.1 Definition of Renewable Energy:

Renewable energy is energy obtained from natural sources that replenish themselves over time, such as sunlight, wind, water, and biomass. Unlike fossil fuels, these sources are inexhaustible, clean, and have a significantly lower environmental impact (Boyle, 2004, pp. 3-4).

2.1.2 Key Environmental Benefits:

Green energy plays a crucial role in addressing environmental challenges by utilizing renewable resources and adopting sustainable practices that minimize ecological impact. The main benefits include:

- **Climate Change Mitigation:** Renewable energy significantly reduces greenhouse gas emissions (CO₂, CH₄, etc.) by replacing fossil fuel-based energy sources. This helps combat global warming and climate change (Owusu & Asumadu-Sarkodie, 2016, pp. 917-918).
- **Ecosystem Preservation:** Clean energy production minimizes pollutants, thereby protecting biodiversity and ensuring the health of ecosystems. Reduced emissions mean healthier plants, animals, and overall biodiversity conservation (Panwar, Kaushik, & Kothari, 2011, pp. 1514-1515).
- **Resource Conservation:** Renewable sources reduce reliance on finite resources, ensuring that energy production remains sustainable. This prevents resource depletion and extends the longevity of natural reserves (Tester, Drake, Driscoll, Golay, & Peters, 2005, pp. 16-17).
- **Public Health Improvement:** Cleaner air and water result from less pollution, leading to fewer health problems caused by respiratory and waterborne diseases. This has a direct positive impact on public health (Fthenakis & Kim, 2011, pp. 1610-1611).

2.2 Environmental Sustainability:

2.2.1 Concept of Environmental Sustainability:

Environmental sustainability is the responsible management of natural resources to meet present needs without compromising future generations' ability to meet theirs. It combines ecological preservation with economic progress and social development (Goodland & Daly, 1996, pp. 1002-1003).

2.2.2 Key Principles of Environmental Sustainability:

- **Ecosystem Integrity:** Maintaining the balance of ecosystems ensures vital functions such as carbon sequestration, water purification, and nutrient cycling, which are crucial for environmental stability (Daly, 1990, pp. 2-3).
- **Intergenerational Equity:** Ensuring that natural resources remain accessible for future generations through responsible and sustainable practices, such as conservation and clean energy initiatives (Goodland & Daly, 1996, pp. 1005-1006).
- **Resource Efficiency:** Encouraging sustainable consumption and production practices to reduce waste, optimize resource use, and promote efficiency (Boyle, 2004, pp. 6-7).
- **Pollution Mitigation:** Reducing harmful emissions and waste discharges to protect ecosystems, biodiversity, and human health, ensuring a cleaner environment (Tester, Drake, Driscoll, Golay, & Peters, 2005, pp. 18-19).

2.2.3 Indicators of Sustainability:

- **Greenhouse Gas Emissions:** Measuring CO₂ reductions and their impact on global warming. (Owusu & Asumadu-Sarkodie, 2016, pp. 919-920)
- **Air and Water Quality:** Assessing pollutants and their effects on ecosystems and human health (Panwar, Kaushik, & Kothari, 2011, pp. 1516-1517).
- **Biodiversity Indicators:** Evaluating species diversity and conservation efforts to maintain ecological balance.
- **Energy Transition Metrics:** Monitoring the integration rate of renewable sources into national and regional energy mixes.

3 Challenges and Strategies in Renewable Energy Utilization:

Renewable energy adoption faces many challenges, and overcoming them requires effective strategies and collaboration for successful integration.

