

## Revisiting Population Pressure and the Pollution Haven Hypothesis: Evidence from Forest Loss in Indonesia

Septriani Septriani\*

Department of Economic Development, Faculty of Economics and Business, University of Bengkulu, Bengkulu, Indonesia.

### \*Corresponding Author

Septriani Septriani

Department of Economic Development, Faculty of Economics and Business, University of Bengkulu, Bengkulu, Indonesia.

### Article History

Received: 19.07.2025

Accepted: 07.08.2025

Published: 30.08.2025

**Abstract:** *This study investigates the determinants of forest loss (tree cover loss) in Indonesia during 2000-2022, focusing on the roles of demographic factors, foreign direct investment (FDI), and economic growth, using a multiple linear regression analysis to quantify the partial effects of each explanatory variable while controlling for others. Annual time series data were compiled from internationally recognized sources, including the World Development Indicators (World Bank) and Global Forest Watch, ensuring reliability and comparability over time. Adapun metode analThe results reveal that population exerts a significant negative effect on forest loss, reflecting the moderating roles of population redistribution, urbanization, agricultural intensification, and forest conservation policies. In contrast, FDI has a significant positive effect on on forest loss, particularly in mining and plantation sectors, confirming the relevance of the Pollution Haven Hypothesis. Economic growth does not exhibit a statistically significant effect on forest loss, consistent with the Environmental Kuznets Curve framework, which emphasizes the nonlinear relationship between development and environmental degradation. Overall, the findings highlight that investment direction, economic sector composition, and governance quality are more influential in shaping deforestation dynamics than aggregate economic growth or demographic pressures alone. Policy implications include the need for sector specific environmental regulation, strengthened law enforcement, promotion of green FDI, and integrated strategies linking urbanization and sustainable agricultural intensification. Future research should explore sectoral and spatial FDI impacts, incorporating institutional and governance indicators as moderating variables, to deepen understanding of deforestation mechanisms in Indonesia and other developing countries.*

**Keywords:** *Forest Loss, Population, Foreign Direct Investment, Economic Growth, Pollution Haven Hypothesis, Environmental Kuznets Curve*

## Introduction

Global forest degradation has become one of the most pressing environmental challenges of the 21st century, given its significant impact on climate stability, biodiversity conservation, and sustainable economic development. Forests play a vital role in carbon sequestration, ecosystem regulation, and livelihood provision, particularly in developing countries. Despite increased international commitment to forest conservation, resource-rich countries continue to experience significant forest loss due to the complex interaction between demographic pressures, economic expansion, and global capital flows.

Data from the 2025 Global Forest Resources Assessment (FRA) report published by the Food and Agriculture Organization (FAO) shows that although the aggregate rate of global deforestation has begun to slow, pressure on the world's forest ecosystems remains at a serious level and has not yet reached the

international target of halting deforestation by 2030. In the period 2015–2025, the world will still lose around 10.9 million hectares of forest each year, although this figure is lower than the average annual loss of 17.6 million hectares in the period 1990–2000. This situation shows that, despite partial progress in global forest governance, such as the expansion of protected areas and increased implementation of long-term forest management plans, absolute forest loss is still occurring on a very large scale and is not yet approaching the level needed to meet global commitments such as the Sustainable Development Goals and the Paris Agreement.

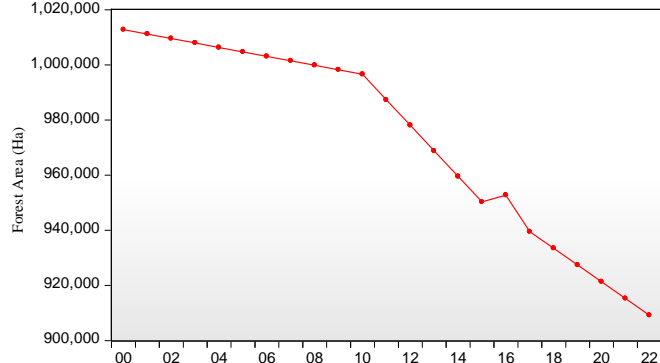
Based on data from the FAO, it is known that global forest cover is currently around 4.14 billion hectares, or about 32% of the total land area of the earth, with almost half of it located in tropical regions, which also include Indonesia as one of the countries with the largest tropical rainforests and the highest level of biodiversity in the world. Based on the data, Indonesia's forest area has continued to decline from year to year, as shown in Figure 1. Figure 1 clearly shows the downward trend in Indonesia's forest

### Cite this article:

Septriani, S. (2025). Revisiting Population Pressure and the Pollution Haven Hypothesis: Evidence from Forest Loss in Indonesia. *ISAR Journal of Economics and Business Management*, 3(8), 90-97.

cover during the period 2000–2022, with a relatively moderate decline at the beginning of the period, but becoming more pronounced from around 2012 to the early 2020s. This pattern indicates that, despite claims of net forest gain in Indonesia in recent years as reported in the FRA FAO 2025, long-term analysis reveals consistent and significant forest cover loss, particularly in natural and primary forests, which have the highest ecological value.

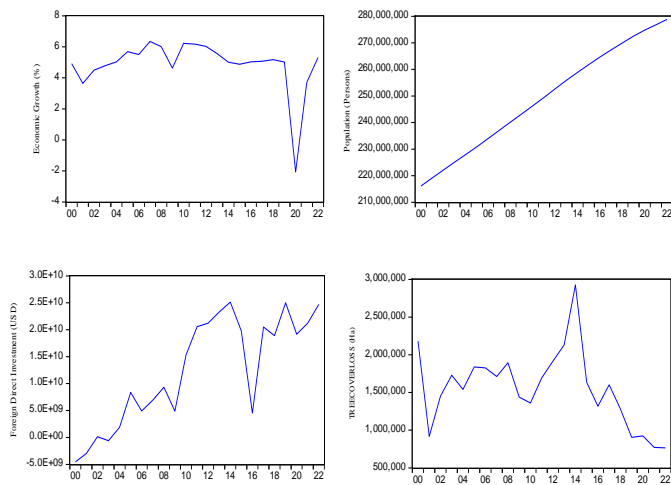
**Figure 1.** Trends in Indonesia's forest cover (2000–2022)



Source: Global Forest Watch (processed by the author)

This decline in forest area shows that the pressure on Indonesia's forests is not only temporary or a short-term fluctuation, but also indicates a long-term process of structural degradation. According to the FAO, the loss of primary forests will have widespread ecological impacts, ranging from a decline in biodiversity to a weakening of carbon sequestration functions, which will ultimately increase the risk of climate change.

