Renewable Energy Transition and Inclusive Growth in ASEAN: Evidence from Panel Data and Spatial Robustness Analysis

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Abstract

This study examines the relationship between green economy transition and inclusive growth in selected ASEAN economies using panel data analysis and spatial robustness checks. Green economy transition is proxied by renewable energy consumption share, while inclusive growth is measured by GNI per capita, PPP (constant international $). Using a balanced panel dataset of seven ASEAN economies Indonesia, Malaysia, Vietnam, Thailand, Singapore, the Philippines, and Cambodia over the 2010–2021 period, this study estimates Pooled OLS, Random Effects, and Fixed Effects models. Model selection tests indicate that the Fixed Effects Model is the most appropriate baseline specification. Spatial diagnostics using Moran's I and spatially augmented models are employed as robustness checks, followed by an additional test excluding Singapore as a high-income outlier. The results show that renewable energy consumption share has a negative and statistically significant relationship with GNI per capita. This finding remains robust across spatial specifications and after excluding Singapore. Spatial diagnostics indicate weak spatial dependence, suggesting that the green economy–inclusive growth relationship in ASEAN is shaped mainly by domestic structural characteristics. The findings do not imply that renewable energy harms welfare. Rather, renewable energy consumption share in ASEAN may not yet fully represent a modern, productivity-enhancing green economy transition. The study concludes that renewable energy expansion should be supported by technological upgrading, green investment, institutional capacity, and inclusive policy design.

Keywords: *green economy transition; renewable energy consumption; inclusive growth; ASEAN economies; panel data; spatial robustness.*

INTRODUCTION

Green economy transition has become a central development agenda in the global effort to reconcile economic growth, environmental sustainability, and social inclusion. This transition represents a shift from conventional growth models toward greener economic systems that require coherent policy frameworks, technological innovation, institutional readiness, and inclusive governance (Najicha et al., 2023; Plachkov, 2024; Radtke, 2025). In principle, the transition is expected to reduce environmental pressure while creating new opportunities for investment, employment, technological upgrading, and welfare improvement. Renewable energy development plays a particularly important role in this agenda because it supports greenhouse gas emission reduction, cleaner energy systems, lower dependence on fossil fuels, energy security, and long-term sustainable development (Olajiga et al., 2024; Najicha et al., 2023). However, the success of green economy transition cannot be measured only by the expansion of renewable energy. It also depends on consistent regulation, appropriate policy incentives, stakeholder participation, and social equity to ensure that the transition is both environmentally sustainable and socially inclusive (Krasniqi, 2024; Plachkov, 2024; Radtke, 2025).

The relationship between green energy and inclusive growth has received increasing attention in recent empirical literature. This reflects the growing recognition that economic expansion alone is insufficient if it is not accompanied by broader welfare improvement, poverty reduction, employment creation, and equitable social participation (Geng et al., 2024). Ghouse et al., (2022)

argue that green energy consumption can contribute to inclusive growth, although its effect differs across income groups and tends to be stronger in high-income countries. This finding is consistent with broader evidence suggesting that higher-income economies usually have stronger institutional, technological, and financial capacity to transform green investment into productive economic outcomes (Phung Thanh, 2022; Tudor & Sova, 2021)

Tudor & Sova, (2021) further suggest that a certain development threshold is required before economies can meaningfully expand renewable energy consumption and convert it into development benefits. In lower-income contexts, renewable energy utilization may not immediately improve inclusive growth because of infrastructure limitations, affordability constraints, and weak technological readiness (Geng et al., 2024; Phung Thanh, 2022). Institutional quality also plays an important mediating role because stronger governance frameworks enable more effective environmental and energy policies (Celik & Celik, 2026; Sheng et al., 2023). Therefore, the contribution of green energy to inclusive growth is not automatic. It depends on development stage, institutional capacity, technological readiness, social inclusion, and supportive policy environments (Doğan et al., 2026; Tian et al., 2024).

Previous studies have widely examined the relationship between renewable energy consumption and economic growth, but the empirical findings remain mixed. Bhuiyan et al., (2022) through a systematic literature review, show that renewable energy consumption generally does not hinder economic growth, although its effect differs across country groups, methods, and development stages. Hieu & Mai, (2023) find that renewable energy consumption positively affects economic growth in developing countries, supporting the growth hypothesis. Wang et al., (2023) also show that different renewable energy sources, including hydropower, solar, wind, biomass, and geothermal energy, positively influence economic growth in selected Asian economies. However, other studies suggest that the effect of renewable energy on economic welfare depends on institutional quality, technology, trade openness, industrial structure, and the type of renewable energy used. These mixed findings indicate that renewable energy expansion cannot be assumed to automatically generate inclusive growth. Instead, its development impact needs to be examined within specific regional and structural contexts.