3.1 Challenges in Renewable Energy Utilization:

Despite the environmental and social benefits, renewable energy faces several challenges:

- **Intermittency of Supply:** Renewable energy sources like solar and wind are dependent on weather conditions, which can vary. This intermittency requires the development of energy storage solutions, such as batteries, to maintain a stable supply of energy (Panwar, Kaushik, & Kothari, 2011, pp. 1518-1519).
- **Economic Barriers:** Developing countries, including Algeria, face high upfront costs for renewable energy infrastructure. The cost of manufacturing, transportation, and installation of solar panels and wind turbines can be substantial.
- **Land Use Impact:** Large-scale installations (solar farms, wind farms) can result in habitat fragmentation, displacing species and altering local ecosystems. Strategies are needed to minimize these environmental impacts, such as eco-sensitive planning (Fthenakis & Kim, 2011, pp. 1612-1613).
- **Technological and Policy Constraints:** Many countries lack advanced renewable energy technologies and have insufficient regulatory frameworks. This slows down integration efforts, requiring investments in research, development, and supportive legislation.

3.2 Strategies to Address Renewable Energy Challenges:

To align renewable energy initiatives with sustainability goals, effective strategies include:

- **Sustainable Design and Planning:** Projects should be designed to minimize land use impacts and protect biodiversity. Eco-sensitive planning can reduce ecological

disturbances and habitat loss (Tester, Drake, Driscoll, Golay, & Peters, 2005, pp. 19-20).

- **Recycling and Circular Economy Innovations:** Developing advanced recycling systems for components like solar panels and turbine blades can reduce waste and prevent hazardous materials from contaminating the environment (Fthenakis & Kim, 2011, pp. 1615-1616).
- **Collaborative Governance and Policy Support:** Governments should create policies that encourage investment in renewable energy projects. This includes incentives like subsidies, tax credits, and support for technological research and innovation.
- **International Collaboration and Technology Transfer:** Facilitating global cooperation allows countries to share knowledge, exchange technologies, and implement best practices, accelerating the transition to sustainable energy solutions (Panwar, Kaushik, & Kothari, 2011, pp. 1522-1523).

By combining these principles, challenges, and strategies, Algeria and other nations can harness renewable energy more efficiently, ensuring sustainable ecological outcomes and contributing significantly to global sustainability objectives.

4 Econometric Study:

This study examines the dynamic relationship between clean energy utilization and environmental sustainability in Algeria during the period 2005–2020. It seeks to understand how the shift to sustainable energy sources affects greenhouse gas emissions and supports the country's sustainability objectives.

4.1 The tools and variables of the econometric study:

The analysis focuses on Total Greenhouse Gas Emissions (TOTAL_GHG) as the dependent variable and production capacity from alternative energy sources (REC) as the independent variable. Annual data from 2005 to 2020, sourced from IPCC and IRENA, covers a pivotal era in Algeria's energy transition initiatives.

A Vector Autoregressive (VAR) model is employed to capture the temporal dynamics between these variables. This statistical approach reveals how changes in clean power generation impact emissions over time. By incorporating lagged values, the model highlights the evolving interplay between energy production and environmental outcomes.

The findings underline the growing significance of clean energy adoption in reducing greenhouse gas emissions, emphasizing the need for technological advancements and supportive policies to maximize its environmental benefits.

4.2 The results of the econometric study:

The results of the econometric study provide valuable insights into the relationships between key variables, offering a clearer understanding of trends and patterns. These findings help inform decision-making and guide future research in the field.

4.2.1 Analytical Study of the Evolution of Renewable Energy Production Capacity and Greenhouse Gas Emissions in Algeria (2005–2020):

The analysis of the relationship between renewable energy development and environmental sustainability requires, first, a descriptive and analytical assessment of the evolution of the key variables over time. This section therefore presents an analytical overview of the evolution of renewable energy production capacity and greenhouse gas (GHG) emissions in Algeria between 2005 and 2020, highlighting the main trends and preliminary relationships between them.