In the long term, pressure on Indonesia's forest cover cannot be separated from the fundamental dynamics between population growth, economic expansion, and investment flows. Malthus's theory states that population growth tends to increase geometrically, while the availability of natural resources (including forest land) will increase only to a limited extent, creating ever-greater ecological pressure (Malthus, 1798). This increasingly high population growth will increase the need for land for settlements, agriculture, and infrastructure, which will ultimately drive forest conversion and accelerate land cover degradation.



Source: Global Forest Watch (processed by the author)

Several studies show strong and relatively consistent empirical evidence that population growth, as measured by growth, size, and density, is associated with higher rates of deforestation or forest cover loss in most low- and middle-income countries and frontier regions. Conversely, a more limited number of studies in high-income countries or regions that are already in an advanced stage of development have found that high population density or urbanization can actually go hand in hand with stability or even an increase in forest area (Velasco et al., 2020; Kustanto, 2021; Georgiev et al., 2024; Oyetunji et al., 2020 ; Oforor et al., 2022; Yusuf, 2023; Odawa & Seo, 2019; Ellis et al., 2021; Khoiriyannah & Oktavilia, 2025; Trisnaputra et al., 2023; Ponce et al., 2021; Wang et al., 2022; Busch & Ferretti-Gallon, 2023; Koranteng et al., 2023).

However, the relationship between population growth, economic dynamics, and deforestation is not always straightforward or simple. The Environmental Kuznets Curve (EKC) theory explains that environmental degradation tends to increase in the early stages of economic development, when production growth and resource utilization are the main priorities. In this case, with increasing income and institutional capacity, pressure on the environment can be reduced because the community begins to demand better environmental protection and the government has the resources to enforce regulations. This is supported by several research findings showing that in developing countries, population growth that occurs simultaneously with GDP growth and market integration actually strengthens the economic incentives to convert forests, so that deforestation increases in the early to middle stages of development (Ponce et al., 2021; Wang et al., 2022; Prochazka et al., 2023). Conversely, in high-income countries or regions that have passed the EKC tipping point, population density and urbanization often no longer lead to forest loss, but in some cases actually result in stabilization or restoration of forest cover..

In addition to population size, foreign direct investment (FDI) also plays an important role in determining environmental quality. The pollution haven hypothesis states that investment flows tend to flow to countries with relatively lax environmental regulations, thereby potentially increasing the exploitation of natural resources and environmental degradation. The Pollution Haven Hypothesis (PHH) states that multinational companies tend to move pollution-intensive industrial activities to countries or regions with relatively lax environmental regulations, thereby potentially worsening environmental quality in recipient countries. In line with the PHH, several studies show that FDI flows tend to flow to countries with looser environmental regulations, which in turn increases environmental degradation (Apergis et al., 2023; Shahbaz et al., 2015; Firoj et al., 2023). Empirical evidence in the ASEAN region and developing countries consistently supports this argument, where FDI has been shown to increase environmental degradation through an increase in ecological footprint and carbon emissions when environmental standards and enforcement are weak (Rasit & Aralas, 2019; Kholil et al., 2025). Based on the results of these studies, it can be concluded that FDI can serve as a channel for environmental degradation in developing countries if it is not balanced with strict environmental regulations.

Furthermore, economic growth also creates a dilemma between development and environmental sustainability. The Environmental Kuznets Curve (EKC) hypothesis posits a nonlinear relationship between income growth and environmental degradation, whereby environmental pressure increases in the early stages of development before declining as income and environmental awareness increase. Various studies show that the relationship between economic development and forest conditions is not linear. In the early stages of economic growth, economic activity generally still relies heavily on the use of natural resources, including forests, thereby potentially increasing forest degradation (Kazungu et al., 2021; Mandal & Das Chatterjee, 2021). However, as the economy develops to a more mature and sustainable stage, pressure on forests tends to decrease. This decline occurs in line with reduced agricultural expansion, increased urbanization and industrialization, and growing public awareness of the importance of environmental protection (Deng et al., 2023).

In line with the Environmental Kuznets Curve (EKC) framework, various studies show that the impact of economic growth on forest degradation and fragmentation is non-linear and can form a U-shaped or inverted U-shaped curve, depending on the regional context and stage of economic development. Zambrano Monserrate et al. (2018) found a U-shaped relationship between deforestation and economic growth in a number of European countries, such as France and Germany. These findings were reinforced by Caravaggio (2020), who confirmed the existence of an EKC relationship between economic growth and forest resources in 114 countries based on forest inventory data. Several studies also support the existence of an EKC pattern between changes in forest resources and economic growth (Hou et al., 2020; Hou & Yao, 2019), although some studies did not find a consistent relationship, which may be influenced by differences in regional characteristics and temporal dynamics (Zhu et al., 2022).

The relationship between economic growth and deforestation is also proven to be very complex and influenced by sectoral, institutional, and development policy factors. In developing countries, such as eight East African countries during the period 1990–2023, GDP growth and long-term capital investment have the potential to reduce the rate of deforestation, while agricultural expansion and increased energy consumption actually accelerate forest loss, thus highlighting the risks of economic development that is not oriented towards sustainability (Mwanga, 2025). Empirical evidence from China, Europe, and Russia increasingly confirms that institutional quality and local moderation mechanisms play an important role in shaping these relationships. In China, regional income disparities produce different EKC patterns with respect to forest fragmentation, with labor migration, energy transition, and agricultural intensification acting as amplifying factors (Li et al., 2025).