For ASEAN economies, this issue is particularly important because the region has followed a distinctive development trajectory marked by rapid economic growth, urbanization, industrialization, and rising energy demand. Major ASEAN economies such as Indonesia, Malaysia, the Philippines, Thailand, and Vietnam have experienced rising income levels and expanding industrial activities, which have contributed to one of the fastest increases in electricity and energy demand globally (Nepal et al., 2021; Phoumin et al., 2021). At the same time, ASEAN has deepened its trade integration and participation in global production networks, with China becoming ASEAN's largest trading partner since 2009 and ASEAN becoming China's largest trading partner by 2020 (F. Yang & Li, 2024). However, this economic progress has also intensified environmental pressure because fossil fuels still dominate the region's power generation mix, while greenhouse gas emissions have continued to rise (Nepal et al., 2021; Phoumin et al., 2021). This creates a fundamental climate and energy paradox: ASEAN is highly vulnerable to climate change, yet its mitigation efforts remain insufficient relative to the scale of the threat (Overland et al., 2021). Therefore, the region's green economy transition requires a careful balance between energy security, affordability, sustainability, and economic competitiveness, particularly in

the face of gaps in clean energy investment, technology readiness, financing capacity, and policy implementation (Chien, Paramaiah, et al., 2023; Phoumin et al., 2021; Zin Lin et al., 2026).

ASEAN also reflects substantial heterogeneity in income levels, industrial structures, energy systems, renewable energy potential, and institutional capacity. Singapore represents a high-income, service-based economy with limited domestic renewable energy resources, while Indonesia, Vietnam, Thailand, Malaysia, the Philippines, and Cambodia differ in terms of industrialization, energy access, renewable energy endowments, infrastructure readiness, and policy capacity. This diversity makes ASEAN a relevant case for examining whether a renewable energy-based green economy transition is associated with inclusive growth. Previous studies emphasize that ASEAN countries face different pathways and constraints in adopting green technologies and cleaner energy systems, including gaps in investment, technological readiness, policy coordination, and institutional capability (Nepal et al., 2021; Phoumin et al., 2021; F. Yang & Li, 2024)

Because of this heterogeneity, a higher renewable energy share may have different meanings across ASEAN economies. In one country, it may reflect modern renewable technologies, clean energy investment, and an advanced transition strategy. In another country, it may still be associated with traditional biomass use, limited industrial energy demand, or lower access to modern energy services (Ghouse et al., 2022; Overland et al., 2021; Tudor & Sova, 2021).

This distinction is important because renewable energy consumption share does not always represent a modern and productivity-enhancing green transition. In developing economies, a high renewable energy share may partly reflect traditional biomass use or low levels of modern commercial energy consumption. Grant et al., (2021), in their study of Malawi's transition from biomass to electrification, show that energy transition in developing settings is closely related to energy justice, health, ecosystem functionality, and electricity access. Dirisu et al., (2024) also highlight that bioenergy is widely available in developing countries in the form of biomass, but its contribution to sustainable development depends on proper policy, technology, and governance. Abdullah-Al-Mahbub & Islam, (2023)further show that renewable energy development in developing economies may face constraints related to infrastructure, technology, electricity access, and implementation capacity. Therefore, renewable energy consumption share must be interpreted carefully, particularly in developing regions where renewable energy may not yet be fully linked to modern green technology, green industrial capacity, or productivity improvement.

The ASEAN literature also emphasizes that green energy should be understood as part of a broader development transformation. Chien et al., (2023b) show that eco-innovation, trade openness, financial development, green energy, governance, and industrialization are important factors in supporting sustainable development in ASEAN countries. Nguyen et al., (2023) find that natural resource extraction and energy consumption affect environmental sustainability in ASEAN, while renewable energy consumption helps mitigate emissions. These findings suggest that ASEAN's green transition is not merely an energy issue, but also a matter of governance, industrial structure, investment capacity, environmental management, and inclusive development strategy.

In addition to domestic structural factors, the spatial dimension is also relevant. ASEAN economies are geographically close and economically connected through trade, investment, infrastructure, migration, energy cooperation, and regional production

networks. Spatial econometric literature suggests that energy transition and economic performance may not be purely domestic processes. Chica-Olmo et al., (2020), using a spatial Durbin model for 26 European countries, show that renewable energy consumption in one country may affect the economic growth of neighboring countries. Radmehr et al., (2024) also find that renewable energy and green technology innovation generate spatial spillover effects on ecological sustainability. However, spatial dependence cannot be assumed automatically. ASEAN consists of mainland, archipelagic, and city-state economies with diverse geography, energy structures, institutional conditions, and development strategies. Therefore, spatial interaction must be tested empirically rather than presumed.

Based on these issues, this study examines the relationship between green economy transition and inclusive growth in selected ASEAN economies. Green economy transition is proxied by renewable energy consumption share, while inclusive growth is measured using GNI per capita, PPP (constant international $). The study covers seven ASEAN economies, namely Indonesia, Malaysia, Vietnam, Thailand, Singapore, the Philippines, and Cambodia, during the 2010–2021 period. The empirical strategy applies panel data analysis using Pooled OLS, Random Effects, and Fixed Effects models, followed by model selection tests. Spatial diagnostics using Moran's I and spatially augmented models are also employed as robustness checks to examine potential spatial interaction among ASEAN economies.

