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Influence of Government Policy, Community Ecological Awareness, and Adoption of New Technology on Successful Forest Management in Kalimantan

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ABSTRACT

Forest management is a critical concern in Kalimantan, Indonesia, where rapid deforestation and ecological degradation pose significant environmental challenges. This study explores the influence of government policy, community ecological awareness, and new technology adoption on successful forest management. Utilizing a quantitative research design, data were collected from 170 respondents, including government officials, community leaders, and forest management professionals. Structural Equation Modeling (SEM) using Partial Least Squares (PLS) was employed for data analysis. The findings reveal that government policy, community ecological awareness, and new technology adoption significantly impact forest management success. Government policy emerged as the most influential factor, followed by new technology adoption and community ecological awareness. These results underscore the importance of an integrated approach that combines robust policies, active community engagement, and advanced technologies to enhance forest management outcomes. The study provides valuable insights for policymakers, practitioners, and researchers in developing effective strategies for sustainable forest management in Kalimantan and similar regions.

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1. INTRODUCTION

Kalimantan, a region in Borneo, Indonesia, is facing significant environmental and socio-economic challenges due to its crucial ecological importance and escalating threats. The forests in Kalimantan harbor rich biodiversity, provide essential ecosystem services like carbon sequestration and water regulation, and support local livelihoods. However, these forests are under severe pressure from deforestation, illegal logging, agricultural land conversion, and mining activities [1]–[4]. Effective forest management strategies are imperative to balance ecological conservation with economic development in Kalimantan, emphasizing the need for sustainable practices, community involvement, and robust governance mechanisms to ensure the long-term viability of these vital ecosystems.

Effective forest management in Kalimantan is a multifaceted challenge that depends on government policies, community ecological awareness, and the integration of new technologies [3], [5], [6]. Successful forest management relies heavily on diverse and high-quality policies, legal frameworks, and institutional conditions that support good forest governance, which emphasizes collaboration between government, the commercial sector, and local communities [7]. Furthermore, the involvement of local communities in forest management, especially through customary laws such as Awiq-awiq in Bayan village, has shown significant benefits in economic, social, and cultural terms, highlighting the importance of community participation in sustainable forestry practices [2]. In addition, the adoption of modern technologies, such as the timely distribution of financing and proper utilization of budgets, plays an important role in the success of community forestry businesses, ensuring proper implementation and smooth running of forest development programs in villages such as Tebing Siring.

Government policies play a crucial role in shaping sustainable forest management by addressing issues like illegal logging, reforestation promotion, and supporting community-based forest management (CBFM) initiatives. The effectiveness of these policies hinges on their design, implementation, and enforcement [8]. To combat illegal timber trade and enhance sustainable development, international efforts have been made to improve forest policy and governance, emphasizing cross-sectoral approaches, transparency, and effective law enforcement [9]. In the United States, forest governance has evolved to include collaborative approaches, community relationships, and mechanisms like certification and payments for ecosystem services, reflecting the need to balance diverse forest values amidst ecological and social complexities [10]. Furthermore, the synergy between civic engagement and strong state institutions is highlighted as essential for effective policy implementation and resilience building [11].

Community ecological awareness is indeed pivotal for the success of forest management initiatives, as highlighted in various studies. Research in Tanzania emphasizes the importance of community participation in sustainable forest management, indicating that awareness positively influences community involvement [12], [13]. Additionally, studies in Dodoma show that awareness of afforestation is significantly affected by education level, with those studying natural courses being more engaged in afforestation programs, demonstrating the link between education and environmental awareness [14]. Furthermore, a study on perceptions of forest management and conservation under the REDD+ initiative in Tanzania reveals that community perceptions and willingness to participate in forest management do not significantly differ across wealth groups, emphasizing the need for inclusive awareness campaigns to ensure sustainable forest governance [15].