Meanwhile, in Europe, GDP growth has gone hand in hand with increased forest cover, while in Russia, deforestation has declined after passing a certain GDP threshold, although institutional weaknesses continue to accelerate forest loss. These findings confirm that the synergy between economic growth and forest conservation is highly dependent on the quality of governance and institutional capacity that supports effective

conservation policies (Dobrovolska et al., 2024; Sohag et al., 2023).

Given that population, economic growth, and FDI flows influence primary forest loss and long-term ecological impacts, including biodiversity loss and carbon sequestration, this research is crucial for understanding the interaction between FDI, economic growth, and population pressure on forest degradation. Therefore, this research is important as a scientific basis for formulating more effective and sustainable forest management policies in Indonesia.

## Method

This study employs a quantitative research design and applies a multiple linear regression framework to examine the effects of demographic and macroeconomic factors on forest degradation in Indonesia. This approach is particularly suitable as it allows the partial impact of each explanatory variable to be identified while controlling for the influence of other factors within the model. The empirical analysis is conducted using annual time-series data for the period 2000–2022, focusing on Indonesia as the unit of analysis. The data are compiled from internationally recognized and widely used sources, including the World Development Indicators (World Bank) and Global Forest Watch, ensuring both reliability and comparability across time. Based on this empirical framework, the regression model is specified as follows:

$$TCL = \alpha + \beta_1 POP_t + \beta_2 FDI_t + \beta_3 EG_t + \varepsilon_t$$

Where TCL is forest loss or tree cover loss (Ha) in period t, EG is Economic Growth in period t (%), FDI is foreign direct investment in period t (USD), then POP is population in period t (person),  $\alpha$  is a constant that describes the influence of fixed factors outside the independent variables, while  $\beta_1$ ,  $\beta_2$ ,  $\beta_3$  are the magnitude of the influence of population, foreign direct investment and economic growth on variations in forest loss (tree cover loss), t is the time (2000–2022), and  $\varepsilon_t$  is an error term that captures the influence of other variables not included in the model.

To ensure the robustness and reliability of the estimation results, a comprehensive set of classical diagnostic tests is conducted in accordance with standard econometric practice. Residual normality is assessed using the Jarque-Bera test, while potential serial correlation is examined through the Breusch–Godfrey LM test. Heteroscedasticity is evaluated using the Breusch-Pagan-Godfrey procedure, and multicollinearity among the explanatory variables is assessed through a correlation matrix. These diagnostic procedures follow the methodological guidelines outlined by (Gujarati & Porter, 2009) and Porter (2009) and (Wooldridge, 2016) which emphasize the importance of verifying classical assumptions to obtain unbiased, consistent, and efficient estimators. After confirming that the classical assumptions are reasonably satisfied, statistical inference is carried out by applying t-tests to evaluate the significance of individual regression coefficients and an F-test to assess the overall significance of the model. The estimated coefficients are then interpreted to determine both the direction and magnitude of the effects of demographic and macroeconomic factors on forest degradation. In addition, the coefficient of determination ( $R^2$ ) is used to assess the extent to which variations in forest degradation can be explained by the explanatory variables included in the model.

## Results and Discussions

**Table 1.** Descriptive Statistics

	Treecoverloss	POP	EG	FDI
Mean	1554562.	2.49E+08	4.876536	1.25E+10
Median	1600861.	2.49E+08	5.033069	1.53E+10
Maximum	2927644.	2.79E+08	6.345022	2.51E+10
Minimum	765700.0	2.16E+08	-2.065512	-4.55E+09
Std. Dev.	511026.6	19950977	1.671810	1.00E+10

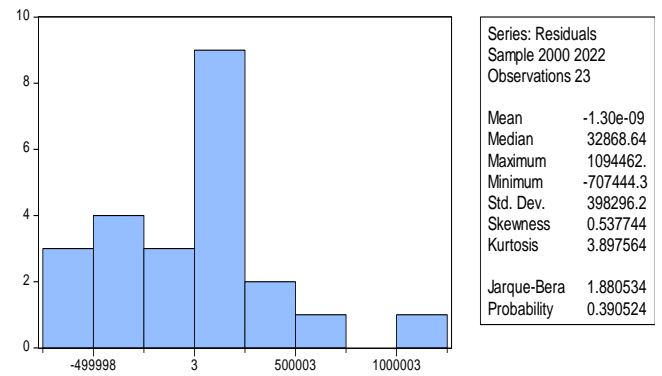
Source: Research data (2025)

Table 1 shows that the average tree cover loss in Indonesia during 2000–2022 was recorded at 1,554,562 ha, with the highest value at 2,927,644 ha and the lowest at 765,700 ha, and a standard deviation of 511,027 ha. These fluctuations indicate considerable annual variation, reflecting the real pressure on forests due to land conversion for agriculture, oil palm plantations, infrastructure development, and extractive industrial activities (Gaveau et al., 2021; Kholil et al., 2025). The median value of 1,600,861 ha, which is slightly higher than the average, indicates that most years experienced above-average forest loss. The relatively large standard deviation indicates that some years experienced much higher forest loss than others, for example during peak periods of plantation expansion or forest fires, which is consistent with empirical findings regarding the impact of FDI on environmental degradation in Indonesia (Rasit & Aralas, 2019).