This study contributes to the literature in three ways. First, it extends the renewable energy-growth literature by examining inclusive growth rather than conventional economic growth alone. By using GNI per capita, PPP (constant international $), this study captures real income improvement and cross-country welfare comparability among ASEAN economies. Second, it provides a cautious interpretation of renewable energy consumption share as a proxy for green economy transition. The study recognizes that renewable energy share in developing economies may reflect different realities, ranging from modern clean energy technologies to traditional biomass use. Third, it incorporates spatial diagnostics and spatial robustness checks to assess whether the relationship between renewable energy consumption share and inclusive growth is influenced by regional spatial interaction.

Accordingly, this study examines two research hypotheses. First, renewable energy consumption share affects inclusive growth in ASEAN economies. Second, spatial interaction may exist in the relationship between green economy transition and inclusive growth among ASEAN economies. By testing these hypotheses, this study aims to provide empirical evidence on whether renewable energy-based green economy transition has been translated into broader welfare improvement in ASEAN.

RESEARCH METHODOLOGY

This study employs a quantitative panel data approach to examine the relationship between green economy transition and inclusive growth in selected ASEAN economies. Panel data analysis is considered appropriate because it combines cross-sectional and time-series dimensions, allowing the study to capture both differences across countries and changes over time. This approach also enables the estimation to account for unobserved country-specific characteristics that may influence inclusive growth, such as institutional capacity, economic structure, geographic conditions, and energy policy orientation.

The study covers seven ASEAN economies, namely Indonesia, Malaysia, Vietnam, Thailand, Singapore, the Philippines, and Cambodia, during the 2010–2021 period. The final dataset is a balanced panel consisting of 84 observations,

representing seven countries observed over twelve years. The selection of countries and period is based on data availability and the need to maintain a balanced panel structure for empirical estimation. Maintaining a balanced panel is important to ensure consistency in model comparison and to reduce potential bias caused by missing observations.

The dependent variable in this study is inclusive growth, proxied by GNI per capita, PPP (constant international $). This indicator is used because it captures real income improvement and allows welfare comparison across countries with different income levels and price structures. Although inclusive growth is a multidimensional concept, GNI per capita in PPP terms provides a comparable measure of average income and welfare performance across ASEAN economies. Therefore, it is suitable for assessing whether green economy transition is associated with broader income improvement.

The main independent variable is green economy transition, proxied by renewable energy consumption share. This variable measures the share of renewable energy in total final energy consumption. Renewable energy consumption share is used because renewable energy development is a key component of the green economy transition, particularly in reducing dependence on fossil fuels and supporting cleaner energy systems. However, this study also recognizes that renewable energy share must be interpreted cautiously, especially in developing economies where it may reflect both modern renewable technologies and traditional biomass use.

The model also includes several control variables to reduce omitted variable bias and to capture broader economic factors that may affect inclusive growth. GDP per capita is included to control for the level of economic development. Trade openness captures the degree of international economic integration. Foreign direct investment represents external capital inflows and potential technology transfer. Government expenditure reflects the role of public spending in supporting economic activity and welfare improvement. These control variables are included because inclusive growth is not determined solely by energy transition, but also by development level, openness, investment, and fiscal capacity.

For estimation purposes, GNI per capita, GDP per capita, and government expenditure are transformed into natural logarithms. This transformation is applied to reduce scale differences across variables, stabilize variance, and allow more meaningful interpretation of estimated coefficients. Renewable energy consumption share, trade openness, and FDI are retained in their original forms because they are already expressed as percentage-based or ratio-based indicators.

The baseline empirical model is specified as follows:

$$lnGNI_PC_{it} = \alpha + \beta_1 Green_Economy_{it} + \beta_2 lnGDPCAP_{it} + \beta_3 TO_{it} + \beta_4 FDI_{it} + \beta_5 lnGovEx_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

where i denotes country and t denotes year. GNI_PC_{it} represents inclusive growth, while $Green_Economy_{it}$ represents renewable energy consumption share. The variables $lnGDPCAP_{it}$ (GDP/Capita), TO_{it} (Trade Openness), FDI_{it} (FDI), and $lnGovEx_{it}$ are control variables. The term μ_i captures unobserved country-specific effects, and ε_{it} is the error term.

This study estimates three panel models: Pooled Ordinary Least Squares, Random Effects, and Fixed Effects. Model selection is conducted using the F-test, Breusch-Pagan Lagrange Multiplier test, and Hausman test. The F-test is used to compare Pooled OLS and Fixed Effects, the Breusch-Pagan LM test is used to compare Pooled OLS and Random Effects, and the Hausman test is used to determine whether Fixed Effects or Random Effects is more appropriate. The Fixed Effects Model is used as the baseline model when

unobserved country-specific characteristics are correlated with the explanatory variables.

To examine the spatial dimension, this study constructs an inverse-distance spatial weight matrix based on the geographic distance between the capital cities of the selected ASEAN countries. The spatial weight matrix is row-standardized so that the spatial weights in each row sum to one. Moran's I is then used to test spatial autocorrelation in GNI per capita, renewable energy consumption share, and residuals from the Fixed Effects Model.

