Available Online at www.e-iph.co.uk
Indexed in Clarivate Analytics WoS, and ScienceOPEN

E-B
Environment - Behaviour
Proceedings Journal

ISSEC-24
https://sites.google.com/view/issec-2024/home
International Social Science & Educational Conference 2024
Virtual conference, 07-08 Dec 2024
Organised by: CLM Publishing Resources, Malaysia

e-IPH
e-International Publishing House Ltd., United Kingdom

Agricultural Exports, Agricultural Methane Emissions, and Food Security in Malaysia: Insights from ARDL and Granger Causality Analysis

Nur Fakhzan Marwan[1*], Mohd Faizal Azrul Azwan Che Harun[2], Asmidar Alias[3], Ratha Krishnan Suppiah[1], Muhammad Zainuddin Mohamed Azudin[1], ʻAinatul Fathiyah Abdul Rahim[4]
*Corresponding Author

[1] Faculty of Business and Management,Universiti Teknologi MARA Pahang Branch, Raub Campus, Malaysia, [2] Faculty of Business and Management,Universiti Teknologi MARA Pahang Branch, Jengka Campus, Malaysia, [3] School of Civil Engineering,Universiti Teknologi MARA Pahang Branch, Jengka Campus, Malaysia, [4] Faculty of Administrative Science & Policy Studies, Universiti Teknologi MARA Pahang Branch, Raub Campus, Malaysia

nurfakhzan@uitm.edu.my, faizalazrul@uitm.edu.my, asmidar@uitm.edu.my, ratha353@uitm.edu.my, zainuddin.azudin@uitm.edu.my, ainatul@uitm.edu.my
Tel: +60 16-328 0035

Abstract
This study examines the relationship between Malaysia's food security, agricultural exports, agricultural methane emissions, agricultural land use, and energy supply from 1990 to 2020. Applying ARDL, variance decomposition, and impulse response analysis, the findings reveal a significant long-term positive impact of all determinants on food security. These findings underscore the need for integrated policies that balance land protection, renewable energy, and export strategies to enhance Malaysia's sustainable and resilient food security framework.

Keywords: ARDL, food security, agricultural methane, Malaysia.

DOI: https://doi.org/10.21834/e-bpj.v10iSI24.6392

1.0 Introduction

Achieving global food security, a key aim of Sustainable Development Goal 2 (SDG 2), has become more challenging, especially in the wake of the COVID-19 pandemic. Malaysia has been notably affected, ranking 41st out of 113 countries in the 2022 Global Food Security Index (GFSI). While the country performed well in food quality (38th) and affordability (30th), it struggled with sustainability (57th) and food availability (56th) (Chung, 2023). This vulnerability is reflected in rising food import costs, which increase from RM35 billion in 2011 to RM78.79 billion in 2023. Additionally, essential food items such as rice and vegetables had self-sufficiency rates of only 62.6% and 44.7%, respectively, in 2022. Moreover, Malaysia's hunger score has worsened, rising from 10.9 in 2014 to 12.5 in 2022, which, although still moderate, is concerning (Global Hunger Index, 2022). Climate change, geopolitical tensions, and volatile energy prices further threaten Malaysia's food security. International advice from bodies like the FAO and WTO to focus on agricultural exports further adds complexity. While export strategies may drive economic growth, they risk undermining efforts to improve domestic food supply and self-sufficiency, creating a conflict between economic ambitions and food security needs.

eISSN: 2398-4287 © 2025. The Authors. Published for AMER by e-International Publishing House, Ltd., UK. This is an open-access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/). Peer–review under the responsibility of AMER (Association of Malaysian Environment-Behaviour Researchers
DOI: https://doi.org/10.21834/e-bpj.v10iSI24.6392

