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Economic Transformation And Ecological Pressures: Determinants Of Deforestation On The Island Of Kalimantan

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Abstract

Deforestation in tropical regions remains a critical environmental challenge, particularly in resource-rich areas where economic development is strongly associated with land-intensive activities. Although economic growth is often considered a driver of environmental degradation, empirical evidence suggests that the relationship between economic expansion and forest loss depends on the structure of economic activities. This study aims to investigate the determinants of tree cover loss in Kalimantan Island by examining the effects of coal mining contribution, oil palm plantation expansion, and regional economic growth. Using provincial panel data from Kalimantan during the period of 2015–2024, this study employs a panel data regression approach based on the Random Effect Model (REM). The dependent variable is annual tree cover loss, while the explanatory variables include the contribution of coal mining to regional GDP, oil palm plantation area, and Gross Regional Domestic Product (GRDP). The empirical results reveal that oil palm plantation expansion is the most influential determinant of forest loss, showing a positive and statistically significant relationship with tree cover loss. This finding indicates that land conversion associated with agricultural expansion remains the primary pressure on forest ecosystems in Kalimantan. Meanwhile, coal mining contribution exhibits a positive but marginal relationship with forest loss, suggesting that extractive activities may increase environmental pressure through direct land conversion and infrastructure development, although the effect is sensitive to governance conditions. In contrast, GRDP does not show a statistically significant effect, indicating that economic growth alone does not necessarily translate into higher deforestation when growth originates from less land-intensive sectors. This study contributes to the environmental economics literature by demonstrating that forest loss in resource-rich regions is shaped more strongly by the composition of economic activities than by aggregate economic

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growth. The findings highlight the importance of sustainable land-use governance, responsible palm oil development, improved post-mining rehabilitation, and economic diversification strategies to achieve a balance between regional development and forest conservation.

Keywords: Tree Cover Loss, Deforestation, Oil Palm Plantation Expansion, Coal Mining, Economic Growth.

INTRODUCTION

The island of Kalimantan is one of the largest tropical rainforest regions in Indonesia, possessing highly strategic ecological and economic value. From an ecological perspective, this region functions as a carbon sink, a habitat for biodiversity, and a buffer for the hydrological system that plays a role in maintaining regional and global environmental balance (FAO, 2022; IPCC, 2022). On the other hand, Kalimantan is also a hub for various natural resource-based economic activities, particularly coal mining and oil palm plantations, which for several decades have been the main drivers of economic growth in the region. However, the development of these two sectors has also been accompanied by increased conversion of forest areas for various economic purposes, thereby triggering deforestation, environmental degradation, habitat fragmentation, and increased carbon emissions (Gaveau et al., 2021; Land, 2020). These conditions indicate that Kalimantan faces a major challenge in maintaining a balance between economic growth and environmental sustainability, in line with Indonesia's commitment to supporting the achievement of the Sustainable Development Goals (SDGs), particularly Goal 13 (Climate Action) and Goal 15 (Life on Land) (United Nations, 2015).



Figure 1. Trends in the Area of Tree Cover Loss in Indonesia, 2015–2024
Source: Global Forest Watch, adapted by the author (2026).

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Figure 1 shows that the island of Kalimantan experienced the greatest loss of tree cover in Indonesia during the 2015–2024 period. According to Global Forest Watch data, the cumulative loss of tree cover in Kalimantan reached approximately 5,355.0 thousand hectares (kha), slightly higher than that of Sumatra, which stood at 5,348.1 kha. In contrast, other regions showed relatively lower rates of tree cover loss: Sulawesi at 1,425.4 kha, Java at 955.0 kha, Papua and Maluku at 902.1 kha, and Bali and Nusa Tenggara at only 143.4 kha. These differences indicate that pressure on Kalimantan's forest ecosystems is relatively higher than in other regions of Indonesia, even though the area of its forests is relatively comparable to that of Sumatra. This finding is also consistent with various studies showing that land-use change is one of the main causes of tree cover loss in tropical regions, including Indonesia (Curtis et al., 2018; Gaveau et al., 2021). Thus, the high rate of tree cover loss in Kalimantan serves as a key indicator that land-use dynamics in the region require greater attention in efforts to achieve sustainable development and more effective natural resource management.

