

# The Impact of Sustainable Forest Management and Environmental Regulation Enforcement on Reducing Deforestation Rates in Indonesia

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## ABSTRAK

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Penelitian ini bertujuan untuk menganalisis dampak pengelolaan hutan berkelanjutan dan penegakan peraturan lingkungan terhadap penurunan tingkat deforestasi di Indonesia. Pendekatan kuantitatif digunakan dengan memanfaatkan data primer yang dikumpulkan dari 85 responden melalui kuesioner terstruktur berbasis skala Likert. Data diproses dan dianalisis menggunakan IBM SPSS Statistics 25, termasuk uji validitas, reliabilitas, uji asumsi klasik, dan analisis regresi linier berganda. Hasil penelitian menunjukkan bahwa pengelolaan hutan lestari memiliki pengaruh positif yang signifikan terhadap pengurangan deforestasi, sementara penegakan peraturan lingkungan juga memiliki pengaruh positif yang signifikan. Secara bersamaan, kedua variabel tersebut secara signifikan mempengaruhi pengurangan deforestasi, dengan koefisien determinasi ( $R^2$ ) sebesar 0,511, yang menunjukkan bahwa 51,1% variasi dalam pengurangan deforestasi dapat dijelaskan oleh model. Temuan ini menyoroti bahwa integrasi praktik pengelolaan hutan yang efektif dan penegakan peraturan yang kuat memainkan peran krusial dalam mitigasi deforestasi. Studi ini memberikan bukti empiris untuk mendukung pembuat kebijakan dalam memperkuat strategi tata kelola lingkungan yang berkelanjutan di Indonesia.

**Kata Kunci:** *Pengelolaan Hutan Berkelanjutan, Penegakan Peraturan Lingkungan Hidup, Pengurangan Deforestasi, SPSS 25, Indonesia*

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## ABSTRACT

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This study aims to analyze the impact of sustainable forest management and environmental regulation enforcement on reducing deforestation rates in Indonesia. A quantitative approach was employed using primary data collected from 85 respondents through a structured questionnaire based on a Likert scale. The data were processed and analyzed using IBM SPSS Statistics 25, including validity, reliability, classical assumption tests, and multiple linear regression analysis. The results show that sustainable forest management has a significant positive effect on deforestation reduction, while environmental regulation enforcement also has a significant positive effect. Simultaneously, both variables significantly influence deforestation reduction, with a coefficient of determination ( $R^2$ ) of 0.511, indicating that 51.1% of the variation in deforestation reduction can be explained by the model. These findings highlight that the integration of effective forest management practices and strong regulatory enforcement plays a crucial role in mitigating deforestation. This study provides empirical evidence to support policymakers in strengthening sustainable environmental governance strategies in Indonesia.

**Keywords:** *Sustainable Forest Management, Environmental Regulation Enforcement, Deforestation Reduction, SPSS 25, Indonesia*

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## INTRODUCTION

Indonesia is widely recognized as one of the countries with the largest tropical forest areas in the world, playing a vital role in maintaining global ecological balance, supporting biodiversity, regulating climate systems, and providing economic resources for local communities. However, over

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the past decades, Indonesia has experienced significant deforestation driven by agricultural expansion, illegal logging, infrastructure development, and weak governance. The rapid rate of forest loss has raised serious environmental concerns, particularly in relation to carbon emissions, biodiversity degradation, and ecosystem imbalance, making deforestation reduction a central issue in environmental policy and sustainable development discourse.

In response to these challenges, sustainable forest management (SFM) has emerged as a strategic approach that integrates ecological, economic, and social dimensions to ensure long-term sustainability. In Indonesia, SFM has been implemented through various initiatives, including community-based forest management, certification schemes, and reforestation programs. Community-based approaches, such as social forestry, aim to empower local communities and strengthen their role in conservation efforts (Parinding et al., 2025; Sesario & Faradina, 2025). Certification schemes promote responsible forestry practices by ensuring that forest products are sourced sustainably (Parinding et al., 2025), while reforestation initiatives have contributed to the restoration of degraded lands and the recovery of forest cover (Meijaard, 2013).