Additionally, methane emissions from agriculture pose a dual challenge, significantly impacting global food security. Livestock and rice production contribute a large share of agricultural methane emissions, reaching 145 $TgCH_4$ per year. Livestock accounts for around 90% of emissions through enteric fermentation, while rice cultivation contributes nearly 30% (Maze et al., 2024). In emerging economies like Malaysia, mitigation efforts targeting methane emissions risk constraining agricultural output, especially where resources and arable land are limited. Despite the relevance of these issues, there has been little research on the impact of agricultural methane emissions and agricultural exports on Malaysia's food security. This study addresses this gap by examining the long run and short run relationship between food security, agricultural exports, agricultural methane emissions, agricultural land use, and energy supply from 1990 to 2020. Using the ARDL model, variance decomposition, and impulse response analysis, this paper offers valuable insights for policymakers to strengthen Malaysia's food security within global agricultural trade. Section 2 reviews the literature, Section 3 presents data, Section 4 discusses findings, and Section 5 offers conclusions and recommendations.

2.0 Literature Review

Land continues to play a crucial role in food security. Ali (2024) discovered that although the amount of land used for grain cultivation in Malaysia was not substantial in the short term, it is anticipated to have a long-term effect on food security. Nevertheless, arable land did not adequately support sustainable food production between 1990 and 2022 in Malaysia, according to Osabohien et al. (2024). On the other hand, Marwan et al. (2024) showed that energy consumption and arable land had a beneficial effect on cereal production in India and that there was a unidirectional causal relationship between the two variables and output.

The difficulties that farmers encounter because of climate change have been the subject of numerous studies. Although carbon dioxide (CO2) is the subject of most research, this study focuses on agricultural methane since it has a shorter atmospheric lifetime than CO2 and can be eliminated naturally through chemical reactions. According to Ahmed et al. (2024), who examined how climate change affected food security in India between 1990 and 2019, methane emissions improved food security, whereas N2O emissions had the opposite effect. Interestingly CO2 had no discernible impact. In a similar vein, Nwosu et al. (2024) discovered a positive correlation between methane emissions and agricultural output in Nigeria between 1981 and 2020, highlighting the intricate role that methane plays in food security.

There isn't much empirical research on the relationship between agricultural exports and food security. By promoting economic growth through export crop specialization, creating foreign exchange, and creating jobs, export-led development and trade liberalization are frequently seen as improving food security. It is anticipated that this expansion will improve access to food for underprivileged households and help them escape poverty. However, Aragie et al. (2018) discovered that while poor farmers saw drops in income and maize consumption, which exacerbated food insecurity, Malawi's prohibition on exporting maize primarily benefited urban non-poor residents. According to their 2023 study conducted in Ethiopia, Kenya, and Uganda, agro-export promotion had a detrimental effect on all aspects of food security in urban regions because of increased food prices, but it had a positive effect on rural households. Van den Broeck et al. (2018), on the other hand, demonstrated that Senegal's horticulture exports improved food availability and nutrition by increasing women's incomes and the country's capacity to import.

Food security depends on the connection between agricultural productivity and energy supply, particularly as fossil fuels grow more costly and limited. The factors influencing food security in Egypt, Morocco, Tunisia, and Lebanon between 2010 and 2019 were investigated by Zhuang et al. (2022). They discovered that whereas energy transition, GDP, and agricultural value- added are beneficial for food security, land usage has a negative influence. On the other hand, Łącka et al. (2024) use panel data from 1992 to 2021 to examine how energy use affects cereal production in EU nations. Their results, based on Quantile Regression (QR) and Feasible Generalized Least Squares (FGLS) models, show that energy consumption—including CO2 emissions and renewable energy—has a nonlinear effect on cereal yields.

3.0 Data and Methodology

3.1 Variables

This study investigates the relationship between food security, agricultural land, agriculture methane emissions, agricultural exports, and energy supply in Malaysia from 1990 to 2020, based on data availability. Table 1 provides a detailed summary of the determinants considered in the analysis. To improve the accuracy of the empirical estimates and aid in understanding the coefficient values, all variables have undergone logarithmic transformation (Ridzuan et al., 2020).