The average population was recorded at 249 million, with a range of 216–279 million and a standard deviation of 19,950,977, indicating relatively stable growth during the observation period, which is theoretically relevant because pressure on forests is influenced not only by population size, but also by geographical distribution and intensity of land use. Average economic growth was 4.88 percent, with a minimum value of -2.07 percent and a maximum of 6.35 percent, indicating considerable economic fluctuations that could affect land expansion and forest degradation patterns. Average FDI flows of USD 12.5 billion, ranging from USD -4.55 billion to USD 25.1 billion, indicate significant foreign investment and the potential for increased forest loss, particularly through extractive or land-intensive industries, in line with the Pollution Haven Hypothesis framework (Apergis et al., 2023; Shahbaz et al., 2015; Firoj et al., 2023; Kholil et al., 2025). These descriptive statistics show that forest loss in Indonesia is influenced by a combination of population pressure, economic fluctuations, and FDI flows. This is consistent with the PHH theory, which emphasizes that foreign investment in countries with weak environmental regulations can exacerbate forest degradation.

### Classical Assumption Test Results

The following figure shows the results of the normality test on the research data.



**Figure 3.** Normality Test Results  
Source: Processed research data (2025)

Based on the Normality test, the Jarque-Bera probability obtained was 0.390524, exceeding the 5% significance threshold ( $\alpha = 0.05$ ). These results, presented in Figure 3, validate the suitability of the data for regression analysis. Furthermore, the autocorrelation test results show a Chi-Square probability value of 0.6091 which is greater than the 5% significance level ( $\alpha = 0.05$ ). This indicates that the regression model does not experience autocorrelation problems. Details of the results are presented in Table 2.

**Table 2.** Autocorrelation test results

Breusch-Godfrey Serial Correlation LM Test			
F-statistic	0.382955	Prob. F(2,17)	0.6876
Obs*R-squared	0.991557	Prob. Chi-Square(2)	0.6091

Source: Research data (Processed 2025)

Then, the regression model was also tested to ascertain the presence or absence of heteroscedasticity. The test results show no indication of heteroscedasticity, as indicated by the Chi-Square probability value on Obs\*R-squared of 0.7507. A summary of the heteroscedasticity test results can be seen in Table 3.

**Table 3.** Heteroskedasticity Test Results

Heteroskedasticity Test: Breusch-Pagan-Godfrey:			
F-statistic	0.351543	Prob. F(3,19)	0.7885
Obs*R-squared	1.209520	Prob. Chi-Square(3)	0.7507

Source: Research data (Processed 2025)

Finally, a multicollinearity test was conducted to assess the relationship between independent variables. The results of these tests are presented in Table 4.

**Table 4.** Multicollinearity Test Results

Variable	FDI	POP	EG
FDI	1	0.85	-0.03
POP	0.85	1	0.25
EG	-0.03	0.25	1

Source : Research data (Processed, 2025)

Furthermore, the regression results of this study can be seen in Table 4, providing insights into the partial and simultaneous effects of FDI, population, and economic growth on forest loss in Indonesia during 2000–2022.

**Table 5.** Multiple Linear Regression Results

Variable	Coeff.	Std. Error	t-Statistic	Prob.
C	7365924.	2399133.	3.070245	0.0063
POP	-0.026472	0.009878	-2.680061	0.0148
FDI	4.24E-05	1.90E-05	2.228037	0.0382
EG	50810.90	60812.74	0.835531	0.4138

R<sup>2</sup>: 0.3925

Adj.R<sup>2</sup>: 0.2966

F-statistic : 4.092408

Prob (F-Statistic) : 0.021256

Source : Research Data (processed, 2025)

Based on the test results in Table 5, the regression equation is obtained as follows:

$$TCL = 7365924 - 0.026472 POP_t + 4.24E - 05 FDI_t + 50810.90 EG_t + \varepsilon_t$$

**Hypothesis Test**

Based on the regression results in Table 4, it shows that the coefficient of determination (R<sup>2</sup>) value is 0.3925. This means that approximately 39.25 percent of tree cover loss variation can be explained by the variables of population, foreign direct investment, and economic growth. Furthermore, an F-statistic value of 4.092408 with a probability of 0.021256 indicates that the variables of population, foreign direct investment, and economic growth simultaneously have a significant effect on tree cover loss at α=5%. This shows that the regression model used is suitable for explaining the dynamics of tree cover loss in Indonesia. Furthermore, based on the partial test, a population coefficient value of -0.0265, a t-statistic of -2.680, and a t-statistic probability of 0.0148 or less than α=5% were obtained, which means that population has a negative and significant effect on forest cover loss. These results show that when there is an increase in population, tree cover loss actually decreases. Conversely, FDI has a coefficient of 0.0000424, a t-statistic of 2.228, and a t-statistic probability of 0.0382, which is less than α=5%. This means that FDI has a positive and significant effect on tree cover loss. This result shows that foreign investment inflows are associated with an increase in forest cover loss, where FDI tends to flow to countries with relatively lax environmental regulations, which can exacerbate forest degradation if investment is directed towards extractive or polluting industries. Meanwhile, economic growth has a t-statistic probability of 0.4138 or greater than α=5%, which means that economic growth has no effect on forest cover loss in the observation period, so that variations in economic growth do not have a direct, identifiable impact on tree cover loss when controlled for POP and FDI.

**Discussion**

Based on the regression results, a coefficient value of -0.026 and a t-statistic probability of 0.014 were obtained. The results show that population has a negative and significant effect on tree cover loss in Indonesia, with a coefficient of -0.026. This means that every additional person is associated with a decrease in tree cover loss of 0.026 ha, and vice versa. This finding differs from Malthus's theory (1798), which states that rapid population growth will increase pressure on natural resources, including forests, thereby accelerating degradation. Indonesia's current conditions show that population redistribution, urbanization, agricultural

intensification, and forest conservation policies also mediate the relationship between population size and forest loss (Kustanto, 2021; Yusuf, 2023; Khoiriyah & Oktavilia, 2025; Trisnaputra et al., 2023). In other words, population growth does not necessarily lead to deforestation when land management and environmental regulations are able to withstand pressure on forest cover.

