Int. J. Renew. Energy Dev. 2024, 13 (6), 1015-1024

Contents list available at CBIORE journal website

International Journal of Renewable Energy Development

Journal homepage: https://ijred.cbiore.id

Research Article

Impact of green trade on green growth in Malaysia: A dynamic ARDL simulation

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Abstract. Green economic growth emphasizes developing an economy that safeguards natural resources, enhances resource capabilities, and promotes sustainable resource utilization. This approach is vital for balancing economic development with environmental preservation, highlighting the efficient and sustainable use of renewable and non-renewable resources to maintain a clean environment and societal well-being. It also stresses the long-term preservation of natural resources for green growth and prosperity. Environmental sustainability is key for economic growth, as poor sustainability can lead to economic decline due to inefficient resource use. The Eleventh Malaysia Plan highlights the importance of green economic growth, focusing on areas such as creating a supportive environment for green growth, adopting sustainable consumption and production practices, conserving natural resources, and strengthening resilience against climate change and natural disasters. This study examines the impact of natural resource use on the green economic growth in Malaysia from 1990 to 2021, with a focus on green trade as a key component. To achieve this objective, this study utlizies the Autoregressive Distributed Lag (ARDL) method and also its extension, the Dynamic ARDL (DYNARDL). Estimation results for both model indicate that green trade has a significant long run positive impact on green economic growth. While for short run, only DYNARDL method found evidence for positive impact of green trade. These findings suggest that policymakers should further promote green trade as a means to enhance sustainable and equitable resource use, thereby supporting the growth of the green economy in Malaysia.

Keywords: Green trade, green growth, dynamic ARDL, simulations.

Received: 16th June 2024; Revised: 19th August 2024; Accepted: 5th Sept 2024; Available online: 20th Sept 2024

1. Introduction

Green economic growth focuses on developing an economy that simultaneously protects natural resources, enhances resource capabilities, and promotes sustainable utilization. In Malaysia, this approach is crucial for balancing economic development with environmental preservation. It emphasizes the efficient and sustainable use of both renewable and non-renewable resources to maintain a clean and healthy environment for societal well-being. Furthermore, green economic growth prioritizes the preservation of natural resources to ensure long-term prosperity. Environmental sustainability is crucial for economic growth, as inadequate environmental sustainability can lead to decline due to inefficient resource use. Thus, green economic growth is essential for enhancing environmental quality.

The Eleventh Malaysia Plan underscores the importance of green economic growth in Malaysia, delineating four main focus areas: fortifying the supportive environment for green growth, adopting sustainable consumption and production practices, conserving natural resources for current and future generations, and strengthening resilience against climate change and natural disasters (Mid-Term Review of the Eleventh Malaysia Plan 2016-2017, 2018). The aim is to reduce fossil fuel usage, particularly in the construction sector, improve energy efficiency, promote conservation, and ensure equitable benefits from natural resources while mitigating the impacts of climate change.

In addition to these strategic focus areas, Malaysia has promoted green trade to advance environmental sustainability. Green trade refers to environmentally friendly activities that do not harm the environment, including the exchange of clean energy, green products, and services. Effective implementation requires strong commitment from the community, businesses, and government. On a global scale, various international organizations support green trade as a strategy for economic growth that protects the environment and benefits economies (Brandi *et al.*, 2020; Wei *et al.*, 2023). The World Trade Organization (WTO) highlighted in 2023 that green trade initiatives help developing countries maximize the benefits of international trade while contributing to sustainable development (World Trade Organization, 2023).

While green trade is essential, economic growth in Malaysia also presents significant challenges. Economic growth, a fundamental indicator, affects several interrelated factors (Chendrawan, 2017). It brings changes, particularly in the

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https://doi.org/10.61435/ijred.2024.60413
ISSN: 2252-4940/© 2024.The Author(s). Published by CBIORE

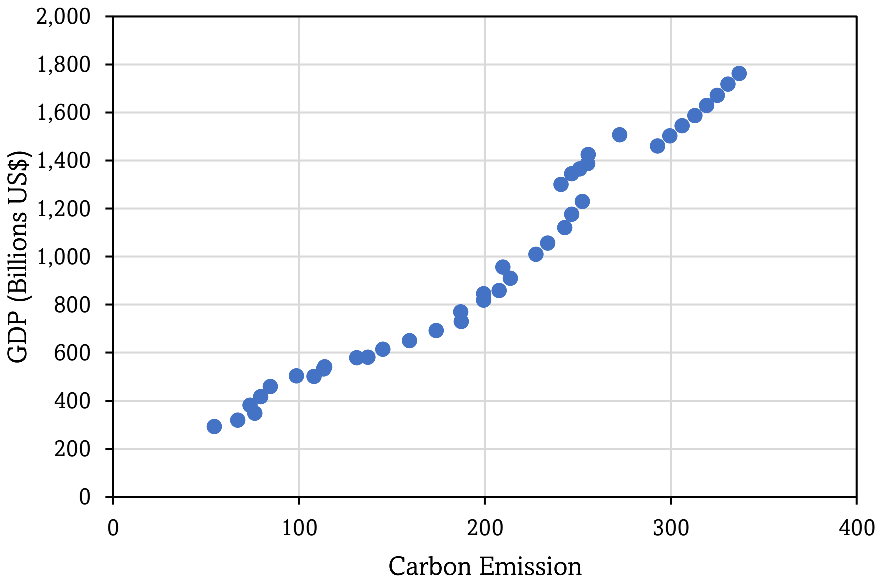

Fig 1 Carbon Emissions and GDP in Malaysia
Source: Energy Institute (2024), World Bank (2024)

production of goods and services, leading to technological advancements that utilize various natural resources. However, this growth often results in environmental degradation due to unsustainable resource use. Therefore, green economic growth encourages the sustainable use of resources in production.

Environmental degradation is frequently linked to poor air quality, largely due to greenhouse gas emissions from non-renewable sources like oil and coal (Tietenberg & Lewis, 2023). According to the National Atmospheric and Oceanic Administration (2024), carbon dioxide emissions peak annually in May, contributing to climate change and global temperature increases. The Intergovernmental Panel on Climate Change (IPCC) 2018 report warns that climate change will worsen if Earth's temperature exceeds 1.5 degrees Celsius above pre-industrial levels (Reddy, 2021).