- **Renewable Energy Production Capacity:**

The renewable energy production capacity in Algeria experienced uneven development during the period from 2005 to 2020. The early years (2005–2012) were marked by a state of stability and stagnation, with capacity fluctuating between 230 and 277 megawatts, without any significant increase. This reflects the weakness of investments in the sector during that phase. However, the production trend began to shift gradually after 2013, with early signs of slight growth in installed capacity, before witnessing a sharp jump in 2015 when it rose from 265 to 537 megawatts—more than doubling within a single year. This shift likely reflects the commissioning of new renewable energy projects or the implementation of a segment of the National Renewable Energy and Energy Efficiency Program (2011–2030), which marked a turning point in Algeria’s energy strategy. The upward trend continued in a more stable manner between 2016 and 2018, reaching around 686 megawatts in both 2019 and 2020, where it plateaued, indicating a relative halt in the expansion of production capacity toward the end of the studied period. Despite these developments, renewable energy still represents a modest share of total electricity generation, reflecting the dominance of fossil fuels in Algeria’s energy structure.

- **Greenhouse Gas Emissions:**

During the same period, greenhouse gas emissions in Algeria followed a fluctuating but generally upward trend. Emissions increased from around 146 thousand tons of CO₂ equivalent in 2005 to about 186 thousand tons in 2010, continuing to rise gradually to approximately 198 thousand tons by 2013. A significant increase was observed thereafter, with emissions reaching 213 thousand tons in 2014 and continuing to climb until hitting their peak in 2019 at nearly 230 thousand tons. In 2020, emissions declined for the first time to around 220 thousand tons — a decrease that may be partially attributed to the slowdown in economic and industrial activities resulting from the global COVID-19 pandemic, making this change more circumstantial than structural.

This overall pattern suggests that while Algeria made initial progress in deploying renewable energy, its impact on emissions reduction remained limited within the study period due to the modest contribution of renewables to the national energy mix and the persistent reliance on hydrocarbons. (See Appendix 01)

- **Comparative Analysis and Preliminary Relationship:**

A comparative examination of the two variables reveals that the increase in renewable energy production capacity has not been immediately accompanied by a substantial reduction in GHG emissions. Despite the doubling of renewable energy capacity between 2005 and 2020, emissions continued to rise for most of the study period, indicating that the environmental

benefits of renewable energy exploitation in Algeria remain limited. The slight decrease observed in 2020 cannot be primarily attributed to renewable energy expansion, but rather to the global economic slowdown caused by the COVID-19 pandemic, which led to a temporary reduction in industrial activity and energy consumption. This decline should therefore be considered an exceptional and circumstantial occurrence, rather than a structural improvement in environmental performance. To achieve sustained reductions in emissions, a deeper integration of renewable energy sources into the national energy system and a gradual reduction of reliance on conventional energy sources are required.

Therefore, to further explore the dynamic linkages identified in this analytical assessment, the following section employs a Vector Autoregression (VAR) model to empirically investigate the interactions and causal relationships between renewable energy development and environmental sustainability in Algeria .

4.2.2 Testing the Stationarity of Time Series Variables:

Stationarity is a critical property of time series data where statistical measures, including mean, variance, and autocorrelation, remain constant over time. Ensuring stationarity is essential for reliable results, particularly when employing Vector Autoregression (VAR) models, as non-stationary data can lead to spurious outcomes. (lütkepohl, 2005, p. 25)

The results indicated that total greenhouse gas emissions and renewable energy production capacity were non-stationary in their levels, as their probability values exceeded the 5% significance threshold, signifying the presence of unit roots. To achieve stationarity, differencing was employed: total greenhouse gas emissions became stationary after the first difference, classifying it as integrated of order one I (1). In contrast, renewable energy production capacity required differencing twice to attain stationarity, making it integrated of order two I (2). (See Appendix 02)

4.2.3 Optimal Lag Selection:

The appropriate lag length is determined to capture the dynamic relationships between variables without overfitting the model. Selecting optimal lags ensures that the model effectively represents temporal dependencies and interactions among variables. (Braun & Mitnik, 1993)

All criteria identified one lag period as optimal, providing a robust foundation for model estimation and ensuring that the dynamics of unemployment and renewable energy production are effectively captured. (See Appendix 03)