The high rate of tree cover loss in Kalimantan is inextricably linked to the characteristics of its economic structure, which remains dominated by natural resource-based sectors. The island of Kalimantan is the national center of coal production and one of the regions with the largest expansion of oil palm plantations in Indonesia (Setiawan et al., 2020; Qaim et al., 2020). Both sectors make significant contributions to the formation of the Regional Gross Domestic Product (RGDP), increased investment, job creation, and local government revenue. However, the expansion of these economic activities also requires vast tracts of land through the clearing of forest areas for mining operations, the construction of coal-hauling roads and ports, and the expansion of oil palm plantation areas. Various studies indicate that land-use changes resulting from these activities have the potential to increase habitat fragmentation, reduce carbon storage capacity, and accelerate biodiversity loss if not balanced by sustainable natural resource management (Gaveau et al., 2021; Rudke et al., 2020; Qaim et al., 2020).

This phenomenon suggests that the loss of tree cover in Kalimantan is likely influenced not only by the scale of mining activities or the size of individual oil palm plantations, but also by the transformation of the regional economic structure, as reflected in the growth of the Regional Gross Domestic Product at Constant Prices (RGDP at CP). In this context, the increasing contribution of the coal mining sector to the RDP may reflect the sector's growing role in the regional economy, which, under certain conditions, has the potential to increase the need for clearing new land for exploration, exploitation, and the construction of supporting infrastructure (Rudke et al., 2020; Setiawan et al., 2020).

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On the other hand, the expansion of oil palm plantations represents an increasing conversion of forested areas into cultivated land, which various studies have identified as one of the main drivers of deforestation in tropical regions (Qaim et al., 2020; Pendrill et al., 2022). Meanwhile, the increase in ADHK GRDP reflects overall economic growth, which has the potential to boost demand for land, infrastructure, energy, and natural resources, thereby increasing pressure on forest areas if not accompanied by sustainability-oriented development policies (Lambin & Meyfroidt, 2011; Stern, 2004). Therefore, these three variables are conceptually expected to be closely interrelated in influencing the dynamics of tree cover loss on the island of Kalimantan.

This relationship is consistent with the Environmental Kuznets Curve (EKC), which explains that environmental degradation tends to increase in the early stages of economic development due to increased exploitation of natural resources, before subsequently declining as income levels, institutional quality, and the adoption of more environmentally friendly technologies improve (Grossman & Krueger, 1995; Stern, 2004). Furthermore, the STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) theory explains that environmental pressure results from the interaction between population, affluence, and technological development, which influence the extent of natural resource use (Dietz & Rosa, 1997; York et al., 2003). Meanwhile, Forest Transition Theory explains that changes in forest cover are part of the process of economic development, in which forest areas generally decline in the early stages of development due to the expansion of agriculture, plantations, and mining, before potentially recovering in line with changes in economic structure, increased productivity, urbanization, and strengthened conservation policies (Mather, 1992; Rudel et al., 2005). These three theoretical perspectives provide a complementary conceptual framework for explaining how economic growth, the expansion of the extractive sector, and land-use changes may influence the dynamics of tree cover loss on the island of Kalimantan.

Based on these empirical findings, the island of Kalimantan serves as a highly relevant case study for examining the relationship between economic development and changes in forest cover. Previous studies have identified that coal mining activities, the expansion of oil palm plantations, and economic growth are factors associated with increased deforestation, both in Indonesia and in other tropical regions (Rudke et al., 2020; Setiawan et al., 2020; Qaim et al., 2020; Khatun et al., 2020; Isnaini & Agustina, 2020; Widiono, 2024). However, most of these studies have analyzed each factor separately and thus have not been able to explain how the simultaneous interaction of these three factors influences the loss of tree cover. In fact, the characteristics of

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Kalimantan's economy indicate that the coal mining sector, the oil palm plantation sector, and economic growth are developing simultaneously and have the potential to interact with one another in exerting pressure on forested areas. Therefore, this study is significant because it simultaneously analyzes the effects of the coal mining sector's contribution to Regional Gross Domestic Product (RGDP), the area of oil palm plantations, and Regional Gross Domestic Product at Constant Prices (RGDP-CCP) on tree cover loss across five provinces on the island of Kalimantan during the 2015–2024 period using a panel data regression approach. This approach is expected to provide more comprehensive empirical evidence regarding the key determinants of tree cover loss in Kalimantan, while also serving as a scientific basis for the formulation of policies on natural resource management, deforestation control, and more sustainable economic development.

LITERATURE REVIEW

Deforestation is one of the major issues in environmental economics because it reduces carbon sequestration capacity, biodiversity, and hydrological functions that play a crucial role in sustainable development (Jayachandran, 2021; Supriatna et al., 2024). In Indonesia, particularly on the island of Kalimantan, forest cover loss is primarily driven by land-use changes resulting from mining activities and the expansion of oil palm plantations (Gaveau et al., 2021; Lim et al., 2024). Hariyanti et al. (2024) add that economic development based on key commodities can boost economic growth but has the potential to increase environmental degradation if not balanced by sustainable natural resource management. This indicates that the relationship between economic growth and deforestation is influenced by economic structure and environmental policies.