In response to global climate shifts, many countries, including Malaysia, have set Net Zero Carbon targets. For instance, Malaysia recorded greenhouse gas emissions of 334 MTCO2e in 2016 and is pursuing these targets (Chan & Sopian, 2022). Despite efforts, challenges remain in reducing carbon emissions, and research has yet to confirm that the desired carbon removal quantities can be achieved as projected by developed countries (Kaya *et al.*, 2019). This is evident in the intensity of carbon dioxide emissions in Malaysia.

A vast body of literature has focused on climate change, its impacts, and mitigation strategies. For instance, Martín-Ortega *et al.* (2024) emphasize the importance of transparency in greenhouse gas mitigation efforts, while Tsepi *et al.* (2024) provide insights into the role of environmental policies in reducing CO2 emissions. Similarly, studies by Losada-Puente *et al.* (2023) and Yassine *et al.* (2024), offer valuable perspectives on the role of policy and community efforts in mitigating emissions, further supporting the arguments presented in this paper.

Given these challenges, this research has significant implications for policymakers, academics, and the private sector. For policymakers, it offers insights to strengthen policies that ensure sustainable resource use, maintain reserves for future generations, and restore environmental quality, aligning with the National Environmental Policy (Department of Environment, 2023). From 1990 to 2021, GDP growth in Malaysia has correlated with increased environmental degradation (Figure 1). Therefore, this study provides valuable input for improving environmental policies.

For academics, this research enhances the understanding of green economic growth and encourages further studies, generating new ideas to achieve sustainable goals. For the private sector, it underscores their crucial role in supporting government efforts and engaging society in green economic growth. This research also examines whether renewable resources can reduce carbon dioxide emissions, focusing on the relationship between resource use and green economic growth in Malaysia.

In brief, understanding the dynamics of green economic growth is crucial. This study contributes a novel perspective by employing the Dynamic ARDL simulation method to explore the intricate relationship between green trade, natural resources, and green economic growth in Malaysia. The Dynamic ARDL method enables the simulation of the impact of increased green trade on future economic growth. By integrating green trade into the analysis alongside traditional factors such as oil and gas reserves, this research provides a comprehensive assessment of both short-term and long-term impacts on sustainable economic growth.

The findings are also applicable to other emerging economies facing similar challenges in balancing economic development with environmental sustainability. The methodological approach and results provide a valuable framework for policymakers and researchers aiming to promote green economic growth in resource-dependent economies. By exploring the interconnections between economic growth, environmental sustainability, and resource management, this research contributes to the broader discourse on sustainable development and informs strategies that can support Malaysia's transition to a greener economy.

2. Literature Review

The concept of green trade and green growth has gained significant attention in recent years as countries strive to balance economic development with environmental sustainability. Green trade refers to environmentally friendly practices that minimize ecological harm, including the exchange of clean energy, green products, and services (Mahajan *et al.*, 2023; Wei *et al.*, 2023). Green growth, on the other hand, emphasizes economic growth that preserves natural resources and promotes sustainable utilization (Smulders *et al.*, 2014). This review explores existing research on the interrelationship and impact of green trade and green growth on economic and environmental sustainability.

Green trade involves the trade of goods and services that contribute to environmental sustainability, such as renewable energy, energy-efficient products, and eco-friendly technologies (Wei *et al.*, 2023). Theoretical perspectives suggest that green trade can drive economic growth while reducing environmental degradation by encouraging sustainable practices (Porter & Linde, 1995). The Environmental Kuznets Curve (EKC) hypothesis posits that economic growth initially leads to environmental degradation, but as income levels rise, societies invest more in environmental protection, leading to improved environmental quality (Grossman & Krueger, 1995; Sarkodie & Strezov, 2019). This hypothesis supports the notion that green trade can foster a transition toward sustainable development.

Empirical studies on green trade and economic growth have produced mixed results. Some research indicates that green trade positively impacts economic growth by creating new markets for green products and technologies (Pereira & Andraz, 2013). For instance, Li *et al.* (2022) found that green trade significantly contributed to economic growth in China by enhancing energy efficiency and reducing carbon emissions. Conversely, other studies suggest that the benefits of green trade may be offset by high initial costs and market barriers, particularly in developing countries (Mahajan *et al.*, 2021). This highlights the need for supportive policies and international cooperation to overcome these challenges.

Green growth policies aim to integrate economic and environmental objectives, promoting sustainable development through regulatory measures, incentives, and public awareness campaigns (Hussain *et al.*, 2022; Smulders *et al.*, 2014). The Eleventh Malaysia Plan, for example, outlines strategies to enhance sustainability and resilience through green growth, focusing on areas such as sustainable consumption and production, conservation of natural resources, and climate change adaptation (Ministry of Economics, 2018). Effective implementation of green growth policies requires strong institutional frameworks, stakeholder engagement, and robust monitoring and evaluation mechanisms (Nhamo & Nhamo, 2014).

While green trade and green growth offer significant opportunities for sustainable development, several challenges must be addressed, including high transition costs, technological barriers, and the need for substantial investment in green infrastructure (Sachs *et al.*, 2019). Additionally, there is a lack of standardized metrics and indicators to measure the effectiveness of green trade and green growth initiatives (Li *et al.*, 2022). Opportunities for advancing green trade and green growth lie in international cooperation, innovation, and the development of green finance mechanisms to support sustainable projects (Cheng *et al.*, 2023).

Case studies from various regions provide insights into the implementation and outcomes of green trade and green growth strategies. For instance, the European Union's Green Deal aims to make Europe the first climate-neutral continent by 2050, promoting green trade and green growth through a comprehensive policy framework (Ossewaarde & Ossewaarde-Lowtoo, 2020). In Asia, countries like China and Japan have adopted green growth strategies focusing on energy efficiency, renewable energy, and sustainable urban development (Li *et al.*, 2022). These regional perspectives highlight the diverse approaches and contextual factors influencing the success of green trade and green growth initiatives.

Green economic growth inherently considers the sustainable use of resources to stabilize a country's economy. However, some countries are less inclined to use the concept of green growth to enhance their development. According to Khan *et al.* (2023), there is a negative relationship between natural resources and economic development in G-7 countries due to uncontrolled resource extraction leading to environmental degradation. Additionally, Gu *et al.* (2023) found that carbon dioxide emissions contribute to economic growth in G-7 countries, but globally, this has a detrimental impact on environmental quality. Furthermore, Wang *et al.* (2023) found a negative relationship between natural resources and green economic growth in Central Asian or BRI countries due to inefficient policy management, which increases the costs of resource use and environmental management.

