Journal of Regional Economics Indonesia
Journal homepage: http://jurnal.unmer.ac.id/index.php/jrei/
Journal email: jrei@unmer.ac.id

Beyond the Environmental Kuznets Curve: The Moderating Role of Governance Quality in the Economic Growth–Deforestation Nexus across ASEAN Economies

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ARTICLE INFO

Article history:
Received 2026-06-11
Revised 2026-06-21
Accepted 2026-07-11
Published 2026-08-18

Keywords:
ASEAN Economies; Deforestation; Environmental Kuznets Curve; Governance Quality; Sustainable Development; Trade Openness

Abstract

Deforestation remains a critical environmental challenge in ASEAN amid rapid economic expansion and increasing trade integration. This study investigates the effects of economic growth and trade openness on deforestation and examines whether governance quality moderates these relationships in five ASEAN countries (Indonesia, Malaysia, Thailand, Vietnam, and the Philippines) during 2002–2023. Using panel data analysis, the Fixed Effects Model (FEM) and Moderated Regression Analysis (MRA) are employed to test the Environmental Kuznets Curve (EKC) hypothesis and the moderating role of governance. The results reveal that economic growth and trade openness significantly influence deforestation. The estimated relationship between economic growth and deforestation follows a U-shaped pattern, indicating that the EKC hypothesis is not supported in the ASEAN context. While governance quality has no significant direct effect on deforestation, it significantly moderates the impacts of economic growth and trade openness, functioning as a pure moderator. These findings highlight the pivotal role of governance in shaping environmental outcomes and underscore the importance of strengthening institutional quality to achieve sustainable development in ASEAN.

How to cite item:
Ainiyah, S. N., & Imaningsih, N. (2026). Beyond the Environmental Kuznets Curve: The moderating role of governance quality in the economic growth–deforestation nexus across ASEAN economies. *Journal of Regional Economics Indonesia, 7*(2), 218–233.

1. Introduction

Economic growth has long been regarded as a central indicator of development success because it reflects improvements in production capacity, income generation, and societal welfare. However, the pursuit of sustained economic expansion often generates environmental pressures, particularly in developing economies that rely heavily on natural resource exploitation. Rapid industrialization, infrastructure development, agricultural expansion, and increasing resource extraction frequently accelerate environmental degradation, raising concerns regarding the compatibility between economic development and environmental sustainability. Consequently, understanding the environmental consequences of economic growth has become an increasingly important issue within the literature on sustainable development and environmental economics.

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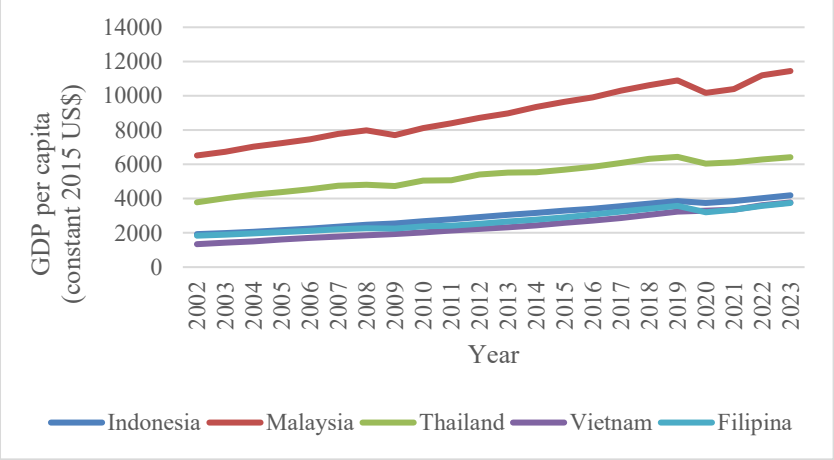
Among various forms of environmental degradation, deforestation remains one of the most critical global environmental challenges. Forest ecosystems provide essential ecological and economic services, including carbon sequestration, biodiversity conservation, water regulation, climate stabilization, and livelihood support for local communities. Nevertheless, global forest resources continue to face significant pressures due to land-use conversion, agricultural expansion, infrastructure development, and other economic activities. According to the Food and Agriculture Organization of The United Nations (2025), approximately 10.9 million hectares of forests are lost annually worldwide. Such losses not only threaten ecological sustainability but also generate substantial economic costs. Kappen et al. (2020) estimate that the total economic value of forest ecosystem services ranges between US$50 trillion and US$150 trillion, while the World Bank (2021) reports that environmental degradation associated with ecosystem loss may reduce global economic output by as much as US$2.7 trillion annually. These findings indicate that deforestation constitutes not merely an environmental issue but also a significant challenge to long-term economic development.

The issue is particularly relevant in Southeast Asia, where economic development has accelerated considerably during the last two decades. Indonesia, Malaysia, Thailand, Vietnam, and the Philippines have experienced substantial economic transformation characterized by industrialization, urbanization, and increasing integration into global markets. At the same time, these countries continue to face persistent challenges in preserving forest resources. ASEAN contributes approximately 28% of global forest loss, accounting for nearly six million hectares annually (Ritchie, 2021). A substantial proportion of this loss occurs in Indonesia, Malaysia, Thailand, Vietnam, and the Philippines (Asia, 2022; Earth, 2023). These developments suggest that economic expansion may continue to exert considerable pressure on forest ecosystems despite improvements in national income levels.