Moran's I is expressed as follows:

$$I = \frac{N}{S_0} \cdot \frac{\Sigma_i \Sigma_j w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\Sigma_i (x_i - \bar{x})^2} \quad (2)$$

where N is the number of spatial units, w_{ij} is the spatial weight between country i and country j, x_i is the observed value, $\bar{x}$ is the mean value, and S_0 is the sum of all spatial weights. A significant Moran's I indicates the presence of spatial autocorrelation, while a non-significant Moran's I indicates weak or no global spatial dependence.

Because the spatial diagnostic results indicate weak spatial dependence, spatial econometric models are not used as the main specification. Instead, spatially augmented models are estimated as robustness checks. These include the Fixed Effects Spatial Lag of X model, the Fixed Effects spatial lag proxy model, and the Fixed Effects Spatial Durbin Model proxy. These models are used to examine whether the coefficient of renewable energy consumption share remains consistent after incorporating spatially lagged variables. This strategy allows the study to assess potential spatial interaction while maintaining the Fixed Effects Model as the baseline specification.

An additional robustness check is conducted by excluding Singapore from the sample. Singapore has a much higher GNI per capita and a distinct energy structure compared with the other ASEAN economies. Its high-income, service-based economy and limited domestic renewable energy resources may influence the overall estimation. Therefore, the exclusion test is used to ensure that the baseline result is not driven by Singapore as a high-income outlier.

Overall, the empirical strategy consists of descriptive analysis, panel model estimation, model selection tests, spatial diagnostic tests, spatial robustness checks, and robustness estimation excluding Singapore. This methodological framework enables the study to examine the relationship between green economy transition and inclusive growth while accounting for country heterogeneity, potential spatial interaction, and sample sensitivity.

RESULTS AND DISCUSSION

The descriptive analysis indicates that inclusive growth, proxied by GNI per capita, improved during the study period. The average GNI per capita of the selected ASEAN economies increased from 23,009.74 in 2010 to 31,707.98 in 2021. This upward trend suggests that the selected ASEAN economies generally experienced real income improvement over time. This finding is consistent with previous studies showing that GNI per capita is commonly used to reflect individual income status, development level, and welfare improvement (Komarulzaman et al., 2022; Masatoshi, 2023).

This pattern also aligns with broader evidence that Southeast Asian economies have experienced sustained income growth driven by industrialization, trade integration, and foreign investment inflows (Azaria & Sihaloho, 2021; Lisaba & Lopez, 2021). However, the improvement was not uniform across countries. Singapore consistently recorded the highest level of GNI per capita, while Cambodia remained at the lower end of the distribution. This contrast reflects persistent income disparities within ASEAN, where countries differ in development stage, productivity capacity, industrial structure, and institutional readiness (Lisaba & Lopez, 2021; Masatoshi, 2023; Viray & Mendoza, 2021).

Therefore, although aggregate income increased during the study period, the distribution of income improvement across ASEAN economies remained uneven. This reinforces the importance of examining inclusive growth rather than focusing only on aggregate output expansion.

In contrast to the rising trend in GNI per capita, the average renewable energy consumption share declined from 27.63% in 2010 to 21.77% in 2021. This pattern suggests that income improvement in the selected ASEAN economies did not necessarily move together with a higher renewable energy share. Singapore recorded the highest average GNI per capita but had a relatively low renewable energy share. Conversely, Cambodia showed a lower GNI per capita but a relatively higher renewable energy share.

This descriptive contrast provides an important initial insight. Renewable energy consumption share should be interpreted carefully, especially in developing economies. A high renewable energy share does not always represent advanced renewable technology, modern clean energy investment, or a mature green economy transition. In some contexts, it may instead reflect the continued use of traditional biomass, limited industrial energy demand, or incomplete access to modern energy services. Previous studies show that renewable energy consumption in Southeast Asia includes traditional biomass, hydroelectricity, wind, solar, and other renewable sources, with biomass historically playing an important role in the regional energy structure (Nepal et al., 2021; Nguyen & Nguyen, 2021).

Nepal et al., (2021) note that many people in Southeast Asia still rely on biomass for cooking, while Hmida & Rey, (2023) emphasize that traditional renewable energy may have different development implications from modern renewable energy. Similarly, Baniya & Aryal, (2022) argue that excluding traditional biomass can substantially reduce the measured renewable energy share in least developed countries. Therefore, the decline in renewable energy share alongside rising GNI per capita may reflect a transition from traditional biomass toward fossil-based modern energy systems before modern renewables expand significantly. This supports the argument that renewable energy share in ASEAN should not be interpreted only as an indicator of advanced green economy transition, but also as a reflection of energy structure, development stage, infrastructure readiness, and access to modern energy.

Before interpreting the regression results, this study conducted model selection tests to determine the most appropriate panel model. The results are presented in Table 1.

Table 1. Panel Model Selection Tests

Test	Null Hypothesis	Statistic	df	p-value	Decision
F-test for country fixed effects	Country fixed effects are jointly zero	36.2977	6, 72	0.0000	Fixed effects are relevant
Breusch-Pagan LM test	Pooled OLS is adequate versus random effects	103.7419	1	0.0000	Random effects are preferred to pooled OLS
Hausman test	Random effects are consistent and efficient	22.2155	5	0.0005	Fixed effects are preferred to random effects

Source: Author's calculation based on secondary data, 2010–2021.