Empirical research generally supports the positive impact of green trade on economic growth. Ahmed *et al.* (2022) concluded that green trade contributes to economic growth while mitigating environmental degradation. Huang and Zhao (2022) discovered that efficient resource utilization can substantially improve due to enhanced green growth in China's economy and the implementation of green trade policies. In Malaysia, several researchers have highlighted the successes and challenges in implementing green growth policies, emphasizing the role of green trade in promoting environmental sustainability (Asha'ari *et al.*, 2016; Kasayanond *et al.*, 2019). However, these studies do not specifically examine the impact of green trade on green economic growth, which includes both economic and environmental dimensions. Thus, this study aims to fill this gap by analyzing the long-term and short-term relationships between green trade and green economic growth in Malaysia from 1990 to 2021. Using the Dynamic ARDL simulation method, this research provides a more accurate and comprehensive understanding of how green trade influences green economic growth, highlighting the need for balanced and sustainable policy measures.

3. Methodology

This study evaluates the impact of green economic growth, green trade, and natural resources using two methods: the Autoregressive Distributed Lag (ARDL) Model and Dynamic ARDL Simulation. The ARDL method is employed to analyze both long-term and short-term relationships among all variables. Additionally, the Dynamic ARDL simulation provides a more accurate assessment of these relationships. The purpose of applying these methods is to detect and estimate the long-term relationship between natural resources and green economic growth. In evaluating natural energy resources, oil and gas reserves are used as proxies. Both methods aim to assess the relationship among three variables: green economic growth, green trade, and natural resources. Therefore, based on the study by Xu (2022), the determinants used to develop the evaluation and economic model are as follows:

$$\boldsymbol{GGDP = f(RG, RO, GT, EMP)} \quad (1)$$

Where GGDP represents green economic growth, RG and RO represent gas reserves and oil reserves, respectively and GT represents green trade. Therefore, the equations that constitute the econometric model can be expressed as follows:

$$GGDP_t = \theta_0 + \theta_1 RG + \theta_2 RO + \theta_3 GT + \theta_4 EMP + e_t \quad (2)$$

Where Θ_0 is the intercept and Θ_1 to Θ_4 are the coefficients of the independent variables. his study employs the Autoregressive Distributed Lag (ARDL) method. However, before implementing the ARDL method, several steps are necessary to determine whether the variables involved in this study can be effectively utilized. The first step is to conduct the VAR test, which helps determine the optimal lag length to ensure that the maximum lag is appropriate. The model for ARDL is expressed as follows:

$$\Delta GGDP_t = \alpha_0 + \sum_{i=1}^{p} \theta_1 \Delta GGDP_{t-i} + \sum_{i=0}^{q} \theta_2 \Delta GT_{t-i} + \sum_{i=0}^{r} \theta_3 \Delta RO_{t-i} + \sum_{i=0}^{s} \theta_4 \Delta RG_{t-i} + \sum_{i=0}^{s} \theta_5 \Delta EMP_{t-i} + \delta_1 GGDP_{t-1} + \delta_2 GT_{t-1} + \delta_3 RO_{t-1} + \delta_4 RG_{t-1} + \delta_5 EMP_{t-1} + V_t \quad (3)$$

Above is the model for ARDL, where Δ represents the symbol for change. The optimal lag lengths p, q, r, s, and t are determined by the Schwarz Information Criterion (SIC). The symbols for short-term coefficients are Θ_1 to Θ_5 and for long-term coefficients are δ_2 to δ_4. The symbol Vt represents the error term. This study also conduct unit root test to assess the stationarity of time series data, a critical step before regression analysis. This study uses both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to determine if the data is stationary, ensuring valid regression results. The tests help confirm whether the variables exhibit stationary behavior, which is essential for the accuracy of the ARDL model.

The ARDL bounds test is essential for assessing cointegration. The F-bound test examines the long-term effects between variables. Before running the F-bound test, it is necessary to determine the optimal lag length to establish the maximum lag rate. The statistical F value is then compared with the upper bound critical value I(1) and the lower bound critical value I(0). If the statistical F value exceeds the upper bound critical value, the null hypothesis is rejected, indicating a long-term relationship between the variables. Diagnostic tests are also important for conducting ARDL analysis. These tests aim to detect issues such as multicollinearity, autocorrelation, heteroscedasticity, normality violations, Ramsey's RESET test, CUSUM, and CUSUM squares. The Durbin-Watson test addresses autocorrelation issues, while the Breusch-Pagan-Godfrey test is used for heteroscedasticity and normality violations. Diagnostic tests ensure the relevance of the tests conducted.

The dynamic ARDL simulation, a novel approach in this study, detects future shocks for socioeconomic indicators and climate factors. This simulation framework is depicted through prediction graphs showing positive and negative states of different factors. It evaluates short-term and long-term relationships between variables and improves accuracy and understanding of ARDL results. The method estimates factor variations and their effects on outcomes. Based on the study by Sarkodie and Owusu (2020), the model used in the ARDL Dynamic Simulation is as follows:

$$\Delta GGDP_t = \delta_0 + \alpha_0 GGDP_{t-1} + \vartheta_1 \Delta RG_t + \alpha_1 RG_{t-1} + \vartheta_2 RO_t + \alpha_2 \Delta RO_{t-1} + \vartheta_3 GT_t + \alpha_3 GT_{t-1} + \vartheta_4 POP_t + \alpha_4 POP_{t-1} + \varepsilon_t \quad (4)$$

Where, δ_0 is the term for the constant, α_0 is the coefficient for the error correction term. The coefficients for the short term are ϑ_1 to ϑ_4. Meanwhile, for the long term it is α_1 to α_4. As for the error term, it is ε_t.

The advantage of the Dynamic ARDL (DYNARDL) simulation method is its ability to evaluate the long-term relationship between two variables. In this study, it examines the relationship between the use of natural resources and green economic growth over the long term. Additionally, this method assists policymakers in formulating effective policies, which can be implemented over periods exceeding one year. To first step in the DYNARDL simulation is to perform a bound test to determine whether there is a long-term relationship between the variables. In this DYNARDL simulation method, Shockvar is used to identify potential shocks, while Shockval represents the magnitude of the shock applied to the target variable. For example, an increase in the use of non-renewable energy significantly impacts environmental quality due to the emission of carbon dioxide. Based on the target, this study simulates the impact of 1 unit increases in GT in 2022 on green growth for up to 2030.