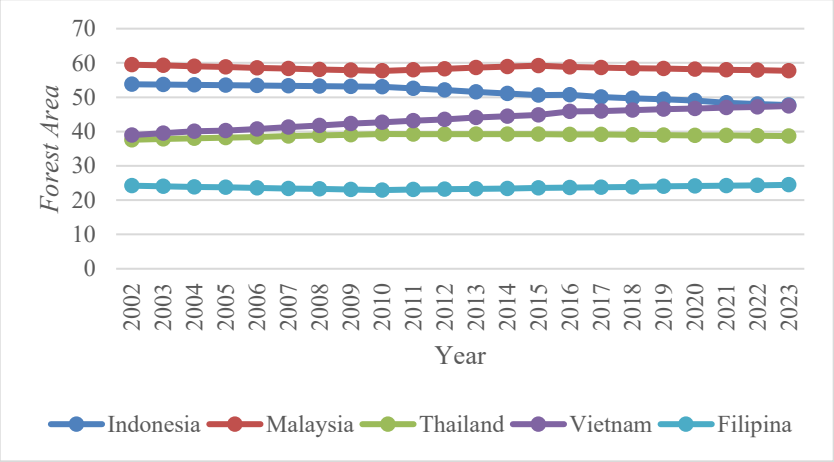
Figure 1. GDP per Capita (Constant 2015 US$) in Five ASEAN Countries, 2002–2023



Source: Processed from World Bank (2025b).

As illustrated in Figures 1 and 2, economic growth across the five ASEAN countries exhibits a consistently upward trend over the study period. In contrast, changes in forest area display heterogeneous patterns. While some countries experience continuous declines in forest cover, others show relatively stable or improving forest conditions. These divergent trends indicate that the relationship between economic growth and deforestation is unlikely to be purely linear and may be influenced by additional institutional and structural factors.

Figure 2. Forest Area Trends in Five ASEAN Countries, 2002–2023



Source: Processed from World Bank (2025a).

The theoretical framework most frequently employed to explain the relationship between economic development and environmental degradation is the Environmental Kuznets Curve (EKC) hypothesis. Originating from Kuznets (1966), the EKC proposes that environmental degradation initially increases during the early stages of economic development as production activities expand and natural resources are intensively utilized. However, after income reaches a certain threshold, environmental degradation is expected to decline due to technological advancement, stronger environmental awareness, improved regulatory frameworks, and structural transformation toward less resource-intensive sectors. Although the EKC has been widely examined, empirical findings regarding deforestation remain inconclusive. Some studies provide evidence supporting the EKC hypothesis, suggesting that rising income eventually contributes to forest conservation (Hutajulu et al., 2025). In contrast, other studies report that economic growth continues to exacerbate deforestation, thereby rejecting the EKC proposition (Ajong, Kechia and Ndzifon, 2022; Sousa, Irffi and Asevedo, 2022).

These inconsistent findings imply that the relationship between economic growth and deforestation may depend on country-specific institutional characteristics. Within the institutional economics perspective, governance quality plays a crucial role in determining how economic activities affect environmental outcomes. Governance reflects the effectiveness of public institutions in designing and implementing policies, enforcing laws, controlling corruption, maintaining political stability, and ensuring accountability in resource management (Mardiasmo, 2018; Nugroho, 2023). Strong governance systems can improve environmental regulation and strengthen monitoring mechanisms, thereby mitigating the adverse environmental consequences of economic activities. Conversely, weak institutions may allow economic growth to occur at the expense of environmental sustainability (Yusuf, 2023; Directory, 2025).

Previous studies have predominantly focused on the direct effects of economic growth or governance on environmental quality. However, limited attention has been given to the moderating role of governance in shaping the relationship between economic growth, trade openness, and deforestation, particularly within the ASEAN context. Moreover, substantial differences in institutional quality across ASEAN countries suggest that governance may influence how economic expansion translates into environmental outcomes. This research gap remains largely unexplored in the regional literature.

Therefore, this study investigates the relationship between economic growth and deforestation in five ASEAN countries, namely Indonesia, Malaysia, Thailand, Vietnam, and the Philippines, over the period 2002–2023. Specifically, it examines whether governance quality moderates the impacts of economic growth and trade openness on deforestation within the Environmental Kuznets Curve framework. By integrating environmental economics and institutional perspectives, this study contributes to the growing literature on sustainable development while providing policy-relevant evidence for strengthening governance mechanisms to balance economic growth and forest conservation in ASEAN.

2. Literature Review

Deforestation and Sustainable Development

Deforestation has become one of the most pressing environmental challenges confronting both developed and developing countries. The phenomenon refers to the permanent conversion of forested land into non-forest uses, including agricultural expansion, urban development, industrial activities, infrastructure construction, and mining operations. Forest ecosystems perform essential ecological functions by serving as carbon sinks, regulating hydrological cycles, preserving biodiversity, and supporting the livelihoods of millions of people. Consequently, the continued decline of forest resources raises serious concerns regarding environmental sustainability, climate change mitigation, and long-term economic resilience.