The F-test shows that country fixed effects are statistically significant, indicating that unobserved country-specific characteristics are relevant in explaining differences in inclusive growth among the selected ASEAN economies. The Breusch-Pagan LM test indicates that the Random Effects Model is preferred to Pooled OLS,

suggesting that the panel structure should not be ignored. However, the Hausman test rejects the null hypothesis that Random Effects is consistent and efficient. This means that unobserved country-specific effects are likely correlated with the explanatory variables. Therefore, the Fixed Effects Model is selected as the baseline model.

The selection of the Fixed Effects Model is theoretically appropriate because ASEAN countries differ substantially in geography, institutional capacity, energy policy, income level, industrial structure, and renewable energy potential. These country-specific characteristics may influence both renewable energy consumption and inclusive growth. Ignoring such heterogeneity may lead to biased estimation. Therefore, the Fixed Effects Model provides a more reliable baseline specification for examining the relationship between green economy transition and inclusive growth in the ASEAN context.

Table 2. Baseline Panel Regression Results

Variable	Pooled OLS Coef.	Random Effects Coef.	Fixed Effects Coef.
Constant	2.4951***	4.7250***	2.8765***
Green_Economy	-0.0022	-0.0080***	-0.0094***
ln_GDP_per_Capita	0.7693***	0.6963***	0.4668***
Trade_Openness	0.0010***	-0.0009**	-0.0013***
FDI	-0.0068*	0.0021	-0.0011
ln_Gov_Expenditure	0.0200	-0.0316	0.1124*
Observations	84	84	84
R-squared	0.9916	0.9060	0.9979
Adjusted R-squared	0.9910	0.9000	0.9976
AIC	-157.3394	-253.7636	-262.3074
BIC	-142.7545	-239.1787	-233.1376

Notes: ***, **, and * indicate significance at 1%, 5%, and 10%, respectively.
Source: Author's estimation based on secondary data, 2010–2021.

The regression results show that the coefficient of renewable energy consumption share is negative across all model specifications. In the Fixed Effects Model, the coefficient is -0.0094 and statistically significant at the 1% level. Since the dependent variable is expressed in logarithmic form, a one-point increase in renewable energy consumption share is associated with an approximately 0.94% decrease in GNI per capita, ceteris paribus. This finding indicates that, within the selected ASEAN economies, a higher renewable energy consumption share is not yet associated with higher inclusive growth as measured by GNI per capita.

However, this result should not be interpreted as evidence that renewable energy inherently reduces economic welfare. Rather, the negative coefficient needs to be understood within the structural context of ASEAN's energy transition. In developing economies, a higher renewable energy share may reflect traditional biomass dependence, limited industrial energy demand, or incomplete access to modern energy systems rather than advanced green energy investment. Therefore, the coefficient may capture the structural characteristics of economies where renewable energy consumption remains linked to low-productivity energy use.

Previous studies show that traditional renewable energy may generate different development outcomes from modern renewable energy. Hmida & Rey, (2023) find

that traditional renewable energy consumption can negatively affect human development, while modern renewables tend to generate more positive outcomes in countries with higher development capacity. Similarly, Nepal et al., (2021) emphasize that excluding traditional biomass substantially reduces the measured renewable energy share in ASEAN economies. This suggests that the negative coefficient in this study is better interpreted as evidence of an incomplete green transition. Without adequate technological capability, institutional quality, research capacity, and modern energy infrastructure, renewable energy consumption may not yet translate into productivity-enhancing and welfare-improving outcomes (Damu et al., 2023; Georgescu & Kinnunen, 2024; Sheng et al., 2023). Therefore, a higher renewable energy share in some ASEAN economies may still signal structural development constraints rather than a mature green economy transition.

The empirical findings regarding the control variables provide further insight into the determinants of inclusive growth in ASEAN economies. The coefficient of lnGDPCap is positive and statistically significant, indicating that higher levels of economic development are strongly associated with higher GNI per capita. This result confirms the well-established relationship between economic development and welfare improvement. Higher productivity, stronger output capacity, and more advanced economic structures remain fundamental drivers of income growth in developing economies (Azam Khan et al., 2024; Lao & Luo, 2025).

Meanwhile, trade openness has a negative and statistically significant coefficient in the Fixed Effects Model. This finding suggests that greater trade openness does not automatically translate into welfare improvement in the selected ASEAN economies. Previous studies also show that the effect of trade openness on growth and sustainable development can be heterogeneous across countries and development levels (Ngo et al., 2026; Soyu Yıldırım & Tuğlu Dur, 2024). In the ASEAN context, this result may reflect participation in global value chains that does not always generate sufficient domestic value added, industrial upgrading, labor absorption, or inclusive distribution of trade benefits (Azaria & Sihaloho, 2021; Lisaba & Lopez, 2021). Thus, trade openness may contribute more effectively to inclusive growth when it is accompanied by domestic capability building, industrial upgrading, and stronger labor market linkages.