4.2.4 Evaluating the Relationship Between Greenhouse Gas Emissions and Renewable Energy Production Capacity Using the VAR Model:

This analysis investigates the interaction between total greenhouse gas emissions (TOTAL_GHG) and renewable energy production capacity (REC) using a Vector Autoregressive model with a single lag VAR (1). In this model:

$$Total_GHG = Total_GHG(-1) + C_2 \times REC(-1) + C_3$$

$$REC = C_4 \times Total_GHG(-1) + C_5 \times REC(-1) + C_6$$

The estimated model using the Ordinary Least Squares (OLS) method highlights the impact of renewable energy exploitation on greenhouse gas emissions in Algeria, with a focus on the relationship between renewable energy capacity (REC) and total greenhouse gas emissions (TOTAL_GHG):

$$Total_GHG = 0.974068 \times Total_GHG(-1) - 17.77171 \times REC(-1) + 15954.73$$

Statistical and Economic Evaluation:

- **Statistical Significance:**
The lagged greenhouse gas emissions variable TOTAL_GHG (-1) demonstrates statistical significance, indicating a persistent and substantial influence on current emission levels. In contrast, the lagged renewable energy production variable REC (-1) and the constant term lack statistical significance at the 5% level.
- **Elasticity Analysis:**
The coefficient for TOTAL_GHG (-1) is 0.974068, signifying a near-proportional relationship between past and current emissions. A 1% increase in emissions in the prior year corresponds to an approximate 0.974% rise in the current year.
- **Coefficient of Determination (R²):**
The model's R² value of 0.9305 demonstrates a high explanatory power, accounting for 93.05% of the variation in greenhouse gas emissions.
- **Findings and Insights:**
The analysis confirms a notable persistence effect in greenhouse gas emissions. The limited statistical impact of renewable energy exploitation highlights the need for expanded deployment and integration of renewable technologies. (See Appendix 04)

4.2.5 Model Stability Analysis:

Stability assessment in the Vector Autoregression (VAR) model involves examining the eigenvalues of the companion matrix to determine whether they fall within the unit circle. This is a critical condition to ensure system stability, which guarantees the validity and consistency of the model's results over the sample period. (Hamilton, 1994, p. 260)

The stability of the VAR model was confirmed using eigenvalue analysis. All eigenvalues lie within the unit circle, ensuring the model's reliability and consistent parameter estimation. (See Appendix 05)

4.2.6 Diagnostic Tests for the Estimated Model:

Diagnostic tests for the estimated model assess its validity and reliability, identifying issues like misspecification or multicollinearity to ensure robust results.

4.2.6.1 Test for Autocorrelation in Residuals:

This test checks whether residuals are uncorrelated over time. Uncorrelated residuals ensure the model accurately captures variable relationships without systematic errors.

The LM test showed a p-value greater than 0.05, confirming the absence of significant autocorrelation and validating the model's ability to represent the data's dynamics. (See Appendix 06)

4.2.6.2 Test for Heteroscedasticity in Residuals:

Heteroscedasticity occurs when residual variance is not constant, potentially biasing parameter estimates.

A Chi-square test indicated no evidence of heteroscedasticity ($p > 0.05$), ensuring consistent residual variance across observations and supporting the model's reliability and robustness. (See Appendix 07)

4.2.7 Analysis of Model Dynamics:

4.2.7.1 Causality Test:

the Granger causality test was employed to determine whether renewable energy production (REC) exerts a causal influence on greenhouse gas emissions (TOTAL_GHG).

The test operates based on the following criteria:

- A p-value < 0.05 indicates a causal relationship.
- A p-value > 0.05 suggests no evidence of causality.