From the sustainable development perspective, forests represent a form of natural capital that contributes directly and indirectly to economic welfare. The depletion of forest resources may generate short-term economic gains through increased production and investment opportunities; however, it can also create long-term environmental costs that undermine sustainable growth. According to Kappen et al. (2020), the economic value of forest ecosystem services is estimated to range between US$50 trillion and US$150 trillion globally, highlighting the substantial contribution of forests to economic and environmental systems. Similarly, the World Bank (2021) reports that environmental degradation resulting from ecosystem loss could reduce global economic output by approximately US$2.7 trillion annually.

In the ASEAN region, deforestation remains a particularly important issue due to the area's high dependence on natural-resource-based economic activities. Countries such as Indonesia, Malaysia, Thailand, Vietnam, and the Philippines continue to experience significant pressure on forest resources as a consequence of agricultural expansion, industrialization, infrastructure development, and trade integration. According to Ritchie (2021), ASEAN contributes approximately 28% of global forest loss, equivalent to nearly six million hectares annually. Such trends indicate that understanding the determinants of deforestation is crucial for designing effective environmental policies capable of balancing economic development and ecological sustainability.

Environmental Kuznets Curve Hypothesis

The relationship between economic growth and environmental degradation is commonly explained through the Environmental Kuznets Curve (EKC) hypothesis. The EKC framework originates from the work of Kuznets (1966), who initially proposed a nonlinear relationship between income inequality and economic development. This concept was subsequently adapted to environmental economics to explain how environmental quality evolves alongside economic growth.

The EKC hypothesis suggests that environmental degradation initially increases during the early stages of economic development due to industrialization, urbanization, capital accumulation, and the intensive utilization of natural resources. As income levels rise further, societies begin to demand higher environmental quality, governments strengthen environmental regulations, and firms adopt cleaner

technologies. Consequently, environmental degradation eventually declines after a certain income threshold is reached.

The EKC relationship is commonly represented as an inverted U-shaped curve:

$$DEF_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + \varepsilon_{it}$$

where: DEFrepresents deforestation, GDPdenotes economic growth, GDP^2captures the nonlinear effect of income.

The EKC hypothesis is supported when:

$$\beta_1 > 0 \text{ and } \beta_2 < 0$$

indicating that environmental degradation increases initially and subsequently decreases after a turning point is achieved.

Empirical evidence regarding the EKC remains mixed. Hutajulu et al. (2025) find support for the EKC hypothesis, suggesting that higher income levels eventually contribute to environmental improvement and forest conservation. In contrast, Ajong, Kechia and Ndzifon (2022) and Sousa, Irffi and Asevedo (2022) report that economic growth continues to exert pressure on environmental resources, thereby rejecting the EKC proposition. These conflicting findings imply that economic growth alone may be insufficient to explain environmental outcomes and that institutional factors may play an important moderating role.

Trade Openness and Deforestation

Trade openness has become an increasingly important determinant of environmental change in developing economies. Greater integration into international markets can stimulate economic growth through increased exports, foreign investment, technological transfer, and productivity gains. However, trade liberalization may also increase pressure on natural resources by expanding production activities in export-oriented sectors.

The relationship between trade openness and environmental degradation is generally explained through three mechanisms: the scale effect, composition effect, and technique effect. The scale effect suggests that increased trade stimulates production and resource utilization, potentially accelerating environmental degradation. The composition effect occurs when countries specialize in sectors where they possess comparative advantages, which may either increase or reduce environmental pressure depending on industrial structure. Meanwhile, the technique effect implies that international trade facilitates technological diffusion and environmental innovation, thereby improving environmental quality.

For resource-rich economies, trade expansion often increases demand for agricultural commodities, timber products, and other natural resources associated with forest conversion. Consequently, greater trade openness may contribute to deforestation if environmental regulations remain weak. Several empirical studies report a positive association between trade openness and environmental degradation, particularly in developing countries where institutional capacity remains limited (Ajong, Kechia and Ndzifon, 2022; Sousa, Irffi and Asevedo, 2022). Nevertheless, other studies indicate that trade openness can improve environmental outcomes through technology transfer and higher environmental standards.

These contrasting findings suggest that the environmental consequences of trade openness depend largely on institutional quality and governance effectiveness.

Governance Quality and Environmental Outcomes

Governance quality represents a critical institutional factor influencing environmental sustainability. Governance broadly refers to the processes through which authority is exercised in

managing a country's economic and social resources. Effective governance contributes to policy implementation, regulatory enforcement, transparency, accountability, and institutional stability (Mardiasmo, 2018; Nugroho, 2023).

The World Governance Indicators (WGI) framework conceptualizes governance through six dimensions: Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, Control of Corruption.

Strong governance institutions enhance governments' capacity to formulate and enforce environmental regulations, monitor resource exploitation, and prevent illegal logging activities. Conversely, weak governance may encourage rent-seeking behavior, regulatory failures, and unsustainable resource extraction practices that accelerate deforestation.

Yusuf (2023) argues that institutional effectiveness plays a decisive role in achieving sustainable development objectives, particularly in countries facing significant environmental pressures. Similarly, Directory (2025) emphasizes that governance quality determines the effectiveness of environmental management systems and policy implementation. Consequently, governance quality is increasingly recognized as a key determinant of environmental performance.