This relationship is explained by the Environmental Kuznets Curve (EKC), which states that environmental degradation increases in the early stages of development but then declines as income, technological progress, and institutional quality improve (Grossman & Krueger, 1995; Stern, 2004; Anwar et al., 2022). However, Jayachandran (2021) and Supriatna et al. (2024) show that this pattern does not always occur because it is influenced by the effectiveness of conservation policies and regional characteristics. This study also employs the Forest Transition Theory (FTT), which explains that the decline in forest cover is part of an economic transformation that will eventually enter a stabilization phase once development begins to be supported by conservation policies (Mather, 1992). Furthermore, STIRPAT explains that environmental pressures are influenced by economic activities, levels of prosperity, and technological development

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(Dietz & Rosa, 1997; York et al., 2003). The integration of these three theories provides a more comprehensive foundation for explaining the relationship between economic growth and the loss of tree cover.

Previous research has shown that coal mining and oil palm plantations are the main drivers of deforestation. Rudke et al. (2020) found that mining activities increase habitat fragmentation through land clearing, while Lim et al. (2024) demonstrated that the intensification of the oil palm industry still has the potential to accelerate deforestation. On the other hand, Qaim et al. (2020) explain that oil palm expansion boosts the local economy but also reduces forest cover. These findings are reinforced by Hariyanti et al. (2024), who state that development based on primary commodities must be balanced with the principles of sustainable development so that economic benefits do not come at the expense of environmental quality.

Nevertheless, previous studies have generally examined the impacts of mining or oil palm plantations separately, while studies integrating both sectors with economic growth remain limited. Furthermore, most studies have been conducted at the national level and thus do not yet capture the regional characteristics of the island of Kalimantan (Gaveau et al., 2021; Rudke et al., 2020; Hariyanti et al., 2024). Therefore, this study offers a novel approach by integrating the Environmental Kuznets Curve (EKC), Forest Transition Theory (FTT), and STIRPAT to analyze the impact of the coal mining sector's contribution to GRDP, the area of oil palm plantations, and GRDP per capita on tree cover loss across five provinces on the island of Kalimantan during the 2015–2024 period.

The relationships among these variables are illustrated in Figure 1:

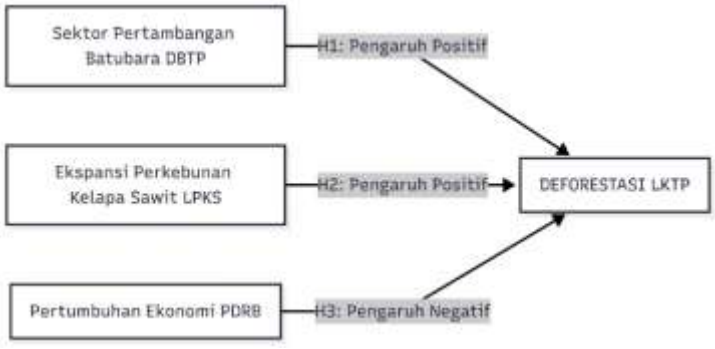


Figure 2. Conceptual Framework

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Based on this conceptual framework, the following research hypotheses were formulated.

H1: The contribution of the coal mining sector to GRDP has a positive and significant effect on tree cover loss on the island of Kalimantan (Rudke et al., 2020; Hariyanti et al., 2024).

H2: The area of oil palm plantations has a positive and significant effect on tree cover loss on the island of Kalimantan (Lim et al., 2024; Qaim et al., 2020).

H3: ADHK GRDP has a negative and significant effect on tree cover loss on the island of Kalimantan, consistent with the Environmental Kuznets Curve concept (Grossman & Krueger, 1995; Stern, 2004; Anwar et al., 2022).

RESEARCH METHODOLOGY

This study employs a quantitative approach with an explanatory research design to analyze the impact of natural resource-based economic activities on tree cover loss on the island of Kalimantan. This approach was chosen because it allows for testing the causal relationship between the coal mining sector's contribution to the Regional Gross Domestic Product (RGDP), the area of oil palm plantations, and economic growth on the dynamics of tree cover loss during the observation period. The units of analysis for this study consist of five provinces on the island of Kalimantan: West Kalimantan, Central Kalimantan, South Kalimantan, East Kalimantan, and North Kalimantan. The study uses balanced panel data with an observation period from 2015 to 2024, resulting in 50 observations (5 provinces × 10 years). All provinces were included in the study using census sampling, as the entire population met the study criteria, eliminating the need for a sampling process.