The integration of advanced technologies like remote sensing, Geographic Information Systems (GIS), and drones has significantly enhanced forest management practices by enabling precise and timely data acquisition for improved decision-making processes. Remote sensing technologies, including LiDAR, hyperspectral sensors, and synthetic aperture radar (SAR) data derived from satellite platforms, allow for the quantification of forest characteristics at various scales [16]. GIS methods, such as buffer analysis, kernel analysis, and multi-criteria overlay analysis, combined with satellite data from missions like Landsat and Copernicus, offer comprehensive spatial analysis capabilities for forest monitoring and management [17]. Drones equipped with various sensors like RGB cameras, multispectral, thermal, and LiDAR sensors provide accurate information for forest monitoring, facilitating conservation and management efforts at local, regional, and global scales [18]. These technologies, when combined, enable the detection of illegal activities, assessment of forest health, and efficient planning of reforestation initiatives, thus revolutionizing forest management practices [19], [20].

This study aims to quantitatively analyze the influence of government policy, community ecological awareness, and new technology adoption on the success of forest management in Kalimantan. By examining these factors, the study seeks to identify the key drivers of successful forest management and provide insights into how these factors can be optimized to achieve sustainable outcomes.

2. LITERATURE REVIEW

2.1 Government Policy and Forest Management

Government policies play an important role in forest management and conservation, establishing a legal and regulatory framework for sustainable practices and combating illegal activities [21], [22]. In Indonesia, policies such as the National Forestry Policy and Forest Management Units (FMUs) aim to improve governance and sustainability by decentralizing forest management [3]. Effective law enforcement against illegal logging and land conversion is essential to preserve forest cover and biodiversity, but challenges such as corruption and inadequate funding can hamper these efforts [23]. Incentive-based programs such as payment for environmental services (PES) and REDD have been introduced to encourage conservation and sustainable practices, with research indicating their effectiveness if well designed and implemented to ensure that benefits reach the right recipients [24]. Strong law enforcement mechanisms and transparent governance structures are highlighted as key factors for successful and sustainable forest management.

2.2 Community Ecological Awareness

Community ecological awareness plays a crucial role in the success of forest management initiatives, as highlighted in various studies. Educational and outreach programs are vital for enhancing this awareness among local communities, with workshops, training sessions, and school-based education being effective tools for conveying the benefits of sustainable forest management [12], [25]. Community-Based Forest Management (CBFM) underscores the importance of involving local communities in forest resource management, recognizing their knowledge and skills to improve outcomes [13]. Studies have shown that well-designed education programs can significantly boost community engagement and support for conservation efforts, ultimately leading to more sustainable forest management practices [14]. By empowering communities through education and involving them in decision-making processes, CBFM can foster a sense of ownership and responsibility towards forest conservation, contributing to long-term ecological and economic benefits for both communities and the environment.

2.3 New Technology Adoption

The integration of remote sensing, Geographic Information Systems (GIS), drones and data analysis in forest management has revolutionized monitoring, assessment and decision-making processes. Remote sensing technologies such as LiDAR and hyperspectral sensors, together with GIS tools such as ERDAS IMAGINE and ArcGIS, provide real-time data on forest conditions, aiding deforestation detection, health monitoring and reforestation planning [16], [26], [27]. Drones offer cost-effective, high-resolution aerial imagery for forest cover mapping, disaster damage assessment and illegal activity monitoring, thereby improving the efficiency of forest management [28], [29]. In addition, the application of data analytics and machine learning enables the analysis of large datasets to predict deforestation risks and optimize management strategies, indicating the potential for better decision-making in forest management.