Governance as a Moderator of the Growth–Deforestation Nexus

Recent developments in environmental economics increasingly emphasize the importance of institutional factors in shaping the relationship between economic development and environmental outcomes. While economic growth and trade openness may influence deforestation directly, their impacts are likely to vary depending on governance quality.

Under strong governance systems, economic growth can be accompanied by stricter environmental regulation, improved forest monitoring, stronger law enforcement, and increased investments in sustainable resource management. In such contexts, governance may weaken the adverse environmental consequences of economic expansion. Conversely, weak institutions may allow growth and trade activities to occur without adequate environmental safeguards, thereby intensifying deforestation.

Similarly, governance quality may influence how trade openness affects forest resources. Effective institutions can ensure that trade-related economic gains are accompanied by environmental protection measures, whereas weak governance may exacerbate resource exploitation driven by international market demand.

Table 1. Summary of Theoretical Relationships

Variable	**Expected Relationship with Deforestation**	**Theoretical Basis**
Economic Growth	Positive/Nonlinear	Environmental Kuznets Curve
Economic Growth²	Negative (EKC)	Environmental Kuznets Curve
Trade Openness	Positive or Negative	Scale, Composition, and Technique Effects
Governance Quality	Negative	Institutional Theory
Growth × Governance	Moderating Effect	Institutional Environmental Governance
Trade × Governance	Moderating Effect	Institutional Environmental Governance

Source: Developed by the authors based on Kuznets (1966), Mardiasmo (2018), Nugroho (2023), Yusuf (2023), and related literature cited in the study.

Despite growing interest in institutional determinants of environmental sustainability, empirical studies examining governance as a moderating factor in the relationship between economic growth, trade openness, and deforestation remain relatively limited, particularly within ASEAN countries. This gap is important because ASEAN economies exhibit substantial variation in governance quality, economic structures, and environmental performance.

Accordingly, this study extends the Environmental Kuznets Curve framework by incorporating governance quality as a moderating variable (See Table 1). By doing so, it contributes to the literature on environmental economics and sustainable development while providing new evidence regarding the institutional conditions under which economic growth and trade integration influence deforestation in ASEAN economies.

3. Methodology

Research Design

This study investigates the relationship between economic growth and deforestation and examines the moderating role of governance quality in five ASEAN countries, namely Indonesia, Malaysia, Thailand, Vietnam, and the Philippines. These countries were selected because they represent the largest forest-resource holders in Southeast Asia and have experienced substantial economic transformation during the last two decades. At the same time, they continue to face considerable challenges related to forest conservation and environmental sustainability.

Data and Sample Selection

The study employs annual panel data covering the period 2002–2023, resulting in a balanced panel dataset. Panel data analysis is particularly suitable because it enables the simultaneous examination of cross-country and time-series variations while increasing the number of observations and improving estimation efficiency.

Secondary data were obtained from internationally recognized databases. Data on forest area and economic growth were collected from the World Development Indicators (WDI) published by the World Bank (2025a; 2025b). Governance quality data were obtained from the Worldwide Governance Indicators (WGI) database developed by the World Bank, while trade openness data were retrieved from the World Development Indicators database.

The selection of the study period was based on data availability and consistency across all variables included in the empirical model. The period also captures significant economic, institutional, and environmental changes experienced by ASEAN countries following increasing globalization and regional economic integration.

Variable Measurement

The study consists of one dependent variable, three independent variables, one moderating variable, and two interaction terms are presented in Table 2 and Figure 3. The dependent variable is Deforestation (DEF), proxied by Forest Area (% of Land Area). Forest area reflects the proportion of land covered by forests and is widely used as an indicator of forest resource conditions in environmental studies. Data were obtained from the World Development Indicators database.

Independent Variables, Economic Growth (GDP) is measured using GDP per capita at constant 2015 US dollars. This variable captures the level of economic development and serves as the primary explanatory variable within the Environmental Kuznets Curve (EKC) framework.

To test the nonlinear relationship proposed by the EKC hypothesis, the study includes GDP Squared (GDP^2) as a quadratic term.

Trade Openness (TO) is measured as the ratio of total exports and imports to Gross Domestic Product (GDP). This indicator reflects the degree of integration of each country into the global economy.

Moderating Variable, Governance Quality (GOV) is measured using the average value of six dimensions of the Worldwide Governance Indicators (WGI), namely: Voice and Accountability (VA), Political Stability and Absence of Violence (PS), Government Effectiveness (GE), Regulatory Quality (RQ), Rule of Law (RL), Control of Corruption (CC).

Following the approach adopted in the original study, governance quality is calculated as:

$$GOV = \frac{VA + PS + GE + RQ + RL + CC}{6}$$

Interaction Variables, to assess the moderating role of governance quality, two interaction terms are incorporated into the empirical model:

$$GDP \times GOV$$

and

$$TO \times GOV$$

These interaction variables capture whether governance quality alters the effects of economic growth and trade openness on deforestation.