The results of the Granger causality test showed no significant causal relationship between renewable energy production and greenhouse gas emissions ($p > 0.05$). This outcome implies that, within the examined timeframe, renewable energy exploitation does not directly impact emission levels. (See Appendix 08)

4.2.7.2 Impulse Response Functions (IRF):

The Impulse Response Functions (IRF) evaluate the dynamic effects of a one-standard-deviation shock in one variable on another over time, offering insights into the temporal interactions between renewable energy exploitation (REC) and greenhouse gas emissions (TOTAL_GHG).

a) Response of TOTAL_GHG to Its Own Shock

- The analysis reveals that TOTAL_GHG exhibits a positive response to its own previous shocks during the short and medium term.
- This response follows a declining trend, gradually dissipating by the sixth period, indicating that past emissions have a temporary but notable influence on future emission levels before their impact fades.

b) Response of TOTAL_GHG to REC Shock

- The immediate response of TOTAL_GHG to a shock in REC is negligible, showing no significant change in the first time period.
- Over subsequent periods, the response becomes slightly negative but remains weak overall. (See Appendix 09)

4.2.7.3 Variance Component Analysis (VCA):

Variance Component Analysis (VCA) serves as a statistical approach to break down total variance in a dataset into its contributing factors. In this study, it is applied to explore the extent

to which renewable energy production (REC) and other variables influence variability in greenhouse gas emissions (TOTAL_GHG).

Variance Analysis Results:

- Immediately following a shock in renewable energy production, REC contributes 0% to the variance in TOTAL_GHG.
- This lack of initial effect suggests no measurable impact of renewable energy production on greenhouse gas emissions in the very short term.
- By the second period, REC accounts for 0.63% of the variance in TOTAL_GHG.
- Over time, this contribution grows, reaching 11.91% by the tenth period. This progression highlights a delayed yet increasing influence of renewable energy production on emission variability. (See Appendix 10)

The findings highlight the growing yet limited role of renewable energy in mitigating greenhouse gas emissions, emphasizing the necessity of fostering technological innovation and adopting supportive policies to achieve more effective environmental outcomes.

5 Conclusion:

Alternative energy sources are essential for curbing greenhouse gas emissions and advancing environmental sustainability. However, their current impact in Algeria is constrained by economic, technological, and policy-related barriers. Addressing these issues is crucial to unlocking the environmental and developmental benefits of clean energy, fostering social and economic growth, and achieving sustainable development goals. Ultimately, renewable energy systems represent a fundamental pathway toward environmental sustainability, economic resilience, and broader social advancement.

The applied analysis of the relationship between renewable energy production capacity and environmental sustainability in Algeria, based on the VAR model, yielded the following key results:

Impulse Response Analysis:

- Greenhouse gas emissions (TOTAL_GHG) respond positively to their own shocks in the short and medium term, indicating a temporary influence of past emissions on future levels before dissipating.
- The response of TOTAL_GHG to shocks in renewable energy production (REC) is initially negligible but becomes slightly negative over time, demonstrating the limited yet emerging role of renewable energy in mitigating emissions.
- The immediate impact of renewable energy production on reducing greenhouse gas emissions is limited, with its effect becoming more pronounced in the long term.

Variance Component Analysis (VCA):

- In the initial periods, renewable energy production contributes minimally to the variability in greenhouse gas emissions.
- Over time, the contribution of REC grows, accounting for approximately 11.91% of the variance in TOTAL_GHG by the tenth period. This finding underscores a delayed but increasing influence of renewable energy on environmental outcomes.

- The findings suggest that the current contribution of renewable energy in Algeria remains modest, constrained by technological, economic, and policy barriers.