FDI is not statistically significant, indicating that foreign investment inflows do not necessarily improve GNI per capita unless they are connected to technology transfer, local employment creation, productivity enhancement, and domestic industrial linkages. This result is consistent with evidence showing that the effect of FDI may be statistically insignificant in some panel settings, depending on the sample, model specification, and outcome variable used (Yıldırım & Dur, 2024). Although Azaria & Sihaloho, (2021)find that FDI contributes to poverty reduction in ASEAN-5, their study uses a different dependent variable. This suggests that the welfare effect of FDI depends on the transmission channel being examined. In this study, FDI appears insufficient by itself to explain income-based inclusive growth.

Government expenditure shows a positive but weakly significant relationship with GNI per capita. This indicates that public spending may contribute to welfare improvement, although its effect remains relatively limited and depends on the quality, efficiency, and allocation of fiscal policy. This finding is consistent with Doğan et al., (2026) who show that government spending can reduce inequality in emerging Asian economies under certain conditions. In the

ASEAN context, government expenditure may support inclusive growth more effectively when it is directed toward productive infrastructure, human capital development, clean energy systems, and social protection.

The negative coefficient of renewable energy consumption share differs from several previous studies that find a positive relationship between renewable energy and economic performance. Hieu & Mai, (2023) show that renewable energy consumption can support economic growth in developing countries, while Azam et al., (2024) also confirm the growth-enhancing role of renewable energy consumption. Other studies further suggest that different renewable energy strategies may contribute positively to sustainable economic growth in Asian economies (Lao & Luo, 2025; Yıldırım & Dur, 2024; Wang et al., 2023). However, the divergence between this study and previous findings can be explained by several methodological and contextual differences.

First, this study uses GNI per capita as a welfare-oriented proxy for inclusive growth rather than GDP growth alone. This allows the analysis to capture broader income and welfare dimensions that output-based measures may overlook (Masatoshi, 2023; Viray & Mendoza, 2021). Second, the country sample focuses specifically on ASEAN economies, where renewable energy consumption may still include traditional biomass and incomplete access to modern energy systems (Hmida & Rey, 2023; Nepal et al., 2021). Third, institutional quality, technological capability, and modern energy infrastructure determine whether renewable energy consumption can be transformed into productive and welfare-enhancing outcomes (Georgescu & Kinnunen, 2024; Sheng et al., 2023; Tabash et al., 2024).

Therefore, this study does not reject the importance of renewable energy. Rather, it emphasizes that renewable energy expansion must be connected with productivity enhancement, technological upgrading, investment mobilization, institutional strengthening, and social inclusion before it can meaningfully improve welfare outcomes in ASEAN economies (Georgescu & Kinnunen, 2024; Sheng et al., 2023).

To examine whether the variables and model residuals exhibit spatial autocorrelation, Moran's I tests were conducted. The Moran's I values for GNI per capita range from approximately -0.135 to -0.119 and are not statistically significant. The Moran's I values for renewable energy consumption share range from approximately -0.0298 to 0.0198 and are also not statistically significant. These results indicate that GNI per capita and renewable energy consumption share do not form strong spatial clusters among the selected ASEAN economies. The Moran's I test on Fixed Effects residuals is presented in Table 3.

Table 3. Moran's I Test on Fixed Effects Residuals

Statistic	Value	Note
Moran's I	0.1280	Computed on stacked panel residuals using block-diagonal W
Permutation p-value, two-sided	0.0633	Monte Carlo, 9,999 replications
Permutation p-value, greater	0.0289	Right-tail probability
Permutation p-value, less	0.9712	Left-tail probability
Decision at 5%	Not significant	Spatial dependence is weak

Source: Author's calculation based on spatial weight matrix and panel estimation results.

The absence of significant spatial autocorrelation in the ASEAN sample contrasts with several previous studies that found stronger spatial dependence in more

institutionally integrated regional groupings. Chica-Olmo et al., (2020) found spatial dependence between renewable energy consumption and economic growth across European countries, where geographic proximity, cross-border energy linkages, and shared regulatory frameworks may strengthen spatial interaction. Similarly, Radmehr et al., (2024) found positive spatial spillover effects of renewable energy consumption and green technology innovation on ecological sustainability. Li et al., (2026) also provide evidence of spillover effects among G-7 economies, suggesting that globalization and cross-border interdependence can transmit changes in energy and environmental variables across countries.

The weaker spatial pattern observed in this study may be explained by ASEAN's structural heterogeneity and relatively limited regional energy integration. ASEAN member states differ substantially in geography, income levels, industrial structures, energy systems, renewable energy composition, and institutional capacity. For example, Singapore represents a highly urbanized and fossil-fuel-dependent high-income economy, while Cambodia's higher renewable energy share may still be associated with biomass reliance and lower access to modern energy services (Lisaba & Lopez, 2021; Nepal et al., 2021).

In addition, regional energy integration in ASEAN remains less advanced than in the European Union. Previous studies note that ASEAN continues to face regulatory barriers, inadequate grid infrastructure, limited clean energy investment, and weak regional policy coordination (Damu et al., 2023; Overland et al., 2021; F. Yang & Li, 2024). Institutional readiness also varies across member states, reducing the possibility that energy transition outcomes in one country will systematically spill over to neighboring economies (Tabash et al., 2024; F. Yang & Li, 2024). Therefore, the insignificant Moran's I results suggest that the green economy inclusive growth relationship in ASEAN is shaped more by domestic structural characteristics than by strong regional spatial clustering.