Table 2. Variable Definitions and Measurements

Variable	Symbol	Measurement	Source
Deforestation	DEF	Forest Area (% of Land Area)	World Bank (2025a)
Economic Growth	GDP	GDP per Capita (Constant 2015 US$)	World Bank (2025b)
Economic Growth Squared	GDP^2	Square of GDP per Capita	Author's Calculation
Trade Openness	TO	(Exports + Imports)/GDP (%)	World Bank
Governance Quality	GOV	Average of Six WGI Indicators	World Governance Indicators
Growth × Governance	GDP×GOV	Interaction Term	Author's Calculation
Trade × Governance	TO×GOV	Interaction Term	Author's Calculation

Source: Compiled by the authors based on the study variables.

Model Specification

To examine the Environmental Kuznets Curve (EKC) hypothesis and the moderating role of governance quality, the study estimates the following panel regression model:

$$DEF_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + \beta_3 TO_{it} + \beta_4 GOV_{it} + \beta_5 (GDP \times GOV)_{it} + \beta_6 (TO \times GOV)_{it} + \varepsilon_{it}$$

where: $i$denotes country, $t$denotes year, $\beta_0$is the intercept, $\beta_1 - \beta_6$are regression coefficients, $\varepsilon_{it}$is the error term.

The EKC hypothesis is supported when:

$\beta_1 > 0$ and $\beta_2 < 0$

indicating an inverted U-shaped relationship between economic growth and environmental degradation.

Estimation Technique

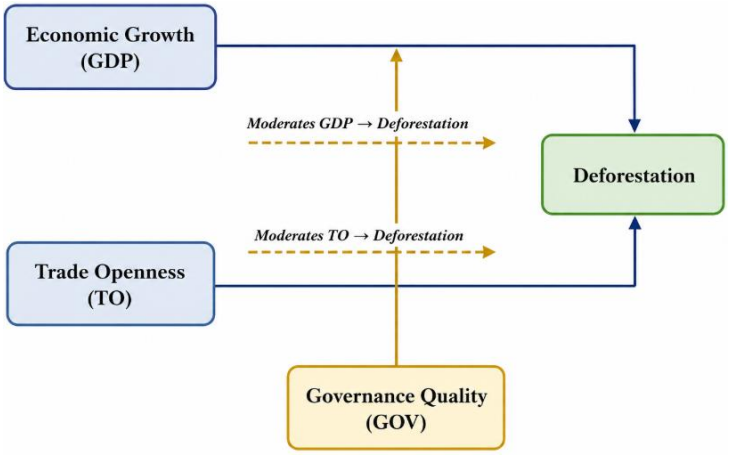
The analysis employs panel data regression techniques. Three alternative panel models are initially estimated: Common Effect Model (CEM), Fixed Effects Model (FEM), Random Effects Model (REM).

To identify the most appropriate specification, several model-selection procedures are conducted, including the Chow Test, Hausman Test, and Lagrange Multiplier Test. Based on the results reported in the study, the Fixed Effects Model (FEM) is selected as the preferred estimator because it adequately controls for unobserved country-specific heterogeneity.

Subsequently, Moderated Regression Analysis (MRA) is applied to evaluate whether governance quality moderates the relationships between economic growth, trade openness, and deforestation.

To ensure the reliability of the estimated coefficients, several diagnostic tests are conducted, including tests for multicollinearity, heteroskedasticity, and normality. These procedures are intended to verify the validity of the regression assumptions and improve the robustness of empirical findings.

Figure 3. Research Framework



Source: Developed by the authors based on the Environmental Kuznets Curve framework and governance theory.

4. Results

Panel Model Selection

The first stage of the analysis involved determining the most appropriate panel-data estimator. Following the empirical strategy outlined in the methodology, model selection was conducted using the Chow Test, Hausman Test, and Breusch–Pagan Lagrange Multiplier (LM) Test. The purpose of these procedures was to identify whether the Common Effect Model (CEM), Random Effect Model (REM), or Fixed Effect Model (FEM) provided the most suitable specification for the dataset (See Table 3).

Table 3. Panel Model Selection Results

Test	Model Comparison	Probability	Decision	Selected Model
Chow Test	CEM vs FEM	0.0000	Reject CEM	FEM
Hausman Test	REM vs FEM	0.0000	Reject REM	FEM
Breusch–Pagan LM Test	CEM vs REM	0.0000	Reject CEM	REM

Source: Processed using EViews 13.

The Chow test produced a probability value of 0.0000, indicating that the Common Effect Model was inappropriate and that the Fixed Effect Model was preferable. Similarly, the Hausman test generated a probability value of 0.0000, confirming that FEM was superior to REM. Although the LM

test suggested the use of REM relative to CEM, the combined evidence from the Chow and Hausman tests strongly supported FEM as the final estimator. Consequently, all subsequent analyses were conducted using the Fixed Effect Model.

The selection of FEM is theoretically justified because the sample consists of five ASEAN countries with different economic structures, governance systems, and environmental conditions. The fixed-effects specification controls for unobservable country-specific characteristics that remain constant over time, thereby reducing omitted-variable bias and improving coefficient consistency.

Diagnostic Tests

Prior to estimating the regression models, a series of diagnostic tests was conducted to evaluate whether the panel regression satisfied the required statistical assumptions. These tests included normality (See Table 4), multicollinearity (See Table 5), and heteroskedasticity assessments.

Table 4. Normality Test

Statistic	Value
Jarque–Bera Probability	0.910129

Source: Processed using EViews 13.