The analysis emphasizes the need for:

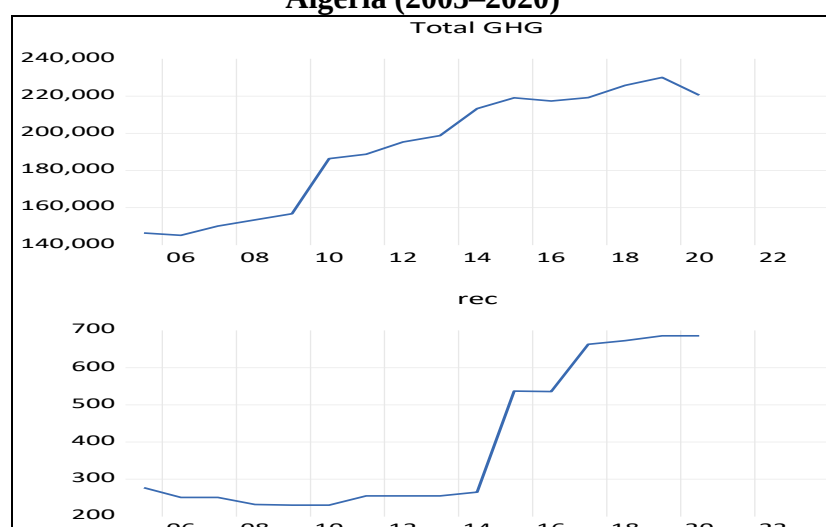
- Advancing renewable energy technologies to enhance efficiency and scalability.
- Strengthening policy frameworks to support the adoption and integration of renewable energy.
- Addressing economic and infrastructure barriers to fully leverage renewable energy's potential in achieving environmental sustainability.
- Promoting international cooperation for knowledge sharing.

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7 Appendixes

Appendix 01: Trends in Renewable Energy Capacity and Greenhouse Gas Emissions in Algeria (2005–2020)



Source: Outputs generated by the author through the application of the software

Appendix 02: Results of the Phillips-Perron Test for the Two Variables

Time series	Type	Unit Root Test Phillips Perron					
		Level		1st difference		2 nd difference	
		T-statistic	Prob	T-statistic	Prob	T-statistic	Prob
REC	Trend and Intercept	-1.9904	0.5672	-3.0364	0.1515	-6.0128	0.001
	Intercept	-0.5465	0.8598	-3.1642	0.0406	-6.2823	0.0001
	None	0.7982	0.8762	-2.9952	0.0052	-6.5823	0.0000
TOTAL_GHG	Trend and Intercept	-1.1121	0.8915	-4.4304	0.0180	-	-
	Intercept	-1.1903	0.6492	-3.5189	0.0239	-	-
	None	1.9637	0.9829	-2.6178	0.0130	-	-

Source: Outputs generated by the author through the application of the software

Appendix 03: Criteria for Determining Optimal Lag Lengths

Included observations: 15						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-266.7890	NA	1.26e+13	35.83853	35.93294	35.83753
1	-234.7985	51.18482*	3.04e+11*	32.10647*	32.38969*	32.10345*

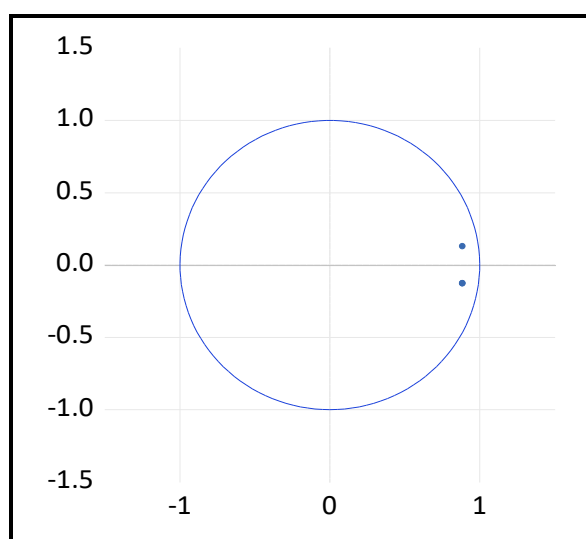
Source: Outputs generated by the author through the application of the software

Appendix 04: Estimation Results of Model Parameters Using the Ordinary Least Squares Method