Finally, the Kernel-based Regularized Least Squares (KRLS) method is also employed in this study. KRLS helps examine cause-and-effect relationships by implementing derivatives with minus points (Sarkodie & Owusu, 2020). In this study, the green trade variable is analyzed for its impact on green economic growth in Malaysia. The plan to boost green economic growth involves increasing green trade, emphasizing its importance in maintaining sustainable green economic growth in Malaysia, reducing carbon dioxide emissions, and promoting sustainable natural resource use. The expected outcomes for the variables are as follows: i. Green Trade is expected to have a positive impact on green economic growth. Green trade activities, such as the trade of solar panels (a renewable resource), can contribute to national income and consequently foster green economic growth by reducing carbon dioxide emissions; ii. Oil and gas reserves are expected to have a negative impact on green economic growth. The production and use of these non-renewable resources can deteriorate environmental quality and impose negative externalities on third parties; iii. The labor force is expected to have a positive impact on green economic growth. An increase in the labor force enhances the capacity to produce green goods and services, boosting demand for these products and subsequently promoting green economic growth. However, sustainable economic growth is challenging to achieve without sustainable resource use.

This study is grounded in the theory of green economic growth, focusing on the interplay between green growth, green trade, and natural resources. It assesses the impact of natural

Table 1
Variables Information and Data Sources

Variables	Unit	Sources
Green GDP (GGDP)=GDP- NRD-CO^2 damage	% growth	World Bank (2024)
GDP= Gross Domestic Product (annual %)		
NRD= Natural Resources Depletion (% of GNI)		
CO^2 damage= Carbon dioxide damage (% of GNI)		
Green Trade (GT)	% growth	International Monetary Fund (2024)
Oil Reserve (RO)	% growth	Energy Institute (2024)
Gas Reserve (RG)	% growth	Energy Institute (2024)
Labor Force (EMP)	% growth	Department of Statistics Malaysia (2024)

resources on green economic growth, facilitating effective green growth and transformation. This study was conducted in Malaysia, and all data were collected within the Malaysian context. The data spans a period of 31 years, from 1990 to 2021. This period was chosen because it marks a time of significant industrial growth in Malaysia, which led to environmental degradation and a reduction in natural resources. The data were sourced from trusted organizations such as the World Bank, the International Monetary Fund (IMF), the Energy Institute, and the Department of Statistics Malaysia. Table 1 provides the overview information of variables used.

4. Results

This section presents the results of the empirical analysis using the Autoregressive Distributed Lag (ARDL) Model and Dynamic ARDL (DYNARDL) simulation. The analysis was conducted to evaluate the long-term and short-term relationships between green economic growth, green trade, oil reserves, gas reserves, and the labor force in Malaysia from 1990 to 2021. Descriptive statistics for the variables, including the mean, median, maximum, minimum, standard deviation, skewness, and kurtosis, are shown in Table 2. These statistics describe the distribution and central tendencies of the variables GGDP (Green Gross Domestic Product), RO (Oil Reserves), RG (Gas Reserves), GT (Green Trade), and EMP (Employment). Detailed statistics for each variable are presented in Table 2, providing a comprehensive overview of their characteristics and variability within the study period.

The variable with the highest mean and median values is GT, indicating that green trade activities have been relatively stable and substantial over the study period. In contrast, RO and RG have the lowest mean and median values, suggesting that the growth rate of reserve oil and reserve gas has been comparatively modest. GT has the highest maximum value of 0.8608 reflecting significant peaks in green trade growth over the study period. Conversely, GGDP shows the lowest minimum value of -0.3347, suggesting that negative green GDP growth within the study period. Regarding standard deviation, all variables show low data distribution.

The skewness values indicate that all variables are skewed to the right, except for GGDP. All kurtosis values are larger than 3, indicating a leptokurtic distribution, which means the data has heavier tails and a sharper peak than a normal distribution. Next, this study conducts unit root tests to assess the stationarity of the time series data using the Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test at the level and first difference for all variables. At the level, both test shows all variables are significant at least 5% significance level. The ADF test at the level shows significance at 1% for GGDP and EMP, and at 5% for RG and GT.

Based on these observations from Table 3, we can conclude that the variables used in this study are suitable for ARDL modeling. It is important to note that if the dependent variable were non-stationary at the first difference and the independent variables were stationary at the second difference, the ARDL method could not be used in this study. This condition validates the use of the ARDL approach to examine the relationships among the variables. Therefore, based on the stationarity test results, the data meet the necessary conditions for employing the ARDL method in this study. Before conducting ARDL, we evaluate the existence of long-term relationships by using the F-bound test.

Table 4 shows the F-bounds test involving I(0) and I(1), where each represents the lower and upper critical values, respectively. Based on the table, the I(1) critical value of 4.37 is smaller than the F-statistic value of 6.5166 at the 1% level. This indicates a long-term relationship between the variables in this study, specifically the impact of natural resources and green trade on green growth in Malaysia. The ARDL estimation results for both short-run and long-run relationships are summarized in Table 5. In the short run, the lagged differences of reserve gas are negative and significant at the 10% level, indicating that past values of reserve gas negatively impact current green economy.

The error correction term is negative and highly significant at 1%, indicating a strong tendency for the variables to return to equilibrium following a short-term shock, with a speed of adjustment of 86.63%. In the long run, green trade demonstrates a positive effects on green economic growth. This is consistent with our earlier hypothesis and in-line with past studies (Xu, 2022). Diagnostic tests confirm the reliability of the ARDL model results. The Breusch-Pagan-Godfrey test indicates no heteroscedasticity, the Jarque-Bera test shows that residuals are not normally distributed, and the Serial Correlation LM Test indicates no serial correlation. The CUSUM and CUSUM of Squares tests show model stability. However, Ramsey's RESET Test suggests issues with omitted variables or model specification. To obtain more relevant and specific results, the

Table 2
Descriptive Statistics

Indicator	GGDP	RO	RG	GT	EMP
Mean	0.0503	0.1218	0.0262	0.0108	0.0268
Median	0.0623	0.1284	0.0000	0.0070	0.0221
Maximum	0.1936	0.8608	0.8437	0.1482	0.0987
Minimum	-0.3347	-0.2460	-0.2968	-0.1260	-0.0077
Std. Dev	0.1002	0.2218	0.1845	0.0548	0.0229
Skewness	-1.7926	0.9459	2.7974	0.3414	1.6943
Kurtosis	8.1919	5.3971	13.8581	4.0171	6.0314

Table 3
Unit Root Test Results

Variables	Phillips-Perron		Augmented Dickey-Fuller	
	Level	First Difference	Level	First Difference
GGDP	-4.1904***	-16.7857***	-4.2780***	-3.6500**
GT	-7.8540***	-13.8029***	-4.9842***	-4.7097***
RO	-5.0556***	-23.1301***	-5.0590***	-9.6546***
RG	-3.4624**	-14.7905***	-3.5829**	-4.8920***
EMP	-5.0093***	-10.3607***	-5.0202***	-8.7148***

Notes: *, **, and *** denote significant level at 10%, 5% and 1%, respectively.