The Jarque–Bera probability value of 0.910129 exceeds the 5% significance threshold, indicating that the residuals are normally distributed. Thus, the null hypothesis of normality cannot be rejected.

Table 5. Multicollinearity Test (Correlation Matrix)

Variable Pair	Correlation
GDP and GDP^2	0.966
Governance and GDP	0.864
Governance and GDP^2	0.856

Source: Processed using EViews 13.

The multicollinearity assessment indicates that the model is free from serious collinearity problems. Although GDP and GDP^2 exhibit a relatively high correlation (0.966), this result is expected because GDP^2 is a quadratic transformation of GDP used to test the Environmental Kuznets Curve (EKC) hypothesis. Therefore, the correlation does not invalidate the empirical specification.

Baseline Regression Results

The baseline regression model was estimated to evaluate the direct effects of economic growth, economic growth squared, trade openness, and governance quality on deforestation.

The findings indicate that GDP does not exert a statistically significant effect on deforestation in the baseline specification. In contrast, GDP^2 and trade openness display positive and statistically significant coefficients, suggesting that increasing income levels and greater trade integration are associated with changes in forest resources. Governance quality exhibits a negative and statistically significant relationship with deforestation, implying that stronger institutions contribute to environmental protection and forest preservation.

The positive coefficient of GDP^2 is particularly noteworthy because it implies that the relationship between economic growth and deforestation does not follow the conventional inverted-U pattern predicted by the Environmental Kuznets Curve hypothesis. Instead, the empirical evidence suggests a U-shaped relationship, indicating that environmental pressure increases again at higher levels of economic development. This finding implies that economic growth alone is insufficient to guarantee forest conservation in ASEAN economies.

Moderating Role of Governance Quality

To investigate whether governance quality alters the relationship between economic growth, trade openness, and deforestation, Moderated Regression Analysis (MRA) was performed (See Table 6). The moderating model incorporated three interaction terms: GDP × GOV, GDP² × GOV, and TO × GOV.

Table 6. Moderated Regression Results

Variable	Coefficient	t-Statistic	Probability
GDP (X1)	-0.001250	-2.530756	0.0194
GDP² (X2)	3.773172	3.196970	0.0043
Trade Openness (X3)	4.850991	5.007684	0.0001
Governance (Z)	-3.988099	-1.647055	0.1144
GDP × GOV	-0.002873	-2.894503	0.0087
GDP² × GOV	2.98E-07	4.840252	0.0001
TO × GOV	0.049720	2.859597	0.0094

Source: Processed using EViews 13.

The moderating model reveals several important findings. First, GDP becomes statistically significant and exhibits a negative coefficient, while GDP² remains positive and significant. Together, these coefficients confirm the existence of a U-shaped relationship between economic growth and deforestation. Consequently, the Environmental Kuznets Curve hypothesis is not supported within the ASEAN sample.

Second, trade openness maintains a positive and significant effect on deforestation. This finding suggests that increasing integration into international markets may intensify pressure on forest resources through expanding production activities, land conversion, and export-oriented resource extraction.

Third, governance quality itself is no longer statistically significant once interaction terms are included ($p = 0.1144$). However, all interaction variables are significant at the 5% level, indicating that governance significantly modifies the effects of economic growth and trade openness on deforestation. Specifically, GDP × GOV is negative and significant ($p = 0.0087$), GDP² × GOV is positive and significant ($p = 0.0001$), and TO × GOV is positive and significant ($p = 0.0094$).

Classification of Governance as a Moderator

The significance pattern observed in the moderating model allows governance quality to be classified according to moderation theory (See Table 7).

Table 7. Moderation Classification

Variable	Probability	Significance	Moderation Type
GOV	0.1144	Not Significant	–
GDP × GOV	0.0087	Significant	Pure Moderator
GDP² × GOV	0.0001	Significant	Pure Moderator
TO × GOV	0.0094	Significant	Pure Moderator

Source: Processed using EViews 13.

Because governance quality is not significant as a standalone predictor, but all interaction terms are significant, governance functions as a pure moderator. In other words, governance does not directly

determine deforestation outcomes; rather, it shapes how economic growth and trade openness affect forest resources.

Goodness-of-Fit and Hypothesis Testing

The overall model demonstrates substantial explanatory power. The coefficient of determination (R^2) equals 0.994749, while the adjusted R^2 reaches 0.994160, indicating that approximately 99% of variation in deforestation can be explained by the included variables and interaction terms.

Furthermore, the F-statistic of 1687.798 with a probability value of 0.000000 confirms that the model is jointly significant. Therefore, the explanatory variables collectively provide strong evidence in explaining deforestation dynamics across the five ASEAN countries during 2002–2023.

Overall, the empirical results suggest that economic growth and trade openness remain important determinants of deforestation, while governance quality plays a critical role in conditioning the environmental consequences of economic activity. These findings provide strong evidence that institutional quality constitutes a key element in promoting sustainable development and forest conservation within ASEAN economies.

5. Discussion

The primary objective of this study was to examine the relationship between economic growth, trade openness, and deforestation within the Environmental Kuznets Curve (EKC) framework while evaluating the moderating role of governance quality in five ASEAN countries during 2002–2023. The empirical findings provide several important insights into the environmental consequences of economic development and institutional quality in emerging economies.