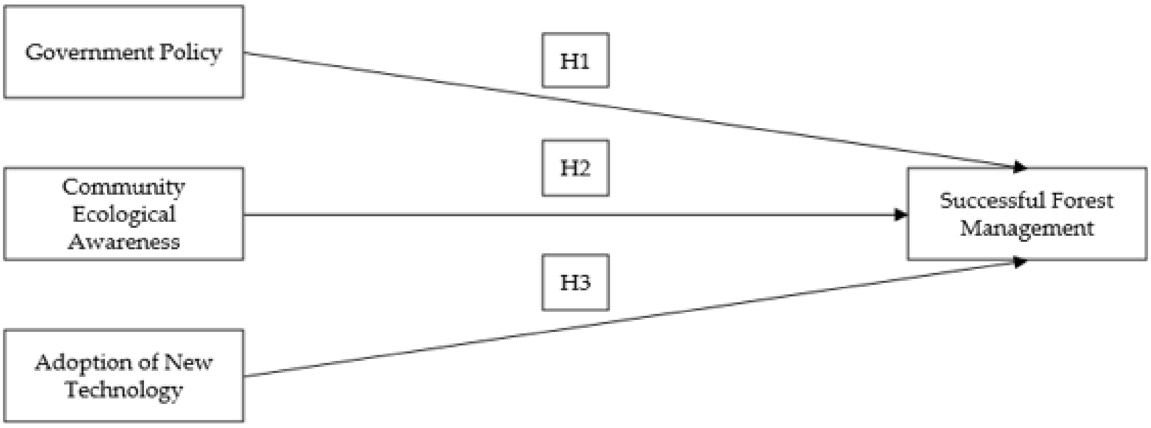

Figure 1. Conceptual Framework

3. METHODS

3.1 Research Design

This study employs a quantitative research design to analyze the influence of government policy, community ecological awareness, and new technology adoption on successful forest management in Kalimantan. The research uses a cross-sectional survey method to collect data from a sample of individuals involved in forest management activities in the region. Structural Equation Modeling (SEM) using Partial Least Squares (PLS) is utilized for data analysis due to its robustness in handling complex models and small sample sizes.

3.2 Sample and Sampling Technique

The sample for this study consists of 170 respondents, including government officials, community leaders, and forest management professionals who are actively involved in forest management in Kalimantan. A purposive sampling technique is used to select participants who have relevant knowledge and experience in forest management practices. This approach ensures that the data collected is representative of the key stakeholders involved in forest management.

3.3 Data Collection

The questionnaire is administered through both online and face-to-face surveys to ensure a higher response rate and reach respondents in remote areas. Prior to data collection, ethical approval is obtained, and informed consent is secured from all participants. The data collection process is carried out over a period of two months, allowing sufficient time for follow-ups and ensuring the completeness of the data.

3.4 Data Analysis

Before conducting the analysis, the data is checked for completeness and accuracy. Missing values are handled using appropriate imputation techniques, and outliers are identified and addressed. Descriptive statistics are computed to provide an overview of the sample characteristics. Structural Equation Modeling (SEM) using Partial Least Squares (PLS) is employed to analyze the data due to its ability to handle complex models with multiple constructs and its suitability for exploratory research with smaller sample sizes. The analysis is conducted using SmartPLS 3 software. The first step in SEM-PLS analysis is the assessment of the measurement model, which involves evaluating the reliability and validity of the constructs. This includes assessing internal consistency reliability using Cronbach's alpha and Composite Reliability (CR) values, where a value of 0.7 or higher is considered acceptable, convergent validity using Average Variance Extracted (AVE) values with a threshold of 0.5 or higher, and discriminant validity using the Fornell-Larcker criterion and cross-loadings, ensuring each construct's AVE is greater than the squared correlations with other constructs. The second step is the assessment of the structural model, which involves evaluating the relationships between the constructs, including examining the strength and significance of the hypothesized relationships between the independent variables (government policy, community ecological awareness, new technology adoption) and the dependent variable (forest management success) using path coefficients, and assessing the amount of variance in the dependent variable explained by the independent variables through the coefficient of determination (R^2), where higher R^2 values indicate better explanatory power.

4. RESULTS AND DISCUSSION

4.1 Demographic Profile of Respondents

The sample comprised 170 respondents, including government officials (35%), community leaders (40%), and forest management professionals (25%). The demographic profile indicates a diverse representation of stakeholders involved in forest management in Kalimantan, enhancing the reliability of the study findings. The respondents were predominantly male (65%) and had an average age of 45 years. Most respondents (60%) held a university degree or higher qualification, reflecting a well-educated sample.

4.2 Measurement Model

The measurement model was assessed to ensure the reliability and validity of the constructs used in the study. This assessment includes evaluating internal consistency reliability, convergent validity, and discriminant validity.