Table 1: Variables Descriptions

Variable	Unit	Database
lnFS	Food production index (2014-2016 = 100)	World Bank.
lnAGRILAND	Agricultural land (sq. km)	World Bank
lnAGRIMETHANE	Agricultural methane emissions (thousand metric tons of CO2 equivalent)	World Bank
lnAGRIEXPORT	Agricultural raw materials exports (% of merchandise exports)	World Bank
LnENERGYSS	ktoe	Suruhanjaya Tenaga Malaysia

3.2 Econometric Specification

Recognizing that the determinants may influence food security in Malaysia, the econometric specification is presented in Eq. (1), in line with the models by Ali et al. (2024) and Ahmed et al. (2024):

$$lnFS_t = f(lnAGRILAND_t, lnAGRIMETHANE_t, lnAGRIEXPORT_t, lnENERGYSS_t) \quad (1)$$

The model's reduced form is expressed as Eq. (2).

$$lnFS_t = \alpha + \beta_1 lnAGRILAND_t + \beta_2 lnAGRIMETHANE_t + \beta_3 lnAGRIEXPORT_t + \beta_4 lnENERGYSS_t + \varepsilon_t \quad (2)$$

In this model, α signifies the intercept, ε_t represents the error term, and the parameters denote the estimated coefficients. It is expected that all coefficients will exhibit a positive sign.

3.3 Econometric Methods

3.3.1 The ARDL model

The long-run relationship among the variables is analyzed using the ARDL model developed by Pesaran et. al (2001). This approach is particularly advantageous for small sample sizes, as it effectively addresses endogeneity concerns and accommodates variables with varying orders of integration. The relevant ARDL model for the specified variables is as follows:

$$\begin{aligned}\Delta lnFS_t = \alpha_0 &+ \sum_{i=1}^{k} \beta_{1i} \Delta lnAGRILAND_{t-i} + \sum_{i=0}^{k} \beta_{2i} \Delta lnAGRIMETHANE_{t-i} + \sum_{i=0}^{k} \beta_{3i} \Delta lnAGRIEXPORT_{t-i} \\ &+ \sum_{i=0}^{k} \beta_{4i} \Delta lnENERGYSS_{t-i} + \beta_5 lnFS_{t-1} + \beta_6 lnAGRILAND_{t-1} + \beta_7 lnAGRIMETHANE_{t-1} \\ &+ \beta_8 lnAGRIEXPORT_{t-1} + \beta_9 lnENERGYSS_{t-1} + \varepsilon_t \quad (3)\end{aligned}$$

In this model, α stands for the constant term, and β for the first difference operator. Long-term coefficients are denoted by $\beta 5$ to $\beta 9$, whilst short-term coefficients are marked by $\beta 1$–$\beta 4$. The two main steps of the ARDL technique are determining the ideal lag duration and looking at the long-term correlations between the variables. In this approach, the null hypothesis—which maintains that cointegration does not exist—is contrasted with the alternative hypothesis. The null hypothesis is evaluated using critical values for the F-statistic, which are given by Narayan (2005) for small sample sizes. The null hypothesis is accepted if the calculated F-statistic is less than the upper bound and rejected if it is more. Uncertain interpretations arise when the F-statistic is within the bounds.

4.0 Empirical Results and Discussions

4.1 Unit root test analyses

This study uses the Zivot and Andrews (1992) test to evaluate stationarity in time series data, addressing potential structural breaks and overcoming the limitations of conventional unit root tests. This strategy is especially pertinent in Malaysia, where such disruptions may result from institutional, political, and economic developments. Except for *lnAGRIEXPORT* and *lnENERGYSS*, all variables show stationarity at the first difference (I(1)) according to the ADF test, as shown in Table 2. Similarly, the ZA test shows that all variables are stationary at level (I(0)), except *lnAGRIMETHANE* and *lnENERGYSS*.