First, the results reveal that economic growth and its quadratic term exhibit statistically significant effects on deforestation, indicating the existence of a nonlinear relationship. Specifically, the coefficient of GDP is negative, while the coefficient of GDP^2 is positive, implying a U-shaped relationship between economic growth and deforestation. This finding suggests that the Environmental Kuznets Curve hypothesis is not supported in the ASEAN context. Instead of observing an inverted-U pattern in which environmental degradation declines after a certain income threshold, the results indicate that deforestation tends to increase again at higher levels of economic development.

This outcome may reflect the structural characteristics of ASEAN economies, where economic growth remains highly dependent on land-intensive sectors such as agriculture, plantations, forestry, mining, and infrastructure development. During the early stages of development, improvements in productivity and technological efficiency may temporarily reduce pressure on forest resources. However, as income levels increase, rising domestic consumption, urban expansion, industrial activities, and demand for export-oriented commodities may intensify land conversion and forest exploitation. Consequently, higher income levels do not automatically translate into environmental improvements. This finding aligns with studies by Ajong, Kechia and Ndzifon (2022) and Sousa, Irffi and Asevedo (2022), which argue that economic growth may continue to generate environmental degradation when institutional capacity and environmental governance remain insufficient.

The rejection of the EKC hypothesis also implies that market-driven economic development alone cannot guarantee forest conservation. Although economic growth generates additional fiscal resources that could support environmental protection, these benefits may not materialize without effective governance mechanisms. Therefore, institutional quality becomes a critical determinant of whether economic expansion contributes to sustainable development or accelerates environmental degradation.

Second, the results demonstrate that trade openness exerts a positive and statistically significant effect on deforestation. This finding suggests that increasing integration into international markets may create additional pressure on forest resources within ASEAN countries. Trade liberalization often

stimulates export-oriented production activities, particularly in sectors such as palm oil, timber products, agricultural commodities, and extractive industries. As global demand for these products increases, producers may expand cultivated land and production capacity through forest conversion.

From a theoretical perspective, this result supports the scale effect argument, which posits that trade expansion increases economic activity and resource utilization. While trade openness may facilitate technology transfer and productivity improvements, the environmental benefits associated with the technique effect appear insufficient to offset the environmental costs generated by increased production. Consequently, the overall impact of trade openness on forest resources remains adverse within the ASEAN sample. These findings reinforce concerns that trade integration without adequate environmental safeguards may accelerate ecosystem degradation and undermine long-term sustainability objectives.

Third, governance quality exhibits a unique role within the empirical model. The results indicate that governance does not exert a statistically significant direct effect on deforestation after interaction terms are introduced. However, governance significantly moderates the relationships between economic growth, trade openness, and deforestation. According to moderation analysis, governance functions as a pure moderator because its direct effect becomes insignificant while all interaction terms remain statistically significant.

The significance of the GDP × GOV interaction suggests that governance quality influences how economic growth affects forest resources. In countries characterized by stronger institutions, economic expansion may be accompanied by more effective environmental regulation, better monitoring systems, enhanced enforcement capacity, and improved accountability mechanisms. Consequently, the environmental costs associated with economic growth can be partially mitigated through institutional interventions. Conversely, weak governance may allow economic activities to proceed without adequate environmental oversight, thereby increasing the likelihood of deforestation.

Similarly, the significance of the trade openness interaction term indicates that governance quality shapes the environmental consequences of international economic integration. Effective governance can encourage sustainable trade practices through regulatory frameworks, certification systems, environmental standards, and enforcement mechanisms. In contrast, weak institutions may create opportunities for illegal logging, regulatory non-compliance, and unsustainable resource extraction. Therefore, governance quality determines whether trade openness contributes to sustainable development or intensifies environmental degradation.

These findings are consistent with institutional theories emphasizing that environmental outcomes are not determined solely by economic factors but are also shaped by the quality of public institutions. As argued by Mardiasmo (2018), Nugroho (2023), and Yusuf (2023), governance effectiveness plays a central role in ensuring that economic development occurs within environmentally sustainable boundaries. The present study extends this argument by demonstrating that governance quality influences not only environmental outcomes directly but also the mechanisms through which economic growth and trade integration affect forest resources.

Overall, the findings suggest that the sustainability of economic development in ASEAN depends not merely on increasing income levels or expanding international trade but also on strengthening institutional capacity. The absence of EKC support indicates that economic growth alone cannot be relied upon to solve environmental problems. Instead, effective governance constitutes a necessary condition for achieving a balance between economic development and forest conservation.

Policy Implications and Recommendations

The findings of this study offer several important policy implications for ASEAN countries seeking to achieve sustainable economic development while preserving forest resources. First, policymakers should recognize that economic growth alone does not automatically lead to environmental improvement. The rejection of the Environmental Kuznets Curve hypothesis indicates that rising income levels may continue to exert pressure on forest ecosystems unless accompanied by effective environmental policies and institutional reforms. Therefore, environmental sustainability objectives should be integrated into national development strategies rather than treated as secondary outcomes of economic growth.

Second, governments should strengthen governance quality by improving regulatory effectiveness, enhancing law enforcement, reducing corruption, and increasing institutional accountability in natural resource management. Because governance functions as a pure moderator, stronger institutions can reduce the adverse environmental consequences of economic growth and trade openness. Particular attention should be directed toward forest monitoring systems, environmental impact assessments, and anti-illegal logging initiatives.