Table 4
Bound Test Results

F-Statistics	Significance Level	I(0)	I(1)
	10%	2.2	3.09
6.5166***	5%	2.56	3.49
	1%	3.29	4.37

Notes: *, **, and *** denote significant level at 10%, 5% and 1%, respectively.

Table 5
ARDL Estimation Results

Variables	Coefficients	Standard Error
Short Run		
ΔRG_t	-0.4482*	0.2394
ECT_{t-1}	-0.8663***	0.1256
Long Run		
GT_t	0.2322**	0.0953
RO_t	0.1846	0.1140
RG_t	0.1377	0.3953
EMP_t	0.9301	0.8275
$Constant$	-0.0151	0.0276
Diagnostic Results		
Breusch-Pagan-Godfrey	0.8034	
Jarque-Bera	14.1468	
Serial Correlation LM Test	0.5122	
Ramsey's RESET Test	24.5630***	
CUSUM	Stable	
CUSUM Square	Stable	

Notes: *, **, and *** denote significant level at 10%, 5% and 1%, respectively.

DYNARDL simulation is used to assess the long-term and short-term relationships of all the independent variables with the dependent variable more accurately. Therefore, Table 6 below can explain these relationships in greater detail.

The dynamic ARDL simulation is used to assess the relationship between variables in both the long and short term. Based on the results from the table, the green trade (GT) variable is significant in both the short term and the long term. Specifically, in the short run, a 1% increase in green trade leads to a 0.1970% increase in green economic growth (GGDP). This positive relationship is further amplified in the long term, where a 1% increase in green trade results in a 0.2882% increase in green economic growth. These findings align with the global trend of integrating sustainability into trade practices, where increased engagement in green trade activities contributes to sustainable economic development.

On the other hand, no significant relationships were found for the other variables in either the short or long term. This indicates that, within the context of this study, green trade stands out as the primary driver of green economic growth, while other factors may not have a statistically significant impact on GGDP during the observed period. This outcome underscores the critical role that green trade plays in promoting sustainable economic growth, potentially serving as a key area of focus for policymakers aiming to enhance green economic development. The model diagnostics indicate strong overall significance with a Prob > F value of 0.0017 (significant at 1%), an R^2 value of 0.683 indicating that the model explains approximately 68.3% of the variance in GGDP, and a Root Mean Square Error (RMSE) of 0.0848, reflecting the average error magnitude.

Referring to the diagram above, a positive shock to green trade indicates a positive outcome, demonstrating that green trade has a positive impact on the growth of the green economy in Malaysia. This positive impact can be attributed to the fact that if green trade is pursued in the long term, it can lead to a

Table 6
Dynamic ARDL Estimation Results

Variables	Coefficient	Standard Error
Short Run		
ΔGT_t	0.1970**	0.0764
ΔRO_t	0.1865	0.1111
ΔRG_t	-0.4839	0.4091
ΔEMP_t	0.9315	0.7719
ECT_{t-1}	-0.9414***	0.2196
Long Run		
GT_{t-1}	0.2882**	0.1195
RO_{t-1}	0.1648	0.1593
RG_{t-1}	0.1613	0.4138
EMP_{t-1}	0.5695	1.1004
Constant	-0.0130	0.0309
Prob > F	0.0017***	
R^2	0.6830	
Root MSE	0.0848	

Notes: *, **, and *** denote significant level at 10%, 5% and 1%, respectively.

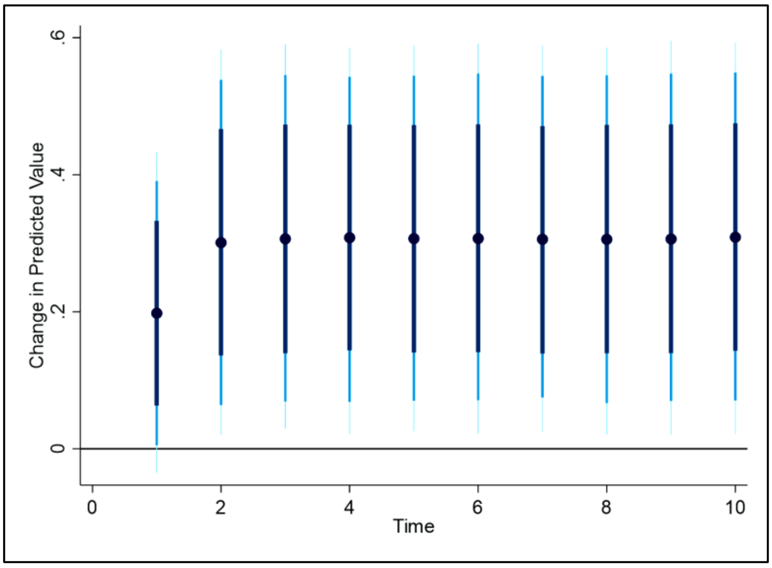

Fig 2 Visualization of Expected Shocks in Green Trade Using Dynamic ARDL Simulations

Notes: Model changes (±1%) in expected green trade on green economic growth (GGDP). The dot shows the average expected value, the dark blue to light blue line represents the confidence interval 75, 90, 95%

Table 7
Pointwise Derivatives from KRLS

GGDP	Avg.	SE	P25	P50	P75
GT	0.1028***	0.0350	0.0394	0.0936	0.1601
RO	-0.0183	0.0466	-0.0435	-0.0241	-0.0004
RG	0.0238	0.1470	-0.0995	0.0514	0.1373
EMP	0.7091*	0.3544	0.2480	0.7124	1.1388
Diagnostic					
Lambda	1.972	Sigma	4.0000	R^2	0.4874
Tolerance	0.031	Eff.Df	6.1220	Looloss	2.746

Notes: *, **, and *** denote significant level at 10%, 5% and 1%, respectively.

decline in green economic growth. This finding is consistent with ARDL's dynamic simulation expectations, where the coefficient value for green trade shows a positive value of -0.2882. Previous study corroborates this result, indicating that green trade can significantly enhance green economic growth and effectively contribute to environmental sustainability (Xu, 2022). This suggests that a strategic focus on green trade can be a powerful driver for boosting green economic growth. It highlights the importance of prioritizing green trade in economic policies, ensuring that these efforts are integrated with broader environmental and economic objectives to maximize their positive impact on the economy.