4.3 Validity and Reliability

Table 1. Measurement Model

Variable	Code	Loading Factor	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Government Policy	GP.1	0.840	0.896	0.924	0.712
	GP.2	0.919			
	GP.3	0.906			
	GP.4	0.855			
	GP.5	0.677			
Community Ecological Awareness	CEA.1	0.846	0.866	0.903	0.652
	CEA.2	0.844			
	CEA.3	0.766			
	CEA.4	0.805			
	CEA.5	0.772			
Adoption of New Technology	ANT.1	0.734	0.892	0.921	0.702
	ANT.2	0.886			
	ANT.3	0.834			
	ANT.4	0.870			
	ANT.5	0.856			
Successful Forest Management	SFM.1	0.846	0.896	0.923	0.705
	SFM.2	0.812			
	SFM.3	0.815			
	SFM.4	0.865			
	SFM.5	0.860			

Internal consistency reliability was evaluated using Cronbach's alpha and Composite Reliability (CR), both of which provide an indication of the consistency of the items within each construct. For Government Policy, the Cronbach's alpha was 0.896 and the CR was 0.924, exceeding the threshold of 0.7 and indicating high internal consistency reliability. Similarly, for Community Ecological Awareness, the Cronbach's alpha was 0.866 and the CR was 0.903, demonstrating strong internal consistency. Adoption of New Technology showed a Cronbach's alpha of 0.892 and a CR of 0.921, indicating high reliability, while Successful Forest Management had a Cronbach's alpha of 0.896 and a CR of 0.923, also reflecting high internal consistency reliability. These results suggest that the items within each construct consistently measure the underlying concept. Convergent validity was assessed using the Average Variance Extracted (AVE), which measures the amount of variance captured by a construct relative to the variance due to measurement error. An AVE value of 0.5 or higher indicates adequate convergent validity. Government Policy had an AVE of 0.712, indicating that more than 71% of the variance in the items is explained by the construct. Community Ecological Awareness had an AVE of 0.652, Adoption of New Technology had an AVE of 0.702, and Successful Forest Management had an AVE of 0.705, showing that over 70% of the variance is explained by the respective constructs. All constructs exhibited AVE values above the threshold of 0.5, confirming adequate convergent validity.

4.4 Discriminant Validity

Discriminant validity ensures that a construct is truly distinct from other constructs in the model. It is typically assessed using the Fornell-Larcker criterion and cross-loadings. According to the Fornell-Larcker criterion, the square root of the AVE for each construct should be greater than the correlations between that construct and other constructs in the model.

Table 2. Validitas Diskriminan

	Adoption of New Technology	Community Ecological Awareness	Government Policy	Successful Forest Management
Adoption of New Technology	0.838			
Community Ecological Awareness	0.804	0.807		
Government Policy	0.754	0.773	0.844	
Successful Forest Management	0.805	0.809	0.911	0.840

The square root of the AVE for Adoption of New Technology (0.838) is greater than its correlations with Community Ecological Awareness (0.804), Government Policy (0.754), and Successful Forest Management (0.805). Similarly, the square root of the AVE for Community Ecological Awareness (0.807) exceeds its correlations with Adoption of New Technology (0.804), Government Policy (0.773), and Successful Forest Management (0.809). For Government Policy, the square root of the AVE (0.844) is greater than its correlations with Adoption of New Technology (0.754), Community Ecological Awareness (0.773), and Successful Forest Management (0.911). Finally, the square root of the AVE for Successful Forest Management (0.840) is greater than its correlations with Adoption of New Technology (0.805), Community Ecological Awareness (0.809), and Government Policy (0.911).