Table 2: Results of ADF and ZA Unit Root Test

Variables	ADF (Level)	ADF (Difference)	ZA (Level)	Break Year	ZA (Difference)	Break Year
lnFS	0.0144	-2.8578**	-4.3369**	2004	-3.1754*	2001
LnAGRILAND	0.6552	-4.047***	-3.9255**	2012	-4.9733***	2014
LnAGRIMETHANE	-2.4090	-6.8735***	-3.4672	2014	-6.0041	2002
LnAGRIEXPORT	-2.9080**	-4.4729***	-3.8304**	1999	-6.3125***	2012
lnENERGYSS	-4.2800***	-3.2253***	-0.7691	2015	-5.8721**	2013

*Note: The symbols ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.*

4.2 Lag Length Selection Criteria

Achieving trustworthy empirical results requires choosing the right lag duration for the model, particularly when working with fewer than 60 data. To ensure reliable results, this study uses a lag duration of 3, determined by the FPE criterion, following Liew's (2004) guidelines.

Table 3: Lag length selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	174.1318	NA	3.90e-12	-12.08084	-11.84295	-12.00811
1	318.7660	227.2824*	7.84e-16	-20.62614	-19.19878*	-20.18978
2	343.8280	30.43242	9.44e-16	-20.63057	-18.01374	-19.83058
3	384.1985	34.60328	5.50e-16*	-21.72846*	-17.92216	-20.56484*

4.3 Results of Bayer-Hanck Cointegration

Using Fisher's formula, Bayer and Hanck (2013) present a novel methodology that combines many non-cointegration tests, producing more accurate and dependable results than traditional cointegration testing. Long-term cointegration among the selected variables is confirmed by the F-values from the EG-J and EG-J-BA-BO tests exceeding the crucial threshold, as indicated in the Bayer-Hanck Cointegration Results in Table 4.

Table 4: Results of Bayer-Hanck Cointegration

	Engle-Granger (EG)	Johansen (J)	Banerjee (Ba)	Boswijk (Bo)
Test- Stat	-3.2891	56.3980	-3.1287	51.3078
p-value	0.4191	0.0000	0.2427	0.0000
Fisher Type Test statistics, Bayer Hanck Test				
EG-J	57.0013		5% critical value	10.576
EG-J-Ba-Bo	115.10		5% critical value	20.143

4.4 Result of ARDL-Bounds Test

The results of the bound testing, shown in Table 5, validate the Bayer-Hanck Cointegration Test, as the F-statistic exceeds the critical value at the 1% significance level. This confirms a significant long-term cointegrating relationship between food security, agricultural land, agricultural methane, agricultural exports, and energy supply in Malaysia.

Table 5: ARDL bound test

Test Statistic	Value	K
F-statistic	10.2968	4
Critical Value Bounds		
Significance	I (0)	I(1)
10%	2.45	3.52
5%	2.86	4.01
1%	3.74	5.06

Source: Author Estimation

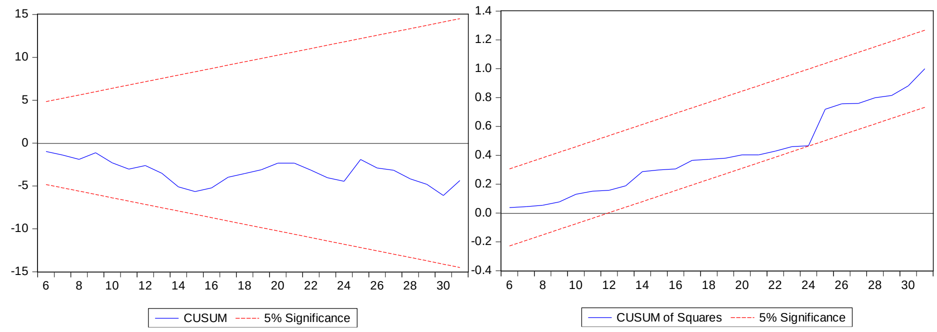
4.5 Estimated Coefficients of Long-Run and Short-Run ARDL Model and Discussion

Table 6 displays the long-run coefficients of the ARDL model, highlighting the statistical significance of all explanatory variables. The diagnostic tests affirm that the model is free from serial correlation, non-normality, and heteroscedasticity. Furthermore, the Ramsey-RESET test substantiates the model's correct functional form, while the CUSUM and CUSUMQ tests confirm its stability and the absence of endogeneity, reinforcing its relevance for policy implications.