Based on the results presented in the table, the average pointwise marginal effects for GT, RO, RG, and EMP are 0.1028, -0.0183, 0.0238, and 0.7091, respectively. The average pointwise marginal effect is analogous to the expected coefficient value from a linear regression and represents the average marginal effect across the dataset. Heterogeneity in the marginal effects can be observed through the distribution percentiles, specifically P25, P50, and P75, which provide a more detailed understanding of the variation in the effects across different quantiles. For instance, the GT variable shows a positive average effect on green economic growth, with percentiles indicating varying levels of impact across different segments, while RO and RG display less significant effects with wider variability.

The histogram diagram for the pointwise marginal effects, as shown in Figure 2, can effectively visualize this heterogeneity, allowing for a clearer and quicker interpretation of the distribution and range of these effects. This comprehensive analysis highlights the importance of a nuanced and balanced approach to green trade and resource utilization. The positive effect of green trade on green economic growth underscores its potential as a driver of economic sustainability. However, the variability observed in the data suggests that the impact of green trade, along with other resources, can differ significantly across contexts. Therefore, policymakers should ensure that green trade initiatives are implemented in a way that maximizes their positive impact while avoiding potential adverse effects. This requires careful management and alignment of green trade with broader environmental and economic objectives to foster a truly sustainable green economy.

Based on Table 7, the average pointwise marginal effects for GT, RO, RG, and EMP are 0.10, -0.02, 0.02, and 0.71, respectively. The average pointwise marginal effect is analogous to the expected coefficient value from linear regression and can be interpreted as the average marginal effect. Heterogeneity in the marginal effect can be detected through percentiles 1 (P25), 2 (P50), and 3 (P75). Additionally, the histogram diagram for the pointwise marginal effect can be used to visualize the heterogeneity effects more easily and quickly, as shown in Figure 3. Figure 3 illustrates the pointwise distribution of the derivatives for the green trade, reflecting its varying marginal effects on green economic growth. The distribution is predominantly positive, with most derivative values concentrated between 0 and 0.2, indicating that green trade generally has a positive impact on GGDP. The diagram indicates no significant problems with heterogeneity across the

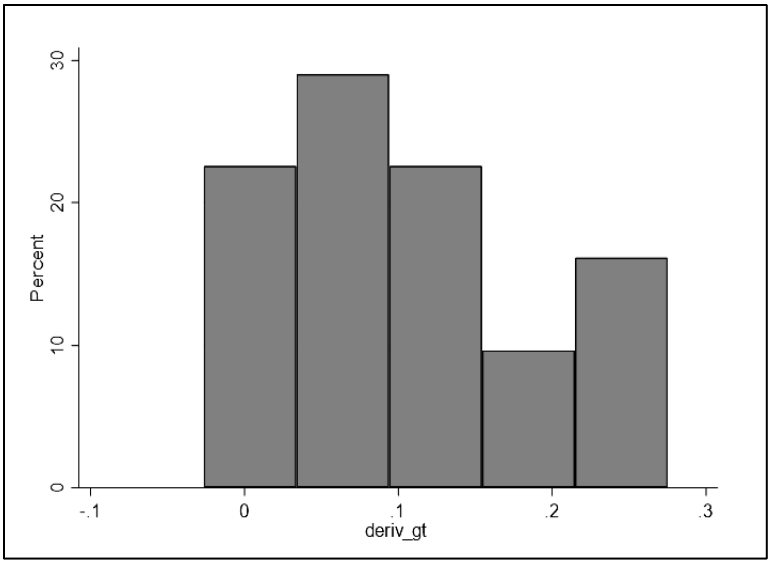

Fig 3 Pointwise Derivatives for Green Trade

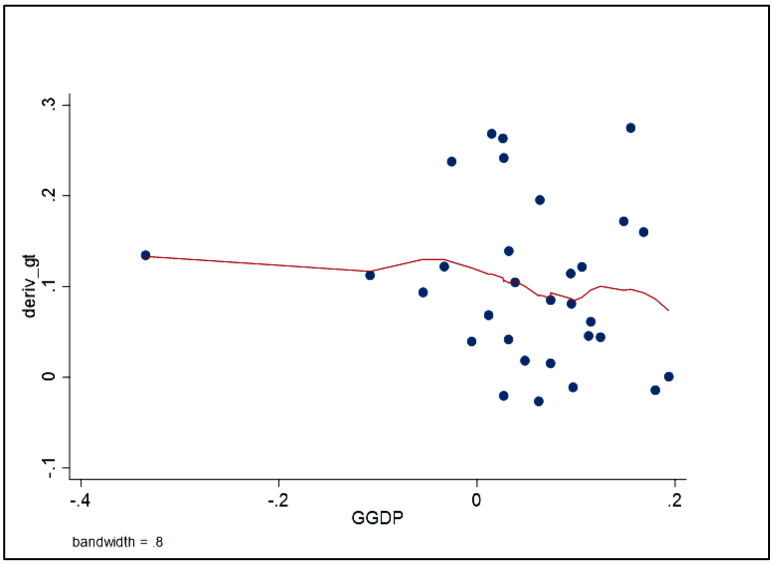

Fig 4 Marginal Effects of Green Trade on Green Economy

marginal effects, affirming the robustness and authenticity of the data used in this analysis. This validation ensures the reliability of the data for this study.

Meanwhile, Figure 4 displays the pointwise marginal effects, focusing on the long-term variations of the green trade variable and its impacts on green economic growth. The graph reveals a varying impact across different levels of GGDP. Initially, at lower levels of GGDP, the marginal effect of green trade appears to be slightly positive, suggesting that green trade has a beneficial impact on economic growth. However, as GGDP increases, the marginal effect gradually decreases and even turns negative at higher levels of GGDP. This indicates that while green trade may contribute positively to economic growth in the early stages, its effectiveness diminishes as the economy grows larger, and it may even have a slightly adverse impact in more developed economic contexts. This pattern suggests that the benefits of green trade are context-dependent, and its impact may vary depending on the level of economic development, highlighting the need for a nuanced approach when leveraging green trade as a tool for sustainable economic growth.