The data used are secondary data obtained from two official sources. Data on tree cover loss were obtained from Global Forest Watch (GFW), while data on the coal mining sector's contribution to GRDP, the area of oil palm plantations, and Gross Regional Domestic Product at Constant Prices (GRDP at Constant Prices) were obtained from publications by the Central Statistics Agency (BPS). All variables are measured annually, ensuring temporal consistency across variables. The dependent variable in this study is tree cover loss (TCL), measured based on the annual area of tree cover loss in each province (hectares). The independent variables consist of three indicators. First, the contribution of the coal mining sector to the Regional Gross Domestic Product (DBTP), measured using the percentage contribution of the mining and quarrying sector to the regional GDP. Second, the area of oil palm plantations (LPKS), measured based on the

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total area of oil palm plantations (hectares). Third, economic growth is proxied using Regional Gross Domestic Product at Constant Prices (PDRB ADHK), expressed in billions of rupiah.

This study uses a panel data regression model because this method can simultaneously accommodate cross-sectional and time-series variations in the data, while improving estimation efficiency through a larger number of observations compared to separate cross-sectional or time-series regressions (Baltagi, 2021; Wooldridge, 2019). The estimated empirical model is formulated as follows:

$$LKTP_{it} = \beta_0 + \beta_1 DBTP_{it} + \beta_2 LPKS_{it} + \beta_3 PDRB_{it} + \varepsilon_{it}$$

Where LKTPit is the area of forest cover loss in province i on the island of Kalimantan in year t (hectares/year), DBTPit is the share of coal in the GRDP of province i on the island of Kalimantan in year t (percentage), LPKSit is the area of oil palm plantations in Province i on the island of Kalimantan in year t (hectares/year), and PDRBit is the value of the ADHK GRDP in Province i on the island of Kalimantan in year t (billions). β0 is the intercept; β1, β2, and β3 are the regression coefficients; and εit is the error term.

The selection of the panel model was conducted through several testing stages to obtain the most appropriate estimator. The first stage used the Chow test to compare the Common Effect Model (CEM) and the Fixed Effect Model (FEM). If the test results showed a p-value less than the 5% significance level ($p < 0.05$), the FEM was selected. Next, the Hausman test is conducted to determine the best model between the Fixed Effects Model (FEM) and the Random Effects Model (REM). A p-value less than 0.05 indicates that the FEM is more appropriate, while a p-value greater than 0.05 suggests that the REM is a more efficient estimator. If the REM is selected, a Breusch–Pagan Lagrange Multiplier (LM) test is conducted to compare the REM with the CEM and to ensure that the use of a panel model is more appropriate than a pooled ordinary least squares model (Breusch & Pagan, 1980; Baltagi, 2021).

After the best model was obtained, hypothesis testing was conducted using the t-test to evaluate the significance of the effect of each independent variable on tree cover loss individually, while the F-test was used to test the significance of the model as a whole. The model's ability to explain the variation in tree cover loss was measured using the coefficient of determination (R^2). The R^2 value indicates the proportion of variation in the dependent variable that can be explained by all the independent variables used in the model. The entire estimation process was performed using EViews 12 software. This

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software was chosen because it provides comprehensive panel data regression estimation procedures, including model selection via the Chow test, Hausman test, and Lagrange Multiplier test, and produces consistent and efficient estimators in accordance with modern econometric analysis standards.

RESULTS AND DISCUSSION

Panel Data Regression Results

Before conducting panel data regression estimates, it is necessary to test the model specification to determine the estimator that best fits the characteristics of the research data. Selecting the appropriate model aims to produce consistent, efficient, and unbiased parameter estimates, so that the relationship between the independent and dependent variables can be interpreted more accurately. In this study, the model selection process was conducted in stages using the Chow test, the Hausman test, and the Breusch–Pagan Lagrange Multiplier (LM) test. These three tests were used to determine whether the most appropriate model is the Common Effect Model (CEM), the Fixed Effect Model (FEM), or the Random Effect Model (REM). A summary of the model specification test results is presented in Table 1.