Although spatial dependence is weak, spatially augmented models were estimated as robustness checks. The results are shown in Table 4

Table 4. Spatial Robustness Check

Model	N	R-squared	Green Coef.	Green p-value	W_Green Coef.	W_Green p-value	W_ln_GNI Coef.	W_ln_GNI p-value
FE Baseline	84	0.9979	-0.0094	0.0000	-	-	-	-
FE-SLX Robustness	84	0.9996	-0.0044	0.0000	0.0008	0.7453	-	-
FE Spatial Lag Proxy	84	0.9991	-0.0064	0.0000	-	-	0.6619	0.0000
FE-SDM Proxy	84	0.9996	-0.0036	0.0002	0.0048	0.0761	0.4409	0.0025

Source: Author's estimation based on secondary data, 2010–2021.

The spatial robustness analysis shows that the coefficient of Green Economy remains negative and statistically significant across all spatially augmented specifications. This confirms that the baseline result is robust after incorporating potential spatial interaction. In other words, renewable energy consumption share in the selected ASEAN economies is not yet associated with higher welfare improvement, even after spatial factors are considered. Therefore, the core empirical finding remains consistent: the relationship between renewable energy consumption share and inclusive growth in ASEAN is shaped mainly by the structural characteristics of each country.

The FE-SDM Proxy model shows that the coefficient of WGreen_Economy is positive and weakly significant at the 10% level. However, this evidence is not strong

enough to be treated as the main finding. It only provides suggestive evidence that potential cross-border spillover effects may exist but remain limited. This result is consistent with Wang et al., (2023) who show that clean energy development may not directly affect local economic growth but can generate positive spillover effects in surrounding regions through technology diffusion and factor mobility.

Cao et al., (2024) also find that clean energy consumption and production can generate spatial spillover effects on sustainable economic development, although the magnitude of these effects may remain limited during the transition period. Similarly, Yang & Cui, (2022) suggest that the spatial effects of energy consumption on economic growth may vary across regions and energy types, particularly when clean energy systems are still at an early stage of development.

In the ASEAN context, the weak spatial result suggests that regional green energy linkages are not yet sufficiently developed to dominate domestic structural factors. Unlike the European Union, where integrated energy markets and more harmonized regulatory frameworks can facilitate stronger cross-border renewable energy spillovers, ASEAN's energy infrastructure and policy coordination remain relatively fragmented (Chica-Olmo et al., 2020; Radmehr et al., 2024). Previous studies note that ASEAN still faces inadequate grid infrastructure, regulatory barriers, limited clean energy investment, and weak regional coordination in energy transition policies (Damu et al., 2023; F. Yang & Li, 2024).

These constraints limit the spatial transmission mechanisms that would allow green energy development in one country to generate strong welfare effects in neighboring economies. Consequently, domestic factors such as traditional biomass dependence, institutional capacity, technological readiness, energy access, and infrastructure quality remain more important than regional spatial dynamics in explaining the renewable energy inclusive growth relationship in ASEAN.

An additional robustness check was conducted by excluding Singapore from the sample. Singapore has a much higher GNI per capita and a distinct energy structure compared with the other ASEAN economies. The result is presented in Table 5.

Table 5. Robustness Check Excluding Singapore

Model	Singapore Included	Observations	R-squared	Adjusted R-squared	Green_Economy Coef.	Green_Economy p-value	Decision
FE Baseline, 7 countries	Yes	84	0.9979	0.9976	-0.0094	0.0000	Original baseline
FE Robustness, without Singapore	No	72	0.9934	0.9923	-0.0094	0.0001	Robustness check

Source: Author's estimation based on secondary data, 2010–2021

The robustness check excluding Singapore confirms that the coefficient of Green_Economy remains negative and statistically significant. In the full sample, the coefficient is -0.0094 with a p-value of 0.0000, while after excluding Singapore the coefficient remains -0.0094 with a p-value of 0.0001. This stability indicates that the negative relationship between renewable energy consumption share and GNI per capita is not driven solely by Singapore as a high-income outlier. Instead, the result reflects a broader pattern within the selected ASEAN economies, where renewable energy consumption share has not yet become a direct driver of inclusive growth.

Overall, the findings should be interpreted as evidence of an incomplete green

economy transition rather than as evidence that renewable energy itself reduces welfare. Renewable energy expansion is necessary for sustainable development, but its contribution to inclusive growth depends on complementary conditions such as modern technology, green investment, institutional capacity, policy coherence, and inclusive development strategies. Previous studies emphasize that ASEAN's clean energy transition continues to face fragmented regulations, limited green finance, underdeveloped carbon markets, and weak regional coordination (Yang & Li, 2024; Lin et al., 2026). Similarly, eco-innovation, green energy, and environmental policy instruments can support environmental and development outcomes only when they are embedded in broader industrialization strategies, sustainable infrastructure, and institutional strengthening (Chien et al., 2023a; Chien et al., 2023b)

The main policy implication is that renewable energy policy in ASEAN should not be designed merely to increase the renewable energy share. It must be connected to broader green industrial transformation. This includes reducing dependence on fossil fuels, improving clean energy infrastructure, expanding green finance and carbon pricing mechanisms, strengthening public and private investment, supporting technology transfer, and improving regional energy cooperation (Diallo, 2025; Nepal et al., 2021; Zin Lin et al., 2026).