5. Conclusion

This study examines the relationship between the use of natural resources and the growth of the green economy in Malaysia. The data and variables include green economic growth, green trade, oil reserves, gas reserves, and the labor force, spanning 32 years from 1990 to 2021. Using the ARDL method, the results show that green trade has a positive relationship with green economic growth in the long run. To gain a clearer and more accurate understanding, the novel Dynamic ARDL (DYNARDL) method was employed. According to the DYNARDL method, green trade has a significant positive relationship with green economic growth in both the long and short term. These findings align with studies by Ahmed *et al.* (2022), which highlight the positive impact of green trade on green economic growth for South Asian countries.

One of the primary challenges faced in this study was the limited availability of comprehensive and reliable data, particularly for green economic growth. This variable required the aggregation and synthesis of several data points, complicating the research process. Additionally, the study's relatively short duration posed further difficulties. Future researchers are recommended to address these limitations by improving access to data sources and extending the study period. Doing so can enhance the reliability and depth of future research. Moreover, future studies should explore the potential positive effects of green trade on green economic growth, which could assist policymakers in formulating strategies to promote sustainability and a greener environment. By overcoming these challenges and focusing on the positive impacts of green trade, future research can provide valuable insights that contribute to sustainable development and environmental policy improvements.

Policy Implications

The findings of this study carry significant implications for policymakers in Malaysia and other nations aiming to integrate economic growth with environmental sustainability. Given the positive impact of green trade on green economic growth, it is crucial for policymakers to prioritize and promote green trade as a strategic element of national economic planning. Policymakers should encourage and support investments in green technologies and sustainable practices, fostering innovation and efficiency in green trade to enhance Malaysia's competitiveness in the global market while promoting environmental sustainability. Additionally, providing financial incentives, such as tax breaks or subsidies, to businesses that adopt sustainable practices can amplify the positive impact of green trade on economic growth and drive the transition towards a greener economy by making sustainable practices more economically attractive.

Furthermore, a comprehensive policy framework that integrates the use of both renewable and non-renewable resources is essential. Policymakers must ensure that economic growth does not compromise environmental sustainability by balancing resource exploitation with conservation efforts. Adopting a long-term perspective in planning and implementing green trade initiatives is also critical. This includes aligning green trade policies with broader economic and environmental goals to ensure that short-term gains do not undermine long-term sustainability. Raising public awareness about the benefits of green trade and educating businesses and consumers on sustainable practices can also foster a culture of sustainability. Policymakers should promote initiatives that encourage informed decision-making and sustainable consumption patterns. By incorporating these recommendations into policy formulation and implementation, Malaysia can effectively leverage green trade as a catalyst for sustainable economic growth, ensuring that the pursuit of economic development goes hand-in-hand with environmental stewardship.

Author Contributions: N.D.R.: Conceptualization, methodology, formal analysis, writing—original draft, H.N.A.H.; writing—review and editing, validation, project administration, M.R.K.V.Z.; writing—review and editing, supervision, resources, N.A.K.; writing—review and editing, validation, M.S.Z.; writing—review and editing, validation. All authors have read and agreed to the published version of the manuscript.

Funding: The authors received no financial support for the research, authorship, and publication of this article.

Conflicts of Interest: The authors declare no conflict of interest.

References

Ahmed, F., Kousar, S., Pervaiz, A., Trinidad-Segovia, J. E., del Pilar Casado-Belmonte, M., & Ahmed, W. (2022). Role of green innovation, trade and energy to promote green economic growth: a case of South Asian Nations. *Environmental Science and Pollution Research*, 29(5), 6871-6885. https://doi.org/10.1007/s11356-021-15881-4

Asha'ari, M., Daud, S., & Hassan, H. (2016). What Is Green Growth Strategy for Government Link Company?. *IOP Conf. Series: Earth and Environmental Science*, 32. https://doi.org/10.1088/1755-1315/32/1/012055.

Brandi, C., Schwab, J., Berger, A., & Morin, J. (2020). Do environmental provisions in trade agreements make exports from developing countries greener?. *World Development*, 129, 104899. https://doi.org/10.1016/j.worlddev.2020.104899.

Chan, H., & Sopian, K. (2022). Transitioning to a high renewable net-zero power generation system in Malaysia. Philosophical transactions. Series A, Mathematical, physical, and engineering sciences, 380. https://doi.org/10.1098/rsta.2021.0132

Chendrawan, T. S. (2017). Sejarah Pertumbuhan Ekonomi. *Tirtayasa Ekonomika*, 12(1), 123. https://doi.org/10.35448/jte.v12i1.4441

Cheng, P., Wang, X., Choi, B., & Huan, X. (2023). Green Finance, International Technology Spillover and Green Technology Innovation: A New Perspective of Regional Innovation Capability. *Sustainability*. https://doi.org/10.3390/su15021112.

Department of Environment, 2023. *National Environment Plan*. Department of Environment, Malaysia. Retrieved November 16, 2023, from https://www.doe.gov.my/dasar-alam-sekitar-negara/

Department of Statistics Malaysia (2024). Em*ployment Data, Labor Force Survey*. Department of Statistics Malaysia. Retrieved April 20, 2024, from https://www.dosm.gov.my/portal-main/time-series

Energy Institute. (2024). *Statistical Review of World Energy*. Energy Institute. Retrieved April 20, 2024, from https://www.energyinst.org/statistical-review

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The quarterly journal of economics*, 110(2), 353-377. https://doi.org/10.2307/2118443

Gu, X., Shen, X., Zhong, X., Wu, T., & Rahim, S. A. (2023). Natural resources and undesired productions of environmental outputs as green growth: EKC in the perspective of green finance and green growth in the G7 region. *Resources Policy*, 82, 103552. https://doi.org/10.1016/j.resourpol.2023.103552

Huang, L., & Zhao, W. (2022). The impact of green trade and green growth on natural resources. *Resources Policy*, 77, 102749. https://doi.org/10.1016/j.resourpol.2022.102749

Hussain, Z., Mehmood, B., Khan, M., & Tsimisaraka, R. (2022). Green Growth, Green Technology, and Environmental Health: Evidence From High-GDP Countries. *Frontiers in Public Health*, 9. https://doi.org/10.3389/fpubh.2021.816697.