Table 1. Results of statistical tests

Pengujian	Statistik	Nilai Statistik	Prob.	Kesimpulan
Chow Test	Cross-section F	9.116850	0.0000	FEM lebih baik daripada CEM
	Cross-section Chi-square	31.250682	0.0000	Mendukung FEM
Hausman Test	Chi-square	4.108382	0.2500	REM lebih baik daripada FEM
LM Test	Cross-section Breusch-Pagan	29.892950	0.0000	REM lebih baik daripada CEM
	Time Breusch-Pagan	0.079974	0.7773	Tidak signifikan
	Both Breusch-Pagan	29.972920	0.0000	Mendukung REM

Source: Data compiled by the author, 2026

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Based on the results of the model specification tests presented in Table 1, the selection of the panel data regression model was conducted in stages using the Chow Test, the Hausman Test, and the Breusch–Pagan Lagrange Multiplier (LM) Test. The first stage used the Chow Test to compare the Common Effects Model (CEM) with the Fixed Effects Model (FEM). The test results showed that the probability values for both the cross-section F-statistic and the cross-section chi-square statistic were 0.0000 ($p < 0.05$), so the null hypothesis stating that the Common Effect Model is more appropriate was rejected. Thus, the Fixed Effect Model (FEM) was deemed better able to accommodate differences in characteristics across provinces compared to the Common Effect Model (CEM).

Next, a Hausman test was conducted to determine the best model between the Fixed Effects Model (FEM) and the Random Effects Model (REM). The test results showed a probability value of 0.2500 ($p > 0.05$), so the null hypothesis was not rejected. This finding indicates that the assumptions of the Random Effects Model (REM) are met and that the REM estimator is more efficient than the FEM because individual variations across provinces are not systematically correlated with the independent variables used in the model.

Next, to confirm that the Random Effect Model (REM) is more appropriate than the Common Effect Model (CEM), the Breusch–Pagan Lagrange Multiplier (LM) test was conducted. The results of the cross-sectional Breusch–Pagan test yielded a p-value of 0.0000 ($p < 0.05$), indicating that the Random Effects Model (REM) is more appropriate than the Common Effects Model (CEM). Meanwhile, the time component of the Breusch–Pagan test was not significant ($p = 0.7773$), suggesting that the variation in the time effect does not make a significant contribution to the model. Conversely, the Both Breusch–Pagan test still yielded a significant result ($p = 0.0000$), further reinforcing the appropriateness of using the Random Effects Model (REM). Based on the results of these three model specification tests, the Random Effects Model (REM) is the most appropriate estimation model for analyzing the impact of the coal mining sector on GRDP, the area of oil palm plantations, and the GRDP of the ADHK on tree cover loss on the island of Kalimantan. Therefore, all empirical analyses in this study were subsequently estimated using the Random Effect Model (REM) (Table 2).

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Table 2. Best Regression Results for Panel Data (Random Effect Model)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	28.57971	24.203657	1.1808012	0.24375
DBTP	1.406176	0.6997798	2.0094560	0.05037
LPKS	7.034194	1.7941078	3.9207198	0.00029
PDRB	-7.51233	6.0981189	-1.231910	0.22424
R-squared	0.266504			
Adjusted R-squared	0.218668			
F-statistic	5.571139			
Prob (F-statistic)	0.002400			

Source: Data compiled by the author, 2026

Based on the regression results in Table 2, the following equation can be derived:

$$LKTP_{it} = 28.57971 + 1.406176DBTP_{it} + 7.034194LPKS_{it} - 7.51233\ PDRB_{it} + \varepsilon_{it}$$

Hypothesis Testing

The regression estimation results indicate that the independent variables comprising the coal mining sector's contribution to GRDP (DBTP), the area of oil palm plantations (LPKS), and GRDP of the ADHK as an indicator of economic growth have a sufficient explanatory power regarding variations in tree cover loss. An R-squared value of 0.266504 indicates that these three independent variables account for approximately 26.65% of the variation in tree cover loss, while the remaining 73.35% is influenced by other factors outside the model, such as land-use policies, infrastructure expansion, forestry activities, forest fires, the region's biophysical characteristics, and institutional factors. The adjusted R-squared value of 0.218668 indicates that, after accounting for the number of predictor variables in the model, the model's explanatory power remains at 21.87%. Furthermore, based on the estimation results, the F-statistic is 5.571139 with a probability of 0.002400. This probability value is smaller than the 1% significance level (p-value < 0.01), so the null hypothesis (H_0) which states that all independent variables collectively have no effect on tree cover loss can be rejected. The research results show that DBTP, LPKS, and PDRB ADHK simultaneously have a significant effect on tree cover loss.

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Furthermore, based on the t-test, the coefficient for the variable “Contribution of Coal Mining to GRDP” (DBTP) was found to be positive at 1.406176, with a p-value of 0.05037. A positive coefficient indicates that an increase in the coal mining sector’s contribution to GRDP tends to increase the loss of tree cover. Economically, a one percentage point increase in the mining sector’s contribution to the GRDP is estimated to increase tree cover loss by 1.406176 units, assuming all other variables remain constant (ceteris paribus). However, the probability value of 0.05037 indicates that this effect is at a marginal level of significance. Although slightly above the conventional 5% threshold, this relationship still provides empirical evidence at a significance level of approximately 10%. The Oil Palm Plantation Area (LPKS) variable shows a positive and significant effect on tree cover loss, with a coefficient of 7.034194 and a probability of 0.00029. A probability value of less than 1% indicates that the Oil Palm Plantation Area variable has a positive and significant effect on tree cover loss. Meanwhile, the GRDP variable has a negative coefficient of -7.51233 with a probability of 0.22424. These results indicate that economic growth has no statistically significant effect on tree cover loss on the island of Kalimantan during the 2015–2024 period.