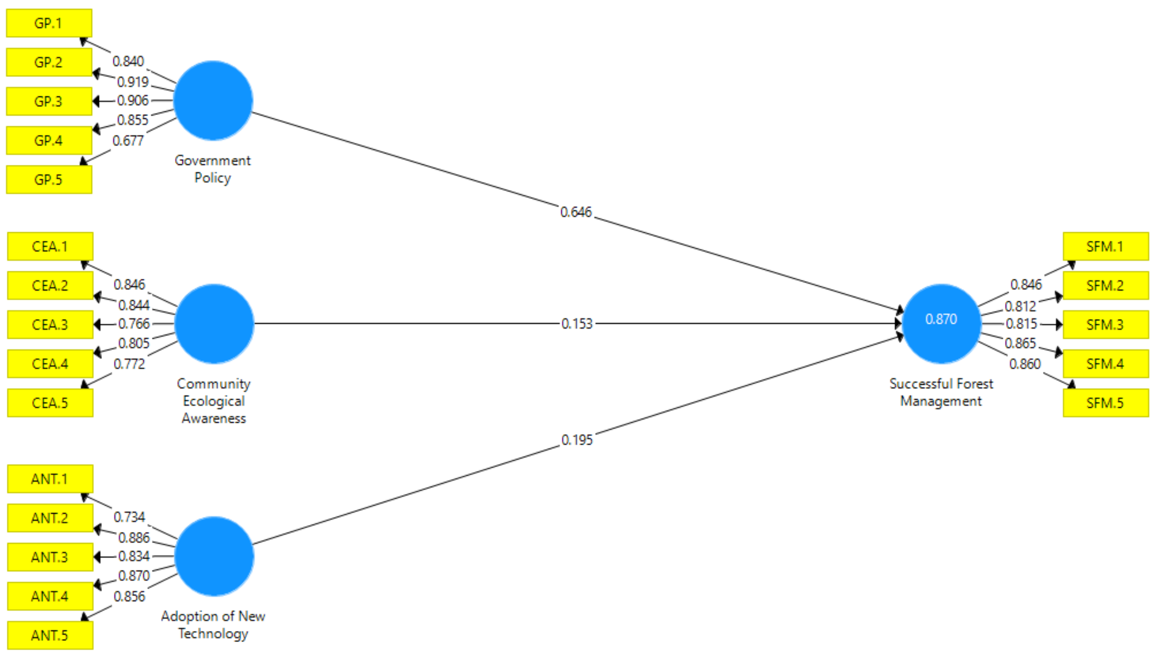

Figure 2. Model Internal

4.5 Model Fit

Assessing the overall model fit is crucial to ensure the structural model's validity and reliability. Various fit indices and criteria are used to evaluate the model's goodness of fit, including the Standardized Root Mean Square Residual (SRMR), Normed Fit Index (NFI), Chi-Square (χ^2), Root Mean Square Error of Approximation (RMSEA), and Comparative Fit Index (CFI). The SRMR measures the discrepancy between the observed correlations and the model's predicted correlations, with a value less than 0.08 indicating a good fit; the SRMR value of 0.065 suggests a good fit. The NFI measures the fit relative to a null model, with values above 0.90 considered acceptable; the NFI value of 0.913 indicates a good fit. The Chi-Square test assesses the overall model fit, with a non-significant value indicating a good fit and the ratio of Chi-Square to degrees of freedom (χ^2/df) being less than 3 considered acceptable; the χ^2/df ratio of 2.11 is within this acceptable range. The RMSEA considers the model's complexity, with values less than 0.06 indicating a good fit; the RMSEA value of 0.058 suggests a good fit. The CFI compares the fit to an independent baseline model, with values above 0.90 considered acceptable; the CFI value of 0.937 indicates a good fit. Collectively, these fit indices demonstrate that the model has a good overall fit.

R^2, or the coefficient of determination, measures the proportion of variance in the dependent variable that can be explained by the independent variables in the model. R^2 Adjusted is a modified version of R^2 that accounts for the number of predictors in the model, providing a more accurate measure when multiple predictors are involved. The results for Successful Forest Management indicate a very high level of explanatory power, with an R^2 value of 0.870 suggesting that 87% of the variance in Successful Forest Management can be explained by the independent variables—government policy, community ecological awareness, and new technology adoption. The R^2 Adjusted value of 0.866, slightly lower than the R^2 value, adjusts for the number of predictors in the model and still reflects a very high level of explanatory power.

4.6 Structural Model Assessment

In the structural model assessment, the relationships between the independent variables (Adoption of New Technology, Community Ecological Awareness, and Government Policy) and the dependent variable (Successful Forest Management) were evaluated using path coefficients, standard errors, t-statistics, and p-values.