Table 6: ARDL Bound Test Results

ARDL Bound Test (Long Run) Dependent Variable: *lnFS* Lag (1,0,1,3,2)			ARDL Bound Test (Short Run) Dependent Variable: *lnFS*		
Variable	Coefficient	t-stat	Variable	Coefficient	t-stat
lnAGRILAND	1.4862***	17.0504			
LnAGRIMETHANE	0.3924*	1.9834	*Δ lnAGRILAND*	1.8336***	4.7478
LnAGRIEXPORT	0.1661***	8.5175	*Δ lnAGRIMETHANE*	0.1818	0.9910
lnENERGYSS	0.3734***	10.1283	*ΔlnAGRIEXPORT*	0.0982***	3.3326
			ΔlnAGRIEXPORT(-1)	-0.0842**	2.325
Diagnostic Test	F- stat	p-value	*ΔlnAGRIEXPORT(-2)*	-0.1212***	-4.0459
BG-LM	0.2928	0.7506	*ΔlnENERGYSS*	0.0144	-1.6228
Breusch-Pagan-Godfrey	1.1184	0.4077	*ΔlnENERGYSS(-1)*	-0.1510	0.6898
Jarque-Bera	1.7688	0.4130	*ΔlnENERGY (-2)*	-0.5393**	-1.6228
Ramsey-RESET	0.1231	0.7306	*ECT(-1)*	-1.2338***	-5.174

*Note: The symbols ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.*



It was discovered that the biggest factor influencing food security is agricultural land; for every 1% increase in *lnAGRILAND,* food security increased by 1.4862%. In contrast to Osabohien et al. (2024), this is in line with Marwan et al. (2024). Malaysia's uneven land usage is exemplified by the small amount of land allotted to food crops (only 1.2 million hectares) as opposed to the seven million hectares used for oil palm and rubber. The importance of agricultural land as a key contributor to food security is emphasized by the limited availability of arable land, which constitutes only 9.7% of all agricultural land (Noordin, 2018). Greater agricultural land significantly improves food security, underscoring the urgency for Malaysia to allocate more arable land for food production to enhance food security. The second-largest contributor to food security is agricultural methane; for every 1% increase in *lnAGRIMETHANE*, *lnFS* rises by 0.3924%. This reinforces doubt about studies that use total CO2 emissions as a stand-in for the effects of climate change and confirms the findings of Ahmed et al. (2024) and Nwosu et al. (2024). Agricultural methane is less likely to harm crops in the long run because of its shorter atmospheric duration (IPCC, 2021). Our results imply that agricultural productivity is not seriously threatened by human climate change, especially through agricultural methane emissions, which will ultimately maintain food security. These findings offer Malaysian officials with the assurance to allocate resources toward rice farming and livestock production, particularly cattle, without apprehension regarding agricultural methane emissions. The livestock industry played a significant part in agricultural growth, created long-term jobs, and met the growing demand for meat, milk, and dairy products in 2022, contributing over 16.51 billion Malaysian Ringgit to the nation's GDP. Furthermore, Malaysia produced about 1.68 million tons of rice and 2.43 million tons of paddy in 2023. Since these industries contribute significantly to food security, more funding and support should be available, recognizing that even though their methane emissions are larger, they are controllable and not necessarily dangerous. In addition to guaranteeing the sustainability of Malaysia's food supplies, this strategic focus can increase agricultural output.