DISCUSSION

Based on the regression estimates, the variable “Coal Distribution as a Percentage of Gross Regional Domestic Product (DBTP)” has a coefficient of 1.406176, a t-statistic of 2.009456, and a p-value of 0.05037. These results indicate that an increase in the coal mining sector’s contribution to the Regional Gross Domestic Product (RGDP) tends to lead to an increase in forest cover loss on the island of Kalimantan. Economically, every 1% increase in the coal mining sector’s contribution is estimated to increase forest cover loss by 1.406176 hectares per year, assuming all other variables remain constant (ceteris paribus). However, since the p-value is slightly above the 5% significance level, this effect is only marginally significant, so its interpretation must be approached with caution.

Although it does not yet show strong statistical evidence at the 5% significance level, the positive direction of the coefficient indicates that the greater the mining sector’s contribution to the regional economy, the greater the potential pressure on forested areas. This finding is consistent with land-use change theory and the resource dependence hypothesis, which explain that regions dependent on the exploitation of natural resources tend to experience greater land-use change due to the need for space to support production activities.

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This situation is relevant to the characteristics of the island of Kalimantan, which is still dominated by the extractive sector, particularly coal mining. In most provinces, the mining sector is the main contributor to the regional gross domestic product (GRDP); thus, an increase in mining activity is generally followed by the expansion of mining areas, the construction of haulage roads, and other supporting infrastructure that requires land conversion. Consequently, pressure on forested areas increases if not balanced by effective environmental management (BPS, 2024).

These findings are supported by Sonter et al. (2017), who state that mining drives deforestation not only through land clearing within concession areas but also through infrastructure development and increased access to forested areas, which in turn trigger other economic activities. In line with this, Rudke et al. (2020) found that regions with high mining intensity tend to experience greater land-use change and forest fragmentation. Lawrence et al. (2022) also emphasize that extractive activities in tropical forest areas are one of the main drivers of landscape change through vegetation loss, habitat fragmentation, and disruption of forest ecological functions.

These findings are also consistent with Austin et al. (2019), who demonstrated that deforestation in Indonesia results from the interaction between economic activities, land-use changes, and the expansion of the primary commodity sector. In the context of Kalimantan as one of the nation's coal production hubs, Widiono (2024) explains that regional development's dependence on the natural resource sector remains a structural factor that increases pressure on the environment.

Nevertheless, the mining sector's impact on forest cover loss is not uniform across all provinces. The lack of statistical significance in this study indicates that mining activities do not always result in the same rate of deforestation. These variations may be influenced by the size of active mining concessions, the implementation of post-mining reclamation, the effectiveness of environmental oversight, and the quality of natural resource governance in each region (Lawrence et al., 2022; Widiono, 2024). Therefore, the impact of mining on deforestation is largely determined by the effectiveness of the management and regulation of extractive activities.

From a sustainable development perspective, the results of this study indicate a trade-off between the economic benefits of the mining sector and its ecological impacts. Barbier (2019) explains that the exploitation of natural resources often improves economic well-being but, at the same time, increases pressure on the environment. In line with this, Doytch et al. (2024) and Zhang et al. (2024) state that regions that remain dependent on natural resources face greater challenges in achieving green development.

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Overall, although the contribution of the coal mining sector has not been proven to be a primary determinant of forest cover loss at the 5% significance level, the positive direction of the relationship indicates that this sector remains a key factor in sustainable forest management. Therefore, development in coal producing regions must be balanced with strengthened environmental controls, improved post-mining reclamation, protection of high conservation value areas, and regional economic diversification to reduce dependence on the exploitation of natural resources.

Furthermore, based on the results of the panel data regression estimates, the variable “Area of Oil Palm Plantations” (LPKS) has a coefficient of 7.034194, a t-statistic of 3.920720, and a p-value of 0.00029. These results indicate that the expansion of oil palm plantations has a positive and significant effect on forest cover loss on the island of Kalimantan at a 5% significance level. Economically, every 1 Hka increase in oil palm plantation area is estimated to increase forest cover loss by 7.034194 hectares per year, assuming all other variables remain constant (ceteris paribus). Compared to other independent variables, LPKS has the highest t-statistic value and the lowest probability, making it the most dominant variable in explaining the variation in forest cover loss on the island of Kalimantan.