Some studies show that population growth does increase the demand for land for agriculture, settlements, and infrastructure, which historically has led to forest conversion, especially in rural and frontier areas (Oyetunji et al., 2020; Odawa & Seo, 2019a; Georgiev et al., 2024; Ofozor et al., 2022; Majjama'a et al., 2020). In addition, several studies in Indonesia, Kenya, and Ghana also show that local population growth is negatively correlated with forest cover, due to the intensification of forest conversion into agricultural land, plantations, and built-up areas (Trisnaputra et al., 2023; Odawa & Seo, 2019a; Koranteng et al., 2023). Furthermore, the interaction between population growth, market integration, and commodity prices strengthens the economic incentives for clearing forests, while weak institutions exacerbate degradation (Prochazka et al., 2023; Ponce et al., 2021; Wang et al., 2022; Busch & Ferretti-Gallon, 2023; D'Antona et al., 2025).

Spatially, rural population growth has a more negative impact on forests than urban growth, because the direct pressure on land is higher, especially in remote or frontier districts (Georgiev et al., 2024; Agrawal et al., 2023; Ellis et al., 2021; Guma et al., 2026). The negative effect of population growth are also exacerbated when local institutions and governance are unable to channel land demand towards agricultural intensification or non-agricultural livelihoods, making frontier expansion the primary strategy for households (Velasco et al., 2020; Odawa & Seo, 2019; Ellis et al., 2021; Trisnaputra et al., 2023; Bogale et al., 2024).

Therefore, based on the results of this study, it can be concluded that the relationship between population and forest loss in Indonesia is contextual and multifactorial, where land management quality, conservation policies, agricultural intensification, and institutional capacity determine the extent of the population's impact on forest cover. The results of this study reinforce the latest literature, which finds that demographic pressure on forests does not occur automatically, but rather through complex interactions with economic, social, and institutional factors. Therefore, in designing effective and sustainable forest management policies, it is important to consider local conditions (Kustanto, 2021; Yusuf, 2023; Khoiriyah & Oktavilia, 2025; Trisnaputra et al., 2023; Busch & Ferretti-Gallon, 2023); D'Antona et al., 2025).

Furthermore, based on the regression results, the coefficient value of the foreign direct investment variable was 4.24E-05 and the t-statistic probability was 0.0382. The results of the study indicate that foreign direct investment has a positive and significant effect on tree cover loss in Indonesia. This means that every additional dollar of FDI is associated with an increase in forest loss of 0.0000424 ha. These results are in line with the Pollution Haven Hypothesis (PHH) theory, which states that investment flows tend to flow to countries with relatively lax environmental regulations, thereby potentially worsening environmental quality and encouraging the exploitation of natural resources (Apergis et al., 2023; Shahbaz et al., 2015; Firoj et al., 2023; Corneo et al., 2025; Lestari et al., 2025).

In addition, the results of this study are also supported by sectoral and empirical data from the Global Forest Watch report (2023), which shows that during 2010–2022, provinces that received large investments in the mining and plantation sectors experienced an average decline in forest cover of more than 0.5 percent per year, which is well above the national average. Furthermore, based on data from the Central Statistics Agency (BPS, 2022), plantation and mining concessions operated by foreign companies cover more than 6 million hectares, most of which were previously natural and primary forests. This data reinforces the finding that foreign direct investment in the primary sector directly drives forest conversion and increases ecological degradation. Foreign direct investment in the mining and plantation sectors often accelerates forest degradation because many extractive activities neglect environmental conservation. Forty percent of deforestation cases in concession areas are related to illegal mining activities and plantation land clearing without adequate environmental permits, while weak law enforcement exacerbates this situation (Nguyen & Nguyen, 2023). These large-scale extractive activities, which require extensive land clearing, directly increase deforestation (Destiariono, 2023). In Indonesia, FDI is more concentrated in the primary and secondary sectors of mining, plantations, and natural resource based industries than in the service sector, resulting in more pronounced and intensive pressure on forest cover (Doytch, 2020; Doytch & Uctum, 2019). Meanwhile, according to (Yusuf, 2023) (Destiariono, 2023), Foreign investment and corruption further reinforce intensive land exploitation.

Several studies in ASEAN countries and developing countries also show similar patterns, where FDI increases environmental degradation through an increase in ecological footprint and carbon emissions when environmental regulations are weak (Rasit & Aralas, 2019; Kholil et al., 2025). Cross-country panel data also show that countries with high FDI inflows in the extractive sector experience a higher rate of forest cover loss of 0.3–0.6% per year compared to countries that receive FDI in the service or light manufacturing sectors (Busch & Ferretti-Gallon, 2023; Apergis et al., 2023; Dewi & Septriani, 2023; Septriani, 2024, Septriani, 2025). Pressure on the economic sector and institutional quality confirms that foreign investment can serve as a channel for environmental degradation (Corneo et al., 2025).

Therefore, the results of this study indicate that FDI flow management must be sectoral and sustainability oriented. Policies directed towards green investment, strengthening environmental regulations, and paying attention to the most at risk sectors are needed to reduce pressure on forest cover, while ensuring that FDI contributes to economic development without damaging ecosystems (Nguyen & Nguyen, 2023; Apergis et al., 2023; Rasit & Aralas, 2019). In this case, strengthening governance is crucial in mitigating the impact of investment on forest cover loss in Indonesia.

Finally, based on the regression results, the t-statistic probability of economic growth is 0.4138 or greater than  $\alpha=5\%$ , which means that economic growth does not affect forest cover loss in Indonesia during the 2000–2022 period. The results of this study indicate that economic growth is not always directly related to changes in forest cover area. Although Indonesia's economy has grown relatively steadily over the past two decades, the dynamics

of economic growth have not automatically translated into increased forest degradation.