The ARDL analysis indicates a positive relationship between *lnENERGYSS* and *lnFS*, with a 1% increase in *lnENERGYSS* resulting in a 0.374% rise in *lnFS.* Energy is crucial to Malaysia's agricultural sector, where fossil fuels are fundamental to primary and secondary food production. In 2023, fossil fuels, particularly coal and natural gas, accounted for 81% of the country's electricity generation, powering a variety of activities, including machinery, irrigation, and fertilizer production. Moreover, energy consumption is also used from food processing and storage, to transportation, indicating agriculture is a highly energy intensive. With Malaysia's population predicted to exceed 40 million by 2050, the country's primary energy demand is expected to rise by 60%, certainly increasing pressure on food management system. Nonetheless, the findings confirm that an increased energy supply enhances food security, highlighting the crucial sustainable energy strategies to support agricultural growth.

A vital nexus between agricultural export promotion and domestic food stability is found, which shows that a 1% increase in agricultural exports results in a 0.1661% improvement in food security. In contrast to Aragie et al. (2018), this finding supports the findings of Van den Broeck et al. (2018). Considering this, the recent 19% drop in Malaysia's mining and agricultural exports to RM156.1 billion in 2023 underscores the pressing need to improve export tactics and agricultural output. This decline stems from ongoing structural changes in Malaysia's economy, broader shifts in global demand, and increasing environmental pressures on essential commodities. As a result, Malaysian authorities must make strategic investments in and encourage export and agricultural development. Such efforts will not only drive economic growth but also fortify the nation's food security, ensuring a sustainable and resilient agricultural sector that can meet the demands of a growing population.

4.6 Forecast Error Variance Decomposition

The relative significance of each shock in influencing a variable's variation inside the VAR model is shown by Forecast Error Variance Decomposition (FEVD) analysis in Table 7. Most of the variation in food security is caused by shocks to the energy supply, which start at about 0% at the time of initial effect (t=0) and rise to over 36% over the next 30 years. Agricultural exports come next, contributing 0% of the variation in food security at t=0 and 18% by t=30. These results clearly show that shocks to the energy supply and agricultural exports have a gradual and significant impact on food security. Together, these variables account for 54% of the variability in food security by the 30th period, underscoring the critical role of energy supply and agricultural exports in explaining and forecasting food security dynamics.

Table 7: Forecast Error Variance Decomposition Results

Period	S.E.	*lnFS*	*lnAGRILAND*	*lnAGRIEXPORT*	*lnAGRIMETHANE*	*lnENERGYSS*
1	0.022411	100.0000	0.000000	0.000000	0.000000	0.000000
5	0.071029	52.31624	4.909716	16.79855	9.562374	16.41312
10	0.097290	38.81786	3.659208	19.71208	7.390585	30.42027
15	0.106458	32.99382	4.032828	19.44924	6.284969	37.23915
20	0.110437	32.00349	5.516152	18.20732	6.532616	37.74042
25	0.112981	32.61189	6.360637	17.80190	6.962290	36.26328
30	0.114323	32.91384	6.502690	17.92473	7.100706	35.55804

4.7 Impulse Response Function

The Impulse Response Function (IRF) captures how a variable responds to shocks in the error terms of other variables, mapping these effects over time. This approach also evaluates a variable's sensitivity to changes in another. While FEVD reveals the significance of one variable in explaining another, the IRF provides insights into the magnitude of shocks and the rate of adjustment to these shocks.

Figure 1: Response of *lnFS* to Cholesky One S.D. *lnENERGYSS*, *lnAGRIEXPORT, lnAGRIMETHANE* and *lnAGRILAND* Innovation