According to land-use transition theory, rising global demand for agricultural commodities drives the conversion of forested areas into productive land. In Indonesia, the expansion of oil palm plantations is one of the largest drivers of land-use change due to the high demand for land to meet the need for crude palm oil (CPO) in both domestic and international markets. The FAO (2024) states that the expansion of commercial agriculture remains the primary cause of forest loss in many developing countries, while Global Forest Watch (2025) indicates that Indonesia continues to experience significant forest cover loss in areas undergoing land-based commodity expansion, including oil palm plantations.

The findings of this study are consistent with those of Austin et al. (2019), who found that the expansion of oil palm plantations is one of the main drivers of deforestation in Indonesia due to land-use changes aimed at meeting global demand for commodities. These findings are supported by Carlson et al. (2018), who demonstrated that the expansion of oil palm plantations is closely linked to the loss of tropical forests, particularly through the conversion of primary and secondary forests. Furthermore, Vijay et al. (2016) explain that the expansion of oil palm plantations not only leads to the loss of forest cover but also triggers habitat fragmentation, a decline in biodiversity, and changes in the ecological functions of forested areas. In line with these findings, Putri et al. (2025) also

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found that the expansion of oil palm plantations in Sumatra is a major factor in the increase in ecological deforestation. Their study indicates that regional economic growth, which remains reliant on land based plantation sectors, has led to increased conversion of forest areas; therefore, economic development must be balanced with policies that prioritize environmental sustainability.

On the other hand, the palm oil industry also makes a significant contribution to economic development. Qaim et al. (2020) explain that the palm oil sector plays a role in creating jobs, increasing community income, and driving regional economic growth. Therefore, the main issue lies not in the existence of the palm oil industry, but in its pattern of expansion. Efforts to increase productivity through intensification, the utilization of degraded land, and the implementation of sustainable production practices are more effective strategies than clearing new forest areas. Lestari et al. (2025) also demonstrate that economic development that continues to rely on the exploitation of natural resources places pressure on environmental quality. Although the study examined air quality, the results confirm that economic growth based on extractive sectors must be integrated with the principles of sustainable development to minimize environmental impacts.

These findings are also supported by Widiono (2024), who states that the expansion of oil palm plantations remains a key driver of deforestation, as much of this expansion occurs through land-use change. This situation is particularly relevant to the island of Kalimantan, which has vast tracts of available land and relies on the plantation sector as one of the pillars of its regional economy. The greater influence of the LPKS variable compared to other variables indicates that pressure on forests in Kalimantan is driven more by economic activities that directly require land conversion than by aggregate economic indicators. On the other hand, Afsari et al. (2025) found that GRDP actually has a negative effect on deforestation at the national level when economic growth is supported by good environmental governance, strict spatial planning oversight, and the application of sustainable development principles. This discrepancy in results indicates that the relationship between economic activity and deforestation is context-dependent. On the island of Kalimantan, the expansion of oil palm plantations remains an activity that directly requires land clearing, so its impact on forest cover loss remains the most significant factor. Therefore, efforts to curb deforestation must be supported by strengthening land governance, protecting areas of high conservation value, increasing transparency in plantation permitting, and utilizing degraded land to support sustainable production expansion.

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Furthermore, based on the regression estimates, the Gross Regional Domestic Product (GRDP) variable has a coefficient of -7.512330, a t-statistic of -1.231910, and a p-value of 0.22424. A probability value greater than the 5% significance level indicates that GRDP does not have a significant effect on forest cover loss on the island of Kalimantan during the 2015–2024 period. Mathematically, a negative coefficient indicates that an increase in GRDP tends to be followed by a decrease in forest cover loss; however, this relationship is not yet supported by sufficient statistical evidence and therefore cannot be concluded as a significant effect.

One reason for the insignificant impact of GRDP is that economic growth on the island of Kalimantan does not stem solely from sectors that require the conversion of forest areas. Based on data from the Central Statistics Agency (BPS, 2024), the structure of GRDP across provinces in Kalimantan exhibits distinct characteristics. East Kalimantan, North Kalimantan, and South Kalimantan are still dominated by the mining and quarrying sectors, while West Kalimantan and Central Kalimantan derive an increasingly large share of their GRDP from agriculture, manufacturing, trade, construction, transportation, and services. Thus, an increase in aggregate GRDP is not always accompanied by an increase in economic activity that directly leads to the loss of forest cover.