Included observations: 16				
Total system (unbalanced) observations 31				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.974068	0.099904	9.750077	0.0000
C(2)	-17.77171	21.34794	-0.832479	0.4130
C(3)	15954.73	15056.67	1.059646	0.2994
C(4)	0.001415	0.000660	2.145313	0.0418
C(5)	0.732359	0.133835	5.472108	0.0000
C(6)	-161.2034	99.38149	-1.622066	0.1173
Determinant residual covariance		1.52E+11		
Equation: TOTAL_GHG = C(1)*TOTAL_GHG(-1) + C(2)*REC(-1) + C(3)				
Observations: 15				
R-squared	0.930584	Mean dependent var	194680.5	

Source: Outputs generated by the author through the application of the software

Appendix 05: Results of the Model Stability Test



Source: Outputs generated by the author through the application of the software

Appendix 06: Results of the Autocorrelation Test for the Residuals Series

Included observations: 15						
Null hypothesis: No serial correlation at lag h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	3.669285	4	0.4526	0.958629	(4, 18.0)	0.4538
2	1.142154	4	0.8875	0.278806	(4, 18.0)	0.8878
3	1.917414	4	0.7509	0.477829	(4, 18.0)	0.7516
4	3.294854	4	0.5097	0.852109	(4, 18.0)	0.5109

Source: Outputs generated by the author through the application of the software

Appendix 07: Results of the Heteroscedasticity Test for the Residuals Series

Included observations: 15		
Joint test:		
Chi-sq	df	Prob.
12.53249	12	0.4039

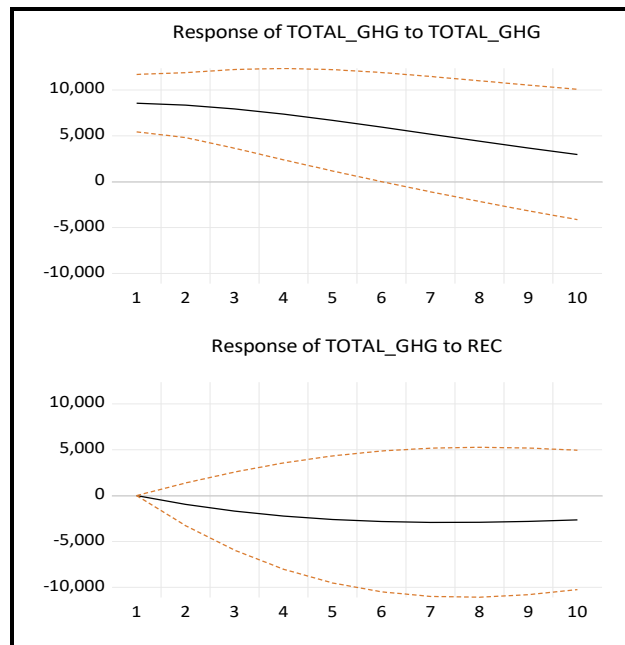
Source: Outputs generated by the author through the application of the software

Appendix 08: Results of the Causality Test

Included observations: 15			
Dependent variable: TOTAL_GHG			
Excluded	Chi-sq	df	Prob.
REC	0.693022	1	0.4051
All	0.693022	1	0.4051

Source: Outputs generated by the author through the application of the software

Appendix 09: Results of the Impulse Response Functions



Source: Outputs generated by the author through the application of the software

Appendix 10: Results of the Variance Decomposition Analysis

Period	S.E.	TOTAL_GHG	REC
1	8557.805	100.0000	0.000000
2	11991.50	99.36601	0.633992
3	14475.19	98.19785	1.802151
4	16392.35	96.73714	3.262857
5	17894.64	95.14647	4.853532
6	19068.30	93.53597	6.464033
7	19974.32	91.98097	8.019027
8	20661.67	90.53305	9.466946
9	21172.08	89.22664	10.77336
10	21541.86	88.08285	11.91715
Cholesky Ordering: TOTAL_GHG REC			

Source: Outputs generated by the author through the application of the software