International Monetary Fund. (2024). *Trade in Environmental Goods*. International Monetary Fund. Retrieved April 30, 2024, from https://climatedata.imf.org/datasets/8636ce866c8a404b8d9baeaffa2c6cb3

Kasayanond, A., Umam, R., & Jermsittiparsert, K. (2019). Environmental Sustainability and its Growth in Malaysia by Elaborating the Green Economy and Environmental Efficiency. *International Journal of Energy Economics and Policy*. https://doi.org/10.32479/IJEEP.8310.

Kaya, Y., Yamaguchi, M., & Geden, O. (2019). Towards net zero CO2 emissions without relying on massive carbon dioxide removal. *Sustainability Science*, 1-5. https://doi.org/10.1007/s11625-019-00680-1.

Khan, Z., Hossain, M. R., Badeeb, R. A., & Zhang, C. (2023). Aggregate and disaggregate impact of natural resources on economic performance: Role of green growth and human capital. *Resources Policy*, 80, 103103. https://doi.org/10.1016/j.resourpol.2022.103103

Li, J., Dong, X., & Dong, K. (2022). Is China's green growth possible? The roles of green trade and green energy. *Economic Research-Ekonomska Istraživanja*, 35, 7084 - 7108. https://doi.org/10.1080/1331677X.2022.2058978.

Losada-Puente, L., Blanco, J. A., Dumitru, A., Sebos, I., Tsakanikas, A., Liosi, I., ... & Rodríguez, E. (2023). Cross-case analysis of the energy communities in Spain, Italy, and Greece: progress, barriers, and the road ahead. *Sustainability*, 15(18), 14016. https://doi.org/10.3390/su151814016.

Mahajan, N., Kaur, N., Singh, V., Gupta, A., & Garg, N. (2023). Green Trade: Transition Towards a Sustainable Economy. *IOP Conference Series: Earth and Environmental Science*, 1279. https://doi.org/10.1088/1755-1315/1279/1/012023.

Malaysian Investment Development Authority. (2024). *Oil & Gas*. Malaysian Investment Development Authority. Retrieved November 16, 2023, from https://www.mida.gov.my/industries/services/oil-and-gas/

Martín-Ortega, J. L., Chornet, J., Sebos, I., Akkermans, S., & López Blanco, M. J. (2024). Enhancing Transparency of Climate Efforts: MITICA's Integrated Approach to Greenhouse Gas Mitigation. *Sustainability*, 16(10), 4219. https://doi.org/10.3390/su16104219.

Ministry of Economics. (2018). *Mid-term Review of Eleventh Malaysia Plan 2016-2020*. Ministry of Economics. Retrieved November 16, 2023, from https://www.ekonomi.gov.my/en/economic-developments/development-plans/rmk/mid-term-review-eleventh-malaysia-plan-2016-2020

Nhamo, S., & Nhamo, G. (2014). Mainstreaming green economy into sustainable development policy frameworks in SADC. *Environmental Economics*, (5, Iss. 2), 55-65.

Ossewaarde, M., & Ossewaarde-Lowtoo, R. (2020). The EU's Green Deal: A Third Alternative to Green Growth and Degrowth?. *Sustainability*. https://doi.org/10.3390/su12239825.

Pereira, A. M., & Andraz, J. M. (2013). On the economic effects of public infrastructure investment: A survey of the international evidence. *Journal of Economic Development*, 38(4), 1-37.

Porter, M. E., & Linde, C. V. D. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives*, 9(4), 97-118. https://doi.org/10.1257/jep.9.4.97

Reddy, S. J. (2021). A note on:"Climate Change/Global Warming versus Climate Crisis. *Journal of Agriculture and Aquaculture*, 3(1), 23p.

Sachs, J. D., Woo, W. T., Yoshino, N., & Taghizadeh-Hesary, F. (2019). Importance of Green Finance for achieving Sustainable Development Goals and Energy Security. *Handbook of Green Finance*, 3. https://doi.org/10.1007/978-981-13-0227-5_13

Sarkodie, S. A., & Owusu, P. A. (2020). How to apply the novel dynamic ARDL simulations (DYNARDL) and Kernel-based regularized least squares (KRLS). *MethodsX*, 7, 101160. https://doi.org/10.1016/j.mex.2020.101160

Sarkodie, S., & Strezov, V. (2019). A review on Environmental Kuznets Curve hypothesis using bibliometric and meta-analysis.. *The Science of the total environment*, 649, 128-145 . https://doi.org/10.1016/j.scitotenv.2018.08.276.

Smulders, S., Toman, M., & Withagen, C. (2014). Growth Theory and "Green Growth". *Oxford Review of Economic Policy*, 30, 423-446. https://doi.org/10.1093/OXREP/GRU027.

Tietenberg, T., & Lewis, L. (2023). *Environmental And Natural Resource Economics*, 12th Edition. Routledge.

Tsepi, E., Sebos, I., & Kyriakopoulos, G. L. (2024). Decomposition Analysis of CO2 Emissions in Greece from 1996 to 2020. *Strategic Planning for Energy and the Environment*, 517-544. https://doi.org/10.13052/spee1048-5236.4332.

Wang, X., Wang, Y., & Wei, C. (2023). The impact of natural resource abundance on green economic growth in the belt and road countries: The role of institutional quality. *Environmental Impact Assessment Review*, 98, 106977. https://doi.org/10.1016/j.eiar.2022.106977

Wei, S., Wen, J., & Saleem, H. (2023). The impact of renewable energy transition, green growth, green trade and green innovation on environmental quality: Evidence from top 10 green future countries. *Frontiers in Environmental Science*, 10. https://doi.org/10.3389/fenvs.2022.1076859.

World Bank (2024). *World Development Indicators*. Retrieved April 30, 2024, from https://databank.worldbank.org/source/world-development-indicators

World Trade Organization (2023). *Harnessing trade for sustainable development and a green economy*. Retrieved November 13, 2023, from https://www.wto.org/english/res_e/publications_e/brochure_rio_20_e.pdf

Xu, X. (2022). The impact of natural resources on green growth: The role of green trade. *Resources Policy*, 78, 102720. https://doi.org/10.1016/j.resourpol.2022.102720

Yassine, C., Sebos, I., & Salah, J. (2024). Unveiling Oman's fisheries sector's carbon emissions and charting reduction pathways. *Journal of Environmental Studies and Sciences*, 1-11. https://doi.org/10.1007/s13412-024-00920-6.