The findings of this study indicate that economic growth has not yet become a primary determinant of deforestation on the island of Kalimantan. These results are consistent with those of Afsari et al. (2025), who found that GRDP has a significant negative effect on deforestation in Indonesia. Afsari et al. (2025) explain that increased economic capacity can curb deforestation if accompanied by strengthened environmental governance, land-use oversight, and the application of sustainable development principles. Although the effect of GRDP was not statistically significant in this study, the negative sign of the coefficient indicates that increased economic activity in Kalimantan is beginning to be accompanied by changes in economic structure and improved environmental management.

These findings also differ from those of Putri et al. (2025), who showed that GRDP has a positive and significant effect on ecological deforestation in Sumatra because the region's economic growth remains heavily dependent on land based sectors, particularly oil palm plantations. This discrepancy in results indicates that the relationship between economic growth and deforestation is strongly influenced by the characteristics of each region's economic structure. In Kalimantan, the increase in GRDP does not entirely stem

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from activities requiring the clearing of forest areas; consequently, its impact on forest cover loss is relatively smaller.

These differences can be explained by changes in the economic structure of several provinces in Kalimantan during the study period. BPS (2025) indicates that the contributions of the manufacturing, construction, transportation, and information and communication sectors have continued to increase. In addition, the development of the Nusantara Capital City (IKN) has helped drive investment in the construction, services, and infrastructure sectors, thereby boosting GRDP without relying entirely on the conversion of forest areas. The government has also strengthened various environmental management policies, such as a moratorium on new permits for primary forests and peatlands, forest and land rehabilitation, and enhanced oversight of forest area utilization. These conditions have enabled economic growth to proceed alongside efforts to control deforestation, although the relationship between the two is not yet statistically significant (BPS, 2025; Ministry of Environment and Forestry, 2024). In line with this, Lestari et al. (2025) demonstrate that economic growth is a factor influencing environmental quality; therefore, the integration of economic policies and sustainable development is necessary to reduce pressure on the environment.

The results of this study also cannot yet be taken as evidence that the island of Kalimantan has reached a turning point as described in the Environmental Kuznets Curve (EKC) theory. According to this theory, environmental quality begins to improve once income levels reach a certain point due to advances in technology, institutional quality, and environmental awareness. However, since the relationship between GRDP and forest cover loss in this study is not significant, the negative coefficient should more accurately be interpreted as an indication that this relationship is influenced by economic structure and the quality of environmental governance, rather than solely by an increase in GRDP. These findings are consistent with Doytch et al. (2024), who state that the impact of economic growth on the environment depends on the sectors driving that growth, as well as Lawrence et al. (2022), who emphasize that changes in forest cover are influenced by the interaction between economic activities, governance, and natural resource management policies.

Overall, the results of this study indicate that economic growth was not the primary determinant of forest cover loss on the island of Kalimantan during the study period. Instead, economic activities that directly require land-use changes such as coal mining and the expansion of oil palm plantations have a stronger association with deforestation. Therefore, efforts to control deforestation must not only focus on boosting economic

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growth but must also be accompanied by a transformation of the economic structure toward more sustainable sectors, the strengthening of environmental governance, and improvements in the effectiveness of natural resource management policies so that economic growth and forest conservation can proceed in a balanced manner.

CONCLUSION

This study analyzes the determinants of tree cover loss on the island of Kalimantan using a panel data approach based on three main variables: the contribution of the coal mining sector to the Regional Gross Domestic Product (DBTP), the area of oil palm plantations (LPKS), and the Regional Gross Domestic Product (PDRB). The results show that economic activities involving high land-use intensity play a greater role in explaining forest cover loss than aggregate economic growth. The area of oil palm plantations proved to be the most dominant determinant, with a positive and significant effect on tree cover loss, indicating that land-based plantation expansion remains the primary source of pressure on forest ecosystems in Kalimantan. Meanwhile, the contribution of the coal mining sector showed a positive but marginal relationship, indicating that extractive activities have the potential to increase pressure on forests, although their impact is highly dependent on the quality of environmental governance and post-mining management. On the other hand, GRDP did not show a significant impact on forest cover loss, indicating that economic growth does not automatically lead to environmental degradation but depends on the structure of the developing economic sectors. The implications of this study suggest that deforestation control policies in Kalimantan should focus on strengthening the governance of sustainable oil palm plantations, monitoring mining activities, protecting high-conservation-value forest areas, and diversifying the economy toward sectors that exert less ecological pressure. However, this study has limitations because it uses only three key economic indicators and does not yet incorporate institutional factors, environmental policies, governance quality, or the spatial characteristics of the region all of which could potentially influence forest cover loss. Future research could integrate these aspects using spatial approaches or dynamic models to gain a more comprehensive understanding of deforestation mechanisms in regions rich in natural resources.

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