Third, ASEAN countries should adopt sustainable trade policies that balance economic competitiveness with environmental protection. Export-oriented industries should be encouraged to comply with environmental certification schemes, sustainable production standards, and responsible land-use practices. Regional cooperation may also facilitate the harmonization of environmental regulations and improve cross-border forest governance.

Finally, future policy frameworks should promote green growth strategies by encouraging investments in environmentally friendly technologies, sustainable agriculture, and low-carbon industries. Such measures would enable ASEAN economies to sustain economic growth while minimizing pressures on forest resources and supporting long-term sustainable development goals.

6. Conclusion

This study investigates the relationship between economic growth, trade openness, and deforestation while examining the moderating role of governance quality in five ASEAN countries during the period 2002–2023. Using panel data analysis with the Fixed Effects Model (FEM) and Moderated Regression Analysis (MRA), the findings provide important insights into the environmental consequences of economic development in the ASEAN region.

The empirical results indicate that economic growth and trade openness significantly influence deforestation. The estimated coefficients of GDP and GDP^2 reveal a U-shaped relationship between economic growth and deforestation, suggesting that the Environmental Kuznets Curve (EKC) hypothesis is not supported in the selected ASEAN countries. This finding implies that increasing income levels do not necessarily lead to environmental improvement and may instead generate renewed pressure on forest resources at higher stages of economic development. Furthermore, trade openness is found to exert a positive and significant effect on deforestation, indicating that greater integration into international markets may accelerate forest resource exploitation.

The study also finds that governance quality does not have a significant direct effect on deforestation after the inclusion of interaction terms. However, governance significantly moderates the effects of economic growth and trade openness on deforestation and functions as a pure moderator. These findings highlight the critical role of institutional quality in shaping environmental outcomes and determining whether economic expansion and trade integration contribute to sustainable development.

Overall, the results underscore that achieving sustainable forest management in ASEAN requires not only economic growth but also strong governance institutions capable of ensuring effective environmental regulation, resource monitoring, and policy implementation. Strengthening governance

quality is therefore essential for balancing economic development objectives with long-term forest conservation and environmental sustainability.

References

Ajong, N., Kechia, A., & Ndzifon, J. (2022). Economic activities and deforestation in the Congo Basin: An environmental Kuznets curve framework analysis. *Environmental Challenges, 8*, 100553. https://doi.org/10.1016/j.envc.2022.100553

Asia, O. L. (2022). *Deforestasi di Asia Tenggara*. RFMRC-SEA. https://rfmrc-sea.org/deforestation-in-southeast-asia/

Bank, W. (2025a). *Forest area (% of land area)*. World Bank Group. https://data.worldbank.org/indicator/AG.LND.FRST.ZS

Bank, W. (2025b). *GDP per capita (constant 2015 US$)*. World Bank Group. https://data.worldbank.org/indicator/NY.GDP.PCAP.KD

Directory, S. (2025). *Environmental market failures*. Sustainability Directory. https://pollution.sustainability-directory.com/term/environmental-market-failures/

Earth, G. (2023). *Deforestation in Asia: A call for conservation*. Green Earth. https://www.green.earth/blog/deforestation-in-asia-a-call-for-conservation

Food and Agriculture Organization of the United Nations. (2025). *Global deforestation slows, but forests remain under pressure, FAO report shows*. FAO. https://www.fao.org/newsroom/detail/global-deforestation-slows--but-forests-remain-under-pressure--fao-report-shows/en

Hutajulu, H. (2025). *Ekonomi sumber daya alam dan lingkungan*. Sonpedia.

Kappen, G. (2020). *The staggering value of forests—and how to save them*. Boston Consulting Group. https://www.bcg.com/publications/2020/the-staggering-value-of-forests-and-how-to-save-them

Kuznets, S. (1966). *Modern economic growth: Rate, structure, and spread*. Yale University Press.

Mardiasmo. (2018). *Akuntansi sektor publik* (Edisi terbaru). Andi Offset.

Nugroho, R. (2023). *Public policy 7: Dinamika kebijakan publik, analisis kebijakan publik, manajemen politik kebijakan publik, etika kebijakan publik*. PT Elex Media Komputindo.

Ritchie, H. (2021). *Deforestation and forest loss*. Our World in Data. https://ourworldindata.org/deforestation

Sousa, W. L. de, Irffi, G., & Asevedo, M. D. G. de. (2022). Deforestation of the Atlantic Forest in the state of Ceará: Analysis of the Environmental Kuznets Curve from panel data, 2011–2017. *Revista de Economia e Sociologia Rural, 60*(1), 1–18. https://doi.org/10.1590/1806-9479.2021.229884

World Bank. (2021). *Protecting nature could avert global economic losses of $2.7 trillion per year*. World Bank Group. https://www.worldbank.org/en/news/press-release/2021/07/01/protecting-nature-could-avert-global-economic-losses-of-usd2-7-trillion-per-year

Yusuf, M. (2023). Corruption, development, and deforestation: An evidence from Southeast Asian countries. *Kinerja, 27*(2), 178–191. https://doi.org/10.24002/kinerja.v27i2.7036