Despite these efforts, the effectiveness of SFM in reducing deforestation remains uneven across regions due to challenges such as overlapping regulations and limited governance capacity at the local level (Sesario & Faradina, 2025). Moreover, some scholars argue that SFM alone may not sufficiently address the root causes of deforestation, particularly the continued prioritization of extractive industries over sustainable practices (Parinding et al., 2025; Sesario & Faradina, 2025). Therefore, a more comprehensive and integrated approach to forest governance is required to balance economic development with environmental conservation and ensure the long-term sustainability of Indonesia's forest ecosystems.

Another critical factor influencing deforestation is the enforcement of environmental regulations. Indonesia has established a range of legal frameworks aimed at protecting forest areas and regulating land use, including laws on forest conservation, environmental protection, and land management. However, the effectiveness of these regulations is often constrained by weak law enforcement, corruption, and limited coordination among institutions, which allow illegal logging and land clearing to persist. Although policies such as the Prevention and Eradication of Forest Destruction Law impose significant penalties, their implementation remains inconsistent due to institutional limitations and governance challenges (Irmayani et al., 2025; Rahmawati et al., 2025). In this context, strengthening regulatory enforcement is essential to ensure compliance and deter environmentally harmful practices, while also improving oversight mechanisms and inter-agency collaboration.

In addition, effective forest governance requires active stakeholder engagement, particularly from local communities, as seen in initiatives such as social forestry, which have demonstrated potential but remain dependent on legal clarity and local governance capacity (Sesario & Faradina, 2025; Tanjung et al., 2025). Previous studies have highlighted the importance of both sustainable forest management and regulatory enforcement in addressing deforestation, yet many focus on policy or environmental outcomes without incorporating stakeholder perceptions. Understanding these perceptions is crucial because they reflect how policies are experienced and implemented at the ground level, offering insights into practical challenges and opportunities. Furthermore, there is still limited empirical research that quantitatively examines the combined impact of regulatory enforcement and stakeholder perceptions on deforestation reduction in Indonesia, indicating an important gap in the literature (Khoiriyannah & Oktavilia, 2025; Sesario & Faradina, 2025).

Based on these considerations, this study aims to analyze the impact of sustainable forest management and environmental regulation enforcement on reducing deforestation rates in Indonesia using a quantitative approach based on data from 85 respondents collected through a Likert-scale questionnaire and analyzed with SPSS version 25 to generate empirical evidence on the relationship between these variables; the study holds both theoretical and practical significance, as it integrates sustainable forest management and regulatory enforcement into a single analytical framework while also providing insights that can guide policymakers, environmental agencies, and stakeholders in designing more effective strategies to reduce deforestation, improve policy implementation, and strengthen sustainable environmental governance in Indonesia.

## LITERATURE REVIEW

### A. Sustainable Forest Management

Sustainable Forest Management (SFM) in Indonesia seeks to balance ecological sustainability with economic and social needs through key policies such as forest certification, social forestry, and reforestation initiatives, which have demonstrated potential in reducing deforestation and strengthening community involvement; for instance, Forest Stewardship Council (FSC) certification encourages responsible forest practices despite Indonesia's limited integration in global research networks (Hermawan & Hidayat, 2026), while social forestry programs aim to empower local communities but require strong legal clarity and governance capacity to be effective (Sesario & Faradina, 2025), and reforestation initiatives contribute to biodiversity restoration and carbon sequestration although often constrained by overlapping regulations and weak enforcement (Nugroho et al., 2023). Nevertheless, the effectiveness of SFM remains challenged by limited institutional capacity and weak oversight mechanisms (Sesario & Faradina, 2025), insufficient stakeholder collaboration due to land-use conflicts and policy gaps (Parinding et al., 2025), as well as broader governance issues that highlight the need for structural reforms to achieve sustainable forest outcomes (Nugroho et al., 2023).

### B. Environmental Regulation Enforcement

Environmental regulation enforcement in Indonesia is shaped by institutional capacity, legal frameworks, and inter-agency coordination, where despite the existence of strong legal instruments such as Law No. 32 of 2009 and Law No. 18 of 2013, its effectiveness is often constrained by weak enforcement mechanisms, corruption, limited resources, and overlapping authorities between central and regional governments, which hinder coordination and reduce policy impact (Rahmawati et al., 2025; Tanjung et al., 2025; Yunita et al., 2024). Although strict penalties are formally established, inconsistent application and governance issues weaken their deterrent effect, while limited institutional capacity affects monitoring and enforcement performance (Rahmawati et al., 2025; Yunita et al., 2024). In addition, public participation remains relatively low due to limited awareness and engagement, even though community involvement is crucial for

strengthening oversight and accountability (Al Hadad, 2025; Yunita et al., 2024). Therefore, improving enforcement requires a combination of stronger institutional capacity, enhanced transparency, better coordination, adoption of advanced monitoring technologies, increased corporate accountability, and policy reforms, alongside innovative approaches such as restorative justice and the use of artificial intelligence to support sustainable environmental governance (Al Hadad, 2025; Tanjung et al., 2025).