In addition, the insignificance of this effect can be seen from the Environmental Kuznets Curve (EKC) framework, which emphasizes that the relationship between economic growth and environmental pressure is nonlinear. In the early stages of development, economic activities tend to rely on the exploitation of natural resources, thereby increasing pressure on forests. However, as income increases, economic structural transformation occurs, urbanization accelerates, and institutional capacity and environmental awareness improve, pressure on forest resources has the potential to decrease. The results of this study are supported by (Kazungu et al., 2021; Mandal & Das Chatterjee, 2021; Deng et al., 2023), which show that economic development and forest conditions are not linear, especially in developing countries.

Based on the data, it can be seen that the period 2000–2022 reflects uneven development dynamics across sectors. Land-intensive sectors such as agriculture, plantations, and mining continue to exert pressure on forests, while the expansion of the service sector, modern industrialization, and urbanization do not always have a direct impact on forest cover loss. This condition reinforces empirical findings that aggregate economic growth indicators are often unable to capture the sectoral and spatial variations that determine changes in forest cover (Prochazka et al., 2023; Wang et al., 2022). Therefore, the insignificant effect of economic growth in the regression model indicates that other factors such as foreign investment, demographic pressures, and governance quality play a more dominant role in driving forest loss.

## Conclusion

Based on the regression results, this study shows that tree cover loss in Indonesia during the period 2000–2022 is not determined by a single factor, but rather by a complex interaction between demographic dynamics, investment, and economic development structure. The estimation results reveal that population has a negative and significant effect on forest loss, which deviates from Malthusian theory predictions. This finding reflects structural transformation in Indonesia, where urbanization, agricultural intensification, and conservation policies play a role in mitigating demographic pressure on forests. Conversely, foreign direct investment (FDI) has been shown to significantly increase forest cover loss, providing empirical support for the Pollution Haven Hypothesis. The concentration of FDI in natural resource-based sectors, particularly mining and plantations, as well as weak enforcement of environmental regulations, make foreign investment a major driver of forest degradation. Meanwhile, economic growth does not show a significant effect on forest loss, in line with the Environmental Kuznets Curve framework, which emphasizes the nonlinear relationship between economic development and environmental degradation. Overall, the results of this study confirm that the direction of investment and the quality of governance play a more decisive role in the dynamics of deforestation in Indonesia than aggregate economic growth or demographic pressure alone.

The implications of this study emphasize the importance of shifting from a growth-based development approach to a sectoral and institutional approach. Strengthening environmental

regulations in high-risk FDI sectors, increasing transparency, and consistent law enforcement are key to reducing deforestation. In addition, shifting investment to high value-added sectors with low land requirements, accompanied by planned urbanization policies and sustainable agricultural intensification, is necessary to ensure the integration of economic development and forest conservation goals.