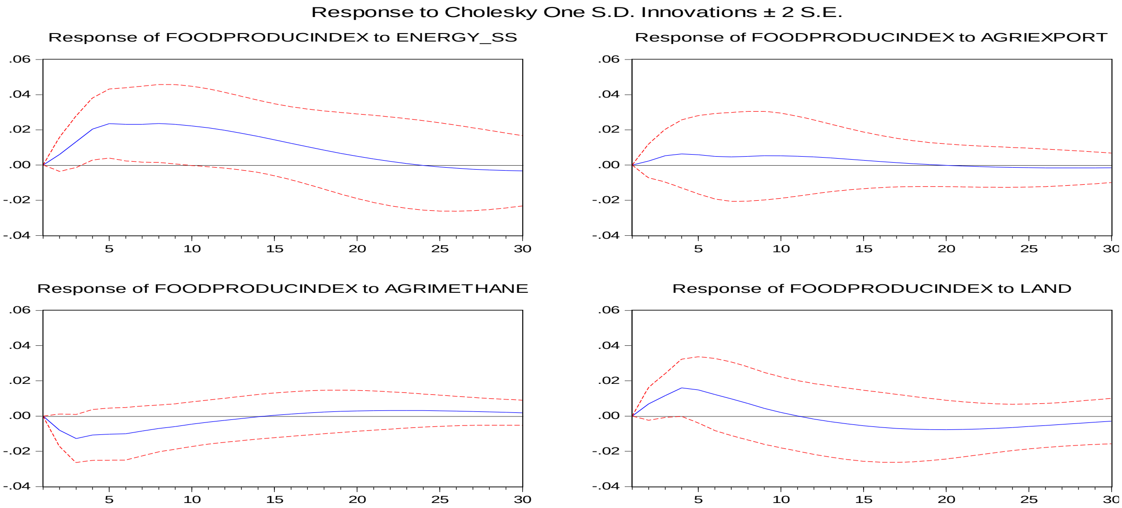


Figure 1 vividly illustrates the initial response of food security to a one standard deviation shock in the energy supply equation, revealing a strong positive effect that peaks after approximately five years before gradually decelerating and ultimately stabilizing at equilibrium after 25 years. Notably, the energy supply shock leads to a rise in food security, escalating from 0% at impact to a peak of 0.02% after five periods, before declining to a permanent level of 0% and turning negative beyond 25 periods. This outcome suggests that an increase in energy supply initially raises food security, followed by a decline in later periods, which aligns with the findings from the ARDL and FEVD analyses. Similarly, the land shock has a positive impact on food security during the initial five years, after which it declines and approaches a steady state of equilibrium within the 11th year, followed by negative effects thereafter. Furthermore, the analysis indicates a weak positive impact of agricultural export shocks on food security initially, with effects gradually reaching a steady state of equilibrium by the twelfth year. In the case of agricultural methane shocks, it is noteworthy that the initial impact is negative; however, it begins to rise by the third period and continues to increase, ultimately reaching a steady state of equilibrium by the fifteenth period.

The IRF results demonstrate a long-run equilibrium, as all shocks return to their respective equilibrium states within designated periods. The speed of adjustment serves as a key indicator of market efficiency. The adjustment of food security to changes in energy supply is the slowest, likely due to higher adjustment costs and inefficient market dynamics arising from structural demand-supply mismatches in the agricultural sector. In contrast, the adjustment concerning land resources is notably more efficient, reaching equilibrium more swiftly. In Malaysia, this efficiency is supported by a well-developed agricultural infrastructure that fosters flexible utilization and provides immediate feedback mechanisms, allowing farmers to make prompt and informed decisions. Lower adjustment costs and proactive government policies promoting sustainable agriculture further enhance the sector's adaptability compared to the energy market, which faces greater structural constraints.

5.0 Conclusion and Policy Implications

This study examines the impact of agricultural methane, agricultural exports, energy supply, and land use on food security in Malaysia between 1990 and 2020. Findings indicate that all these factors positively influence food security in the long term, highlighting the importance of a holistic policy approach. Key policy recommendations include integrating agricultural exports, methane management, sustainable land use, and energy stability. Strengthening Malaysia's energy resilience, particularly through renewable energy in agriculture, can reduce cost fluctuations and enhance food production resilience. Protecting agricultural land from urbanization via zoning laws and incentives for sustainable farming is also crucial. Moreover, balancing export strategies with domestic food security is essential. The National Food Security Plan's integrated framework offers a comprehensive approach to coordinating these sectors. The scope of this study is limited to Malaysia, and the depth of analysis is constrained by the availability of data. Future research should focus on rice production and urbanization trends, employing advanced methods like non-linear ARDL to better understand food security dynamics.