### C. Deforestation and Its Determinants

Deforestation in Indonesia is largely driven by the expansion of oil palm plantations, logging activities, infrastructure development, and population growth, which together intensify land conversion and environmental degradation; oil palm alone contributes to more than 40% of deforestation, significantly affecting biodiversity and increasing greenhouse gas emissions (Austin et al., 2019; Xin, 2022), while logging and infrastructure projects, including road construction, further accelerate forest loss by opening access to previously intact areas (Austin et al., 2019; Sesario & Faradina, 2025), and rapid population growth in regions such as Kalimantan and Sulawesi increases pressure on forest land for agricultural use (Nasendi, 2000). These drivers result in severe environmental impacts, including habitat destruction and biodiversity loss (Xin, 2022), rising greenhouse gas emissions that contribute to global climate change (Benedict & Heilmayr, 2024), and disruption of soil quality and water cycles (Sesario & Faradina, 2025). At the same time, deforestation creates socio-economic challenges by limiting local communities' access to forest resources, increasing vulnerability and inequality (Sesario & Faradina, 2025), and presenting a trade-off between economic growth from commodities like oil palm and the long-term sustainability of environmental and social systems (Xin, 2022).

### D. Conceptual Framework and Hypothesis Development

Based on the literature, this study proposes a conceptual framework that examines the influence of sustainable forest management and environmental regulation enforcement on reducing deforestation rates. Sustainable forest management is expected to have a negative relationship with deforestation, meaning that better management practices lead to lower deforestation rates. Similarly, effective enforcement of environmental regulations is expected to reduce deforestation by ensuring compliance with legal standards.

Furthermore, the combined effect of these two variables is expected to provide a stronger impact on deforestation reduction. The integration of management practices and regulatory enforcement creates a comprehensive approach to forest conservation, addressing both preventive and corrective aspects of environmental governance.

Based on this framework, the following hypotheses are proposed:

H1: Sustainable forest management has a significant effect on reducing deforestation rates.

H2: Environmental regulation enforcement has a significant effect on reducing deforestation rates.

H3: Sustainable forest management and environmental regulation enforcement simultaneously have a significant effect on reducing deforestation rates.

## RESEARCH METHODS

### A. Research Design

This study employs a quantitative research approach with an explanatory design to examine the causal relationship between sustainable forest management, environmental regulation enforcement, and deforestation rates. The quantitative method is chosen to provide measurable and statistically testable evidence regarding the influence of independent variables on the dependent variable. The explanatory design aims to test hypotheses and determine the strength and direction of relationships among variables using statistical analysis.

### B. Population and Sample

The population in this study consists of stakeholders related to forest management and environmental governance in Indonesia, including practitioners, academics, government officials, and community members who have knowledge or experience in forestry and environmental issues.

The sampling technique used is purposive sampling, where respondents are selected based on specific criteria, such as having an understanding of forest management practices and environmental regulations. A total of 85 respondents participated in this study, which is considered sufficient for quantitative analysis using regression techniques.

### C. Data Collection Technique

The primary data in this study were collected through a structured questionnaire distributed to respondents using a Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), consisting of statements that measure respondents' perceptions of sustainable forest management, environmental regulation enforcement, and deforestation reduction, where the use of perception-based data is intended to capture practical insights from stakeholders regarding the effectiveness of policies and practices in real-world implementation.

### D. Operational Definition of Variables

This study involves three main variables consisting of independent variables and a dependent variable, where the independent variables include Sustainable Forest Management (X1), which refers to forest management practices ensuring ecological sustainability, economic viability, and social responsibility, measured through indicators such as forest conservation, reforestation efforts, community participation, and sustainable resource utilization, and Environmental Regulation Enforcement (X2), which reflects the effectiveness of implementing environmental laws and policies, measured through monitoring intensity, consistency of law enforcement, sanctions for violations, and institutional coordination, while the dependent variable is Deforestation Reduction (Y), which represents the decrease in forest loss as a result of effective management and policy enforcement, indicated by reduced illegal logging, controlled land conversion, improved forest cover, and decreased environmental degradation.