## References

- Agrawal, S., Welegedara, N., & Parida, D. (2023). Spatiotemporal Land Use Changes in Remote Rural Regions of India Between 2000 and 2020. *Asia-Pacific Journal of Rural Development*, 33(1), 33–55. <https://doi.org/10.1177/10185291241236307>
- Apergis, N., Pinar, M., & Unlu, E. (2023). How do foreign direct investment flows affect carbon emissions in BRICS countries? Revisiting the pollution haven hypothesis using bilateral FDI flows from OECD to BRICS countries. *Environmental Science and Pollution Research*, 30(6), 14680–14692. <https://doi.org/10.1007/s11356-022-23185-4>
- Bogale, T., Damene, S., Seyoum, A., & Haregeweyn, N. (2024). A mixed method approach for analyzing drivers of land use land cover change in the Northwestern Ethiopian highlands. *Environmental Monitoring and Assessment*, 196(12), 1213. <https://doi.org/10.1007/s10661-024-13342-2>
- Busch, J., & Ferretti-Gallon, K. (2023). What Drives and Stops Deforestation, Reforestation, and Forest Degradation? An Updated Meta-analysis. *Review of Environmental Economics and Policy*, 17(2), 217–250. <https://doi.org/10.1086/725051>
- Caravaggio, N. (2020). A global empirical re-assessment of the Environmental Kuznets curve for deforestation. *Forest Policy and Economics*, 119, 102282. <https://doi.org/10.1016/j.forpol.2020.102282>
- Corneo, T. A., Afsari, A. T., Handayani, L. D., Deli, V. R., & Septriani, S. (2025). Analisis Pengaruh Investasi Dan Pertumbuhan Ekonomi Terhadap Degradasi Lingkungan Di Indonesia. *Salam (Islamic Economics Journal)*, 6(1), 204–223.
- D'Antona, Á. de O., Côrtes, J. C., Alves, J. D. G., Duarte, L. T., & Pelegrina, G. (2025). Spatial distribution of population and forest cover in extractive reserves in the Amazon biome, Brazil. *Revista Brasileira de Estudos de População*, 42, 1–30. <https://doi.org/10.20947/S0102-3098a0294>
- Destiartono, M. E. (2023). The Nexus Between Urbanization, Livestock, And Deforestation In Southeast Asia: Evidence From Pmg And Panel-Causality. *Barekeng: Jurnal Ilmu Matematika Dan Terapan*, 17(1), 0043–0052. <https://doi.org/10.30598/barekengvol17iss1pp0043-0052>
- Deng, D., Dong, J., Zhang, Y., Liang, W., Liu, K., & Li, L. (2023). Analysis of the environmental Kuznets curve for forest fragmentation: The case of Beijing-Tianjin-Hebei region in China. *Forest Policy and Economics*, 151, 102970. <https://doi.org/10.1016/j.forpol.2023.102970>
- Dewi, F. D., & Septriani, S. (2023). Analysis of factors affecting foreign direct investment in ASEAN countries. *ISAR Journal of Economics and Business Management*, 1(6), 36–40.
- Doytch, N. (2020). The impact of foreign direct investment on the ecological footprints of nations. *Environmental and Sustainability Indicators*, 8, 100085. <https://doi.org/10.1016/j.indic.2020.100085>
- Doytch, N., & Uctum, M. (2019). Spillovers from foreign direct investment in services: Evidence at sub-sectoral level for the Asia-Pacific. *Journal of Asian Economics*, 60, 33–44. <https://doi.org/10.1016/j.asieco.2018.10.003>
- Ellis, E. A., Navarro-Martínez, A., & García-Ortega, M. (2021). Drivers of forest cover transitions in the Selva Maya, Mexico: Integrating regional and community scales for landscape assessment. *Land Degradation & Development*, 32(10), 3122–3141. <https://doi.org/10.1002/ldr.3972>
- Firoj, M., Sultana, N., Khanom, S., Rashid, M. H. U., & Sultana, A. (2023). Pollution haven hypothesis and the environmental Kuznets curve of Bangladesh: An empirical investigation. *Asia-Pacific Journal of Regional Science*, 7(1), 197–227.
- FAO. (2025). *Global Forest Resources Assessment 2025*. Rome
- Gandapa, E. N. (2020). Analysis of Influences of Population Increase on Landuse Land Cover Change in Hong Local Government Area, Adamawa State, Nigeria. *Saudi Journal of Humanities and Social Sciences*, 05(05), 257–264. <https://doi.org/10.36348/sjhss.2020.v05i05.003>
- Gaveau, D. L. A., Santos, L., Locatelli, B., Salim, M. A., Husnayaen, H., Meijaard, E., Heatubun, C., & Sheil, D. (2021). Forest loss in Indonesian New Guinea (2001–2019): Trends, drivers and outlook. *Biological Conservation*, 261, 109225. <https://doi.org/10.1016/j.biocon.2021.109225>
- Georgiev, G., Alasaly, S., Fatima, S., & Sommer, J. M. (2024). Does Freedom of Domestic Movement Impact Forest Loss? A Cross-National Analysis. *Socius*, 10, 23780231241238673. <https://doi.org/10.1177/23780231241238673>
- Gujarati, D. N., & Porter, D. C. (2009). *Basic Econometrics*. McGraw-Hill Irwin.
- Guma, I., Rwashana, A., Oyo, B., & Waiswa, D. (2026). *Leveraging Spatial Analysis for Sustainable Land Use Change Management: A Case of the Mountain Elgon Region*. 382–389. <https://www.scitepress.org/Link.aspx?doi=10.5220/0013644800003970>
- Hao, Y., Xu, Y., Zhang, J., Hu, X., Huang, J., Chang, C., & Guo, Y. (2019). Relationship between forest resources and economic growth: Empirical evidence from China. *Journal of Cleaner Production*, 214, 848–859. <https://doi.org/10.1016/j.jclepro.2018.12.314>
- Hou, M., Deng, Y., Yao, S., & Liu, G. (2020). EKC test of the relationship between forest quality and economic growth considering spatial spillover effects. *Journal of Forest Research (Harbin)*, 12, 145–156.
- Hou, M., & Yao, S. (2019). EKC retest of fertilizer non-point source pollution emission under heterogeneous conditions—Grouping based on panel threshold model. *Journal of Agrotechnical Economics*, 4, 104–118. <https://doi.org/10.13246/j.cnki.jae.2019.04.018>
- Khoiriyannah, U., & Oktavilia, S. (2025). A Longitudinal Study on Deforestation Trends in Indonesia from 1996 to 2022. *Research Horizon*, 5(3), 787–796. <https://doi.org/10.54518/rh.5.3.2025.564>
- Kholil, Md. I., Tahrim, F., Esquivias, M. A., Al Mamun, M. A., & Rahmawati, Y. (2025). ASEAN's environmental consequences: Tourism, globalization, and FDI under the pollution haven hypothesis. *Discover Sustainability*, 6(1), 386. <https://doi.org/10.1007/s43621-025-01240-7>
- Koranteng, A., Adu-Poku, I., Frimpong, B. F., Asamoah, J. N., Agyei, J., & Zawila-Niedzwiecki, T. (2023). Urbanization and Other Land Use Land Cover Change Assessment in the Greater Kumasi Area of Ghana. *Journal of Geoscience and Environment Protection*, 11(5), 363–383. <https://doi.org/10.4236/gep.2023.115022>
- Kazungu, M., Velasco, R. F., Zhunusova, E., Lippe, M., Kabwe, G., Gumbo, D. J., & Guenter, S. (2021). Effects of household-level attributes and agricultural land-use on deforestation patterns along a forest transition gradient in the Miombo landscapes, Zambia. *Ecological Economics*, 186, 107070. <https://doi.org/10.1016/j.ecolecon.2021.107070>
- Kustanto, A. (2021). Does Trade Openness Cause Deforestation? A Case Study from Indonesia. *Jurnal Ekonomi Pembangunan*, 19(2), 165–182. <https://doi.org/10.29259/jep.v19i2.15530>
- Lestari, W., Angraini, C. P., Apriyanti, W., Rifa'ah, A. S., & Septriani, S. (2025). Diterminasi Kualitas Udara pada Wilayah