Acknowledgement

We received no financial support for the research, authorship, and/or publication of this article.

Paper Contribution to Related Field of Study

This study explores the impact of methane emissions, agricultural exports, land use, and energy supply on Malaysia's food security from 1990 to 2020. All factors have a positive and significant effect on food security.

References

Ahmed, M., Shuai, J., & Ali, H. (2024). The effects of climate change on food production in India: evidence from the ARDL model. Environment, Development and Sustainability, 26(6), 14601-14619.

Ali, Dayang. (2024). Food Security in Malaysia: An Empirical Analysis of Macroeconomic Determinants. International Journal of Academic Research in Economics and Management Sciences. 13. 10.6007/IJAREMS/v13-i3/22076.

Aragie, E., Balié, J., Morales, C., & Pauw, K. (2023). Synergies and trade-offs between agricultural export promotion and food security: Evidence from African economies. World Development, 172, 106368.

Aragie, E., Pauw, K., & Pernechele, V. (2018). Achieving food security and industrial development in Malawi: Are export restrictions the solution?. World development, 108, 1-15.

Bayer, C., & Hanck, C. (2013). Combining non-cointegration tests. Journal of Time series analysis, 34(1), 83-95.

Chung, H. (2023). Mat Sabu: Malaysia ranked 41st in Global Food Security Index, second among SEA countries. Retrieved at https://theedgemalaysia.com/node/655552 on the 24th October 2024

Łącka, I., Suproń, B., & Szczepaniak, I. (2024). Does Climate Change and Energy Consumption Affect the Food Security of European Union Countries? Empirical Evidence from a Panel Study. Energies, 17(13), 3237.

Marwan, N. F., Harun, M. F. A. A. C., Alias, A., & Suppiah, R. K. (2024). Nexus between Climate Change, Technological Inputs, Energy Consumption and Cereal Production in India: An ARDL approach. Environment-Behaviour Proceedings Journal, 9(SI20), 3-10.

Maze, M., Taqi, M. O., Tolba, R., Abdel-Wareth, A. A., & Lohakare, J. (2024). Estimation of methane greenhouse gas emissions from livestock in Egypt during 1989 to 2021. Scientific Reports, 14(1), 14992.

Narayan, P. (2004). Reformulating critical values for the bounds F-statistics approach to cointegration: an application to the tourism demand model for Fiji (Vol. 2, No. 04). Australia: Monash University.

Noordin, K.A (2018). Forum, The Edge Malaysia Weekly on April 17, 2023 - April 23, 2023. Retrieved at https://theedgemalaysia.com/node/663635 on the 24th October 2024

NWOSU, C. A., Praise, O. N., Charles, A. A., & Basil, C. (2024). Effect of anthropogenic global warming and insecurity on agricultural productivity in Nigeria: ARDL approach. Alvan Journal of Social Sciences1, 1, 1-12.

Osabohien, R., Aderemi, T. A., Jaaffar, A. H., Oloke, E., Bassey, R., Yusoff, N. Y. B. M., ... & Ifekwem, N. E. (2024). Electricity consumption and food production in Malaysia: implication for the sustainable development goal 2. International Journal of Energy Economics and Policy, 14(3), 119-126.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of applied econometrics, 16(3), 289-326.

Ridzuan, N. H. A. M., Marwan, N. F., Khalid, N., Ali, M. H., & Tseng, M. L. (2020). Effects of agriculture, renewable energy, and economic growth on carbon dioxide emissions: Evidence of the environmental Kuznets curve. Resources, Conservation and Recycling, 160, 104879.

Van den Broeck, G., Van Hoyweghen, K., & Maertens, M. (2018). Horticultural exports and food security in Senegal. Global food security, 17, 162-171.

Zhuang, D., Abbas, J., Al-Sulaiti, K., Fahlevi, M., Aljuaid, M., & Saniuk, S. (2022). Land-use and food security in energy transition: Role of food supply. Frontiers in Sustainable Food Systems, 6, 1053031.