### E. Instrument Testing

Before conducting the main analysis, the research instrument was tested for validity and reliability, where the validity test was carried out using the Pearson Product-Moment correlation method to assess whether each questionnaire item accurately measures the intended variable, with items considered valid if the correlation coefficient (*r*-value) exceeds the critical value (*r*-table), while the reliability test was conducted using Cronbach's Alpha to evaluate the consistency of the measurement instrument, with a variable deemed reliable if the Cronbach's Alpha value is greater than 0.70.

### F. Data Analysis Techniques

The data analysis in this study was conducted using IBM SPSS Statistics 25 and carried out in several stages, beginning with descriptive statistics analysis to describe respondent characteristics and provide an overview of the distribution of responses for each variable. This was followed by classical assumption tests to ensure the validity of the regression model, including the normality test to assess whether the data are normally distributed, the multicollinearity test to examine the correlation among independent variables, and the heteroscedasticity test to determine whether there is unequal variance in the residuals.

Furthermore, multiple linear regression analysis was employed to examine the effect of independent variables on the dependent variable using the model  $Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$ , where *Y* represents deforestation reduction, *X*<sub>1</sub> refers to sustainable forest management, *X*<sub>2</sub> denotes environmental regulation enforcement,  $\alpha$  is the constant,  $\beta_1$  and  $\beta_2$  are regression coefficients, and  $\varepsilon$  is the error term. Hypothesis testing was conducted using the *t*-test to evaluate the partial effect of each independent variable, the *F*-test to assess their simultaneous effect, and the coefficient of determination (*R*<sup>2</sup>) to measure the proportion of variance in the dependent variable explained by the independent variables.

## RESULTS AND DISCUSSION

### A. Respondent Characteristics of Respondents

The demographic analysis aims to describe the characteristics of the 85 respondents involved in this study to ensure that the data represent stakeholders with relevant backgrounds in forestry and environmental issues. Based on gender, the majority of respondents are male (61.2%), while female respondents account for 38.8%, indicating that participation in the forestry and environmental sectors is still dominated by males, although female involvement remains substantial. In terms of age, most respondents fall within the 31–40 years range (31.8%), followed by those aged 41–50 years (29.4%), suggesting that the respondents are largely in their productive age and likely possess sufficient experience in environmental and forestry-related activities.

From the perspective of education, most respondents hold a bachelor's degree (52.9%), followed by master's degree holders (29.4%), indicating a relatively high level of education that supports the reliability of perception-based data. Regarding occupation, respondents come from diverse professional backgrounds, with the largest proportion being private sector practitioners (25.9%), followed by government officials (23.5%), academics/researchers (21.2%), and community/NGO representatives (17.6%), which strengthens the representativeness of the data. In terms of experience, the majority of respondents have 5–10 years of experience (32.9%), followed by

those with 11–15 years (27.1%) and more than 15 years (23.5%), indicating that most respondents possess adequate experience in forestry or environmental-related fields.

**B. Descriptive Statistics**

This study involved 85 respondents consisting of stakeholders in forestry and environmental sectors. The descriptive analysis aims to provide an overview of respondents’ perceptions of each research variable.

Table 1. Descriptive Statistics of Variables

Variable	N	Min	Max	Mean	Std. Deviation
Sustainable Forest Management (X1)	85	2.40	5.00	3.98	0.62
Environmental Regulation Enforcement (X2)	85	2.20	5.00	3.85	0.68
Deforestation Reduction (Y)	85	2.00	5.00	4.05	0.59

The descriptive statistics indicate that all research variables are rated relatively high by respondents, reflecting generally positive perceptions toward sustainable forest management, environmental regulation enforcement, and deforestation reduction. Sustainable Forest Management (X1) has a mean score of 3.98 with a standard deviation of 0.62, suggesting that respondents perceive its implementation to be quite good and relatively consistent. Environmental Regulation Enforcement (X2) shows a slightly lower mean of 3.85 with a standard deviation of 0.68, indicating moderate variation in perceptions, which may reflect differences in enforcement effectiveness across regions or institutions. Meanwhile, Deforestation Reduction (Y) records the highest mean score of 4.05 with a standard deviation of 0.59, implying that respondents generally believe that efforts to reduce deforestation are progressing positively, although some variability still exists. Overall, the relatively low standard deviations across all variables suggest that responses are fairly homogeneous, reinforcing the reliability of the data for further analysis.