- Pertambahan: Bukti Empiris dari Peran PDRB, Produksi Batubara, dan Kepadatan Kendaraan Truk di Indonesia. *Salam (Islamic Economics Journal)*, 6(1), 224-237.
30. Li, F., Zhang, Y., Lu, Y., Liang, W., & Li, L. (2025). The Impact of Economic Growth on Forest Fragmentation: Evidence from Chinese counties. *Trees, Forests and People*, 101125. <https://doi.org/10.1016/j.tfp.2025.101125>
  31. Maijama'a, R., Musa, K., Saleh, Z. M., & Garba, A. (2020). *Assessing the Drivers of Deforestation in Nigeria: Evidence From Fully Modified Ordinary Least Squares*. <https://www.semanticscholar.org/paper/Assessing-the-Drivers-of-Deforestation-in-Nigeria%3A-Maijama%E2%80%99a-Musa/65fd152c7ad1fa27e8af29be321db3c4684cce8>
  32. Mandal, M., & Das Chatterjee, N. (2021). Forest landscape and its ecological quality: A stepwise spatiotemporal evaluation through patch-matrix model in Jhargram District, West Bengal State, India. *Regional Sustainability*, 2, 164–176. <https://doi.org/10.1016/j.regus.2021.06.002>
  33. Mwanga, M. (2025). A trade-off analysis of deforestation and economic growth in East Africa. *Trees, Forests and People*, 21, 100980. <https://doi.org/10.1016/j.tfp.2025.100980>
  34. Nguyen, C. P., & Nguyen, B. Q. (2023). Environmental foe or friend: the influence of the shadow economy on forest land. *Land Use Policy*, 124(C), 106456. <https://doi.org/10.1016/j.landusepol.2022.106456>
  35. Odawa, S., & Seo, Y. (2019a). Water Tower Ecosystems under the Influence of Land Cover Change and Population Growth: Focus on Mau Water Tower in Kenya. *Sustainability*, 11(13), 3524. <https://doi.org/10.3390/su11133524>
  36. Odawa, S., & Seo, Y. (2019b). Water Tower Ecosystems under the Influence of Land Cover Change and Population Growth: Focus on Mau Water Tower in Kenya. *Sustainability*, 11(13), 3524. <https://doi.org/10.3390/su11133524>
  37. Ofor, C. A., Abdul-Rahim, A. S., & Sulaiman, C. (2022). Impact of poverty, population density, and trade openness on deforestation: Fresh evidence from Nigeria. *IOP Conference Series: Earth and Environmental Science*, 1102(1), 012037. <https://doi.org/10.1088/1755-1315/1102/1/012037>
  38. Oyetunji, P. O., Ibitoye, O. S., Akinyemi, G. O., Fadele, O. A., & Oyediji, O. T. (2020). The Effects of Population Growth on Deforestation in Nigeria: 1991 – 2016. *Journal of Applied Sciences and Environmental Management*, 24(8), 1329–1334. <https://doi.org/10.4314/jasem.v24i8.4>
  39. Ponce, P., Del Río-Rama, M. de la C., Álvarez-García, J., & Oliveira, C. (2021). Forest Conservation and Renewable Energy Consumption: An ARDL Approach. *Forests*, 12(2), 255. <https://doi.org/10.3390/f12020255>
  40. Prochazka, P., Abrham, J., Cerveny, J., Kobera, L., Sanova, P., Benes, D., Fink, J.-M., Jiraskova, E., Primasova, S., Soukupova, J., & Smutka, L. (2023). Understanding the socio-economic causes of deforestation: A global perspective. *Frontiers in Forests and Global Change*, 6. <https://doi.org/10.3389/ffgc.2023.1288365>
  41. Rasit, N., & Aralas, S. I. (2019). The Pollution Haven Hypothesis: Evidence From Asean Countries. *Journal of Tourism, Hospitality And Environment Management (JTHERM)*, 4(14). <https://gaexcellence.com/jthem/article/view/1515>
  42. Septriani, S. Asymmetric Effects of Trade Openness and Chinese FDI on Indonesia's Economic Growth, 2010–2023.
  43. Septriani, S. POLITICAL RISK INDICATORS AND FOREIGN DIRECT INVESTMENT (FDI) ATTRACTION IN INDONESIA.
  44. Shahbaz, M., Nasreen, S., Abbas, F., & Anis, O. (2015). Does foreign direct investment impede environmental quality in high-, middle-, and low-income countries? *Energy Economics*, 51(C), 275–287.
  45. Sohag, K., Gainetdinova, A., & Mariev, O. (2023). Economic growth, institutional quality and deforestation: Evidence from Russia. *Forest Policy and Economics*, 150, 102949. <https://doi.org/10.1016/j.forpol.2023.102949>
  46. Trisnaputra, A., Barus, B., & Trisasongko, B. H. (2023). Modeling Land Use/Land Cover Change in Berau Pantai Forests, Berau Regency, East Kalimantan Province. *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan (Journal of Natural Resources and Environmental Management)*, 13(3), 386–397. <https://doi.org/10.29244/jpsl.13.3.386-397>
  47. Velasco, R. F., Köthke, M., Lippe, M., & Günter, S. (2020). Scale and context dependency of deforestation drivers: Insights from spatial econometrics in the tropics. *PLOS ONE*, 15(1), e0226830. <https://doi.org/10.1371/journal.pone.0226830>
  48. Wang, J., Khan, Y. A., Khodaei, M., Khezr, S., Karimi, M. S., & Salem, S. (2022). RETRACTED: The Effects of Financial Development and Pandemics Prevalence on Forests: Evidence From Asia-Pacific Region. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.850724>
  49. Wooldridge, J. M. (2016). *Introductory Econometrics A Modern Approach*. Adrian MI South-Western Cengage Learning [Scientific Research Publishing]. <https://www.scirp.org/reference/referencespapers?referenceid=2807432>
  50. 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>
  51. Zambrano Monserrate, M. A., Carvajal Lara, C., Urgiles Sanchez, R., & Alejandra Ruano, M. (2018). Deforestation as an indicator of environmental degradation: Analysis of five European countries. *Ecological Indicators*, 90, 1–8. <https://doi.org/10.1016/j.ecolind.2018.02.049>
  52. Zhu, S., Liu, J., Xu, H., Li, L., & Yang, W. (2022). Has China's new round of collective forest reforms reduced forest fragmentation? A case study of the Beijing-Tianjin-Hebei region. *International Journal of Environmental Research and Public Health*, 19, 6106. <https://doi.org/10.3390/ijerph19106183>