ASEAN countries also need stronger institutional capability and more coherent policy coordination to ensure that renewable energy development contributes to productivity, job creation, energy access, and welfare improvement. Therefore, green economy transition in ASEAN requires an integrated strategy that combines renewable energy adoption, eco-innovation, governance reform, financial development, and inclusive policy design.

CONCLUSION

This study examines the relationship between green economy transition and inclusive growth in selected ASEAN economies. Green economy transition is proxied by renewable energy consumption share, while inclusive growth is measured using GNI per capita, PPP (constant international $). Using a balanced panel dataset of seven ASEAN economies during the 2010–2021 period, this study applies panel data estimation, model selection tests, spatial diagnostics, spatial robustness checks, and an additional robustness test excluding Singapore.

The model selection results indicate that the Fixed Effects Model is the most appropriate baseline specification. The empirical findings show that renewable energy consumption share has a negative and statistically significant relationship with GNI per capita. This result remains consistent after incorporating spatially augmented specifications and after excluding Singapore from the sample. Therefore, the finding is not driven solely by Singapore as a high-income outlier, but reflects a broader pattern across the selected ASEAN economies.

This result should not be interpreted as evidence that renewable energy reduces economic welfare. Rather, it indicates that renewable energy consumption share in ASEAN may not yet fully represent a modern and productivity-enhancing green economy transition. In several developing ASEAN economies, a relatively high renewable energy share may still reflect traditional biomass use, limited industrial energy demand, lower access to modern energy systems, or incomplete clean energy infrastructure. Under these conditions, renewable energy consumption may not automatically translate into income improvement or inclusive growth.

The spatial diagnostic results indicate weak spatial dependence among the selected

ASEAN economies. This suggests that the relationship between green economy transition and inclusive growth in ASEAN is shaped mainly by domestic structural characteristics rather than strong regional spatial interaction. Differences in institutional capacity, technological readiness, energy infrastructure, industrial structure, and development stage appear to play a more important role than geographic proximity or regional spillover effects.

Overall, this study concludes that renewable energy expansion remains essential for sustainable development, but it is not sufficient by itself to promote inclusive growth. For ASEAN economies, green economy transition needs to be supported by technological upgrading, green investment, institutional capacity, modern energy infrastructure, and inclusive policy design. Renewable energy policy should therefore be integrated with broader development strategies that enhance productivity, expand access to modern energy, create employment opportunities, and ensure that the benefits of the green transition are distributed more equitably.

RECOMMENDATION (Optional)

Based on the findings, ASEAN economies should not treat green economy transition merely as an effort to increase the share of renewable energy consumption. Although renewable energy expansion is important, its contribution to inclusive growth depends on whether it is connected to productivity improvement, modern energy infrastructure, green industrial development, and broader welfare outcomes. A higher renewable energy share will have limited impact on inclusive growth if it is not supported by adequate technology, investment, institutional capacity, and policy coherence.

ASEAN policymakers should distinguish between traditional renewable energy use and modern renewable energy transition. In several developing economies, renewable energy consumption may still reflect biomass reliance, limited industrial energy demand, or incomplete access to modern energy services. Therefore, policy should prioritize the expansion of modern renewable energy systems, including solar, wind, geothermal, sustainable hydropower, and modern bioenergy. This expansion should be supported by grid modernization, energy storage technology, reliable electricity access, and stronger regulatory frameworks.

Green economy transition should also be integrated with inclusive development policies. Renewable energy development should not only reduce environmental pressure but also create employment opportunities, support small and medium enterprises, improve rural energy access, and reduce welfare gaps across regions and income groups. Without inclusive policy design, renewable energy expansion may remain concentrated in certain sectors or regions and may not automatically generate broad-based welfare improvement.

Stronger green investment and financing mechanisms are also needed to accelerate the transition. ASEAN countries should expand green finance, carbon finance, renewable energy incentives, public-private partnerships, and technology transfer mechanisms. These instruments are particularly important for countries with limited fiscal capacity, infrastructure constraints, and technological gaps. Financial support should be directed not only toward increasing renewable energy capacity, but also toward strengthening local industrial capability, research and innovation, and human capital development.

Finally, ASEAN should strengthen regional cooperation in green energy transition. Although the spatial results indicate weak regional dependence, cooperation remains important for building cross-border clean energy projects, regional

electricity trade, green technology transfer, and shared standards for sustainable investment. Stronger regional coordination can help reduce transition costs, improve energy security, and increase the capacity of member states to adopt modern renewable energy technologies. Renewable energy can support inclusive growth only when it becomes part of a broader strategy involving technological upgrading, institutional strengthening, green investment, and social inclusion.

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