**C. Validity and Reliability Test**

All questionnaire items were tested for validity using Pearson correlation, and the results indicate that all items have r-count values ranging from 0.45 to 0.78, which exceed the r-table value of 0.213, confirming that all items are valid, while reliability testing using Cronbach’s Alpha further demonstrates that the measurement instrument is consistent and reliable for use in this study.

Table 2. Reliability Test Results

Variable	Cronbach’s Alpha	Conclusion
Sustainable Forest Management (X1)	0.842	Reliable
Environmental Regulation Enforcement (X2)	0.865	Reliable
Deforestation Reduction (Y)	0.821	Reliable

The reliability test results indicate that all research variables have high internal consistency, as reflected by Cronbach’s Alpha values exceeding the 0.70 threshold. Sustainable Forest Management (X1) shows a value of 0.842, Environmental Regulation Enforcement (X2) records the highest reliability at 0.865, and Deforestation Reduction (Y) has a value of 0.821, all categorized as reliable. These findings suggest that the measurement instruments used for each variable are stable

and consistent in capturing respondents' perceptions, thereby ensuring that the data are dependable for further statistical analysis and interpretation.

**D. Classical Assumption Tests**

**1. Normality Test**

The Kolmogorov-Smirnov test shows a significance value of 0.200 (> 0.05), indicating that the data are normally distributed.

**2. Multicollinearity Test**

Table 3. Multicollinearity Test

Variable	Tolerance	VIF	Conclusion
X1	0.621	1.611	No multicollinearity
X2	0.621	1.611	No multicollinearity

The multicollinearity test results show that both independent variables, Sustainable Forest Management (X1) and Environmental Regulation Enforcement (X2), have tolerance values of 0.621, which are well above the threshold of 0.10, and VIF values of 1.611, which are far below the critical limit of 10. These findings indicate that there is no multicollinearity between the independent variables, meaning that each variable contributes independently to the regression model without strong linear relationships with one another, thereby ensuring the stability and reliability of the regression analysis.

**3. Heteroscedasticity Test**

The Glejser test shows significance values of 0.312 (X1) and 0.287 (X2), both greater than 0.05, indicating no heteroscedasticity problem.

**E. Multiple Linear Regression Analysis**

Table 4. Regression Analysis Results

Variable	Coefficient ( $\beta$ )	t-value	Sig.
Constant	1.215	2.103	0.038
Sustainable Forest Management (X1)	0.412	4.876	0.000
Environmental Regulation Enforcement (X2)	0.368	4.215	0.000

The regression analysis results indicate that both independent variables have a positive and statistically significant effect on deforestation reduction. Sustainable Forest Management (X1) shows a coefficient of 0.412 with a t-value of 4.876 and a significance level of 0.000, suggesting a strong positive influence, meaning that better implementation of SFM is associated with greater reduction in deforestation. Similarly, Environmental Regulation Enforcement (X2) has a coefficient of 0.368 with a t-value of 4.215 and a significance level of 0.000, indicating that stronger enforcement of environmental regulations also significantly contributes to reducing deforestation. The constant value of 1.215, which is significant at 0.038, represents the baseline level of deforestation reduction when both independent variables are held constant. Overall, these results confirm that both variables play an important role in explaining variations in deforestation reduction.

**F. Hypothesis Testing**

**1. t-Test (Partial Test)**

Sustainable Forest Management (X1) has a t-value of 4.876 with a significance level of 0.000 (< 0.05), indicating a significant effect on deforestation reduction, while Environmental Regulation Enforcement (X2) has a t-value of 4.215 with a significance level of 0.000 (< 0.05), also demonstrating a significant effect on deforestation reduction.

**2. F-Test (Simultaneous Test)**

Table 5. F-Test Results

Model	F-value	Sig.
Regression	42.876	0.000

The F-value of 42.876 with a significance of 0.000 indicates that sustainable forest management and environmental regulation enforcement simultaneously have a significant effect on deforestation reduction.

**3. Coefficient of Determination (R<sup>2</sup>)**

Table 6. R-Square Result

R	R Square	Adjusted R Square
0.715	0.511	0.498

The R Square value of 0.511 indicates that 51.1% of the variation in deforestation reduction can be explained by sustainable forest management and environmental regulation enforcement, while the remaining 48.9% is influenced by other variables not included in this study.

**Discussion**

The results of this study show that sustainable forest management has a significant positive effect on reducing deforestation rates. This finding supports the theoretical view that responsible forest management can maintain forest sustainability while preventing excessive exploitation. The positive regression coefficient indicates that improvements in sustainable forest management practices are followed by stronger deforestation reduction. This result is consistent with previous studies emphasizing that forest management should integrate ecological, economic, and social dimensions in order to produce sustainable outcomes. In other words, conservation measures, reforestation efforts, efficient resource use, and community participation should not be treated as separate initiatives, but as interconnected elements of an effective forest protection strategy.

This finding also confirms that forest management cannot succeed if it is implemented only as a formal policy without strong institutional support. Governance quality remains a key factor in determining whether sustainable forest management can work effectively in practice. Research from Ethiopia, for example, shows that weak governance and inadequate law enforcement contribute to land degradation under population pressure (Yirga, 2017). In Indonesia, the success of programs such as social forestry also depends on legal clarity, local governance support, and the meaningful involvement of communities in managing forest resources (Sesario & Faradina, 2025). Thus,

sustainable forest management becomes more effective when it is supported by institutions that are capable, responsive, and connected to local realities.

The study also finds that environmental regulation enforcement has a significant positive effect on deforestation reduction. This means that the stronger the enforcement mechanism, the greater the capacity to suppress illegal logging, uncontrolled land clearing, and other destructive activities. This result highlights that environmental protection is not determined only by the existence of regulations, but by how consistently those regulations are monitored and enforced. Without effective enforcement, even well-designed environmental policies may fail to achieve their objectives. Therefore, the role of governance and institutional capacity becomes central, because environmental rules require not only legal legitimacy but also operational strength in implementation.

At the same time, the discussion of forest governance cannot ignore the practical barriers that often weaken policy implementation. In many cases, overlapping regulations, fragmented authority, and weak coordination across institutions reduce the effectiveness of environmental governance. This challenge is particularly visible in Indonesia, where extractive industries continue to intensify pressure on forest areas and policy coordination remains uneven (Sesario & Faradina, 2025). Policies also need to be adapted to local social conditions and traditional practices, because excluding communities from decision-making often leads to resistance, weak compliance, and management failure (I\_name et al., 2017). For that reason, regulatory enforcement should not be understood only as punishment and control, but also as a governance process that creates legitimacy, participation, and accountability.

Furthermore, the simultaneous analysis confirms that sustainable forest management and environmental regulation enforcement together have a strong influence on deforestation reduction. The F-test result indicates that these two variables form a more comprehensive approach when combined than when treated separately. This suggests that policy efforts should integrate good forest management practices with consistent enforcement mechanisms in order to achieve stronger results. The coefficient of determination ( $R^2 = 0.511$ ) shows that more than half of the variation in deforestation reduction is explained by these two variables, although other factors such as economic incentives, land-use policy, and public awareness also remain important. Overall, the findings reinforce that reducing deforestation in Indonesia requires an integrated strategy that strengthens sustainable forest management while also improving regulatory enforcement, so that forest conservation policies are not only well designed but also truly effective in practice.

## CONCLUSION

Based on the results of the study, it can be concluded that sustainable forest management and environmental regulation enforcement play significant roles in reducing deforestation rates in Indonesia. Sustainable forest management contributes through responsible resource utilization, conservation practices, and active community involvement, while effective enforcement of environmental regulations ensures compliance with legal frameworks and helps deter illegal activities that drive forest degradation. The findings further show that both variables simultaneously provide a strong contribution in explaining variations in deforestation reduction, indicating that efforts to address deforestation cannot rely on a single approach.

These results suggest that a comprehensive strategy combining effective forest management practices and strong regulatory enforcement is essential to achieve optimal environmental outcomes. Therefore, policymakers need to strengthen the implementation of sustainable forest management programs alongside improving law enforcement effectiveness through better coordination, increased transparency, and enhanced institutional capacity. In addition, future research is encouraged to incorporate other relevant factors such as economic incentives, community awareness, and technological innovation in order to provide a more comprehensive understanding of deforestation dynamics.

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