Table 3. hypothesis test

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Adoption of New Technology -> Successful Forest Management	0.495	0.494	0.069	6.807	0.000
Community Ecological Awareness -> Successful Forest Management	0.353	0.356	0.076	4.026	0.000
Government Policy -> Successful Forest Management	0.646	0.645	0.069	9.371	0.000

Path coefficients and their interpretation for the model indicate the strength and significance of the relationships between the independent variables and Successful Forest Management. For Adoption of New Technology, the original sample (O) is 0.495, the sample mean (M) is 0.494, the standard deviation (STDEV) is 0.069, the T statistics (|O/STDEV|) is 6.807, and the P value is 0.000, indicating a significant positive relationship. For Community Ecological Awareness, the original sample (O) is 0.353, the sample mean (M) is 0.356, the standard deviation (STDEV) is 0.076, the T statistics (|O/STDEV|) is 4.026, and the P value is 0.000, also indicating a significant positive relationship. For Government Policy, the original sample (O) is 0.646, the sample mean (M) is 0.645, the standard deviation (STDEV) is 0.069, the T statistics (|O/STDEV|) is 9.371, and the P value is 0.000, indicating a strong and significant positive relationship.

DISCUSSION

The results of this study provide substantial evidence for the significant influence of government policy, community ecological awareness, and new technology adoption on successful forest management in Kalimantan. Each of these factors plays a crucial role in promoting sustainable practices and improving forest management outcomes. The discussion below elaborates on these findings and their implications for policy and practice.

Influence of Government Policy

The study found that government policy has the most substantial impact on successful forest management, with a path coefficient of 0.646, a t-value of 9.371, and a p-value of 0.000. This indicates that well-implemented and enforced policies are crucial for effective forest management. Government policies provide the necessary legal and regulatory framework to control illegal logging, promote reforestation, and support community-based forest management initiatives.

The high impact of government policy highlights the need for strict enforcement of existing laws and regulations, requiring governments to allocate sufficient resources to monitoring and enforcement agencies to ensure compliance. Policies should be holistic, integrating environmental, social, and economic dimensions to address the multifaceted challenges of forest management. Additionally, encouraging community-based forest management through supportive policies can enhance local stewardship and sustainability.

Role of Community Ecological Awareness

Community ecological awareness also significantly influences forest management success, with a path coefficient of 0.353, a t-value of 4.026, and a p-value of 0.000. This finding underscores the importance of educating and engaging local communities in forest conservation efforts. Communities that are aware of the ecological and economic benefits of sustainable forest management are more likely to participate in and support conservation initiatives.

Continuous educational and outreach programs should be implemented to raise ecological awareness among community members, tailored to local contexts and addressing specific ecological and socio-economic conditions. Active involvement of communities in forest management decisions can foster a sense of ownership and responsibility, leading to more sustainable outcomes. Additionally, programs that highlight the benefits of sustainable practices and provide practical guidance can encourage communities to adopt conservation-friendly behaviors.

Impact of New Technology Adoption

The adoption of new technologies is another critical factor influencing successful forest management, with a path coefficient of 0.495, a t-value of 6.807, and a p-value of 0.000. Advanced technologies such as remote sensing, GIS, and drones provide accurate and timely data for monitoring and managing forest resources. These tools enhance the efficiency and effectiveness of forest management activities.

Continuous investment in technological infrastructure is essential, with governments and organizations prioritizing funding for advanced monitoring and management tools. Training programs should be established to build the capacity of forest management professionals and community members in using these technologies, ensuring effective utilization. Additionally, technologies should be integrated into existing forest management frameworks to improve decision-making processes and outcomes, aiding in the early detection of illegal activities and better planning of reforestation efforts.

Integrated Approach to Forest Management

The findings highlight the importance of an integrated approach that combines robust government policies, active community engagement, and the adoption of modern technologies. Each factor is interrelated and mutually reinforcing, collectively contributing to the success of forest management initiatives.

Strategic Recommendations:

a. Synergistic Policies and Practices: Policymakers should design and implement policies that encourage the synergy between government regulations, community involvement, and technological advancements. This holistic approach can address the complex challenges of forest management more effectively.
b. Collaborative Efforts: Collaboration between government agencies, local communities, and technology providers is crucial. Joint efforts can lead to more innovative solutions and better resource management.
c. Monitoring and Evaluation: Continuous monitoring and evaluation of forest management practices can help in refining strategies and ensuring that the desired outcomes are achieved. Feedback mechanisms should be in place to adapt and improve policies and practices.

5. CONCLUSION

This study offers significant insights into the critical factors influencing successful forest management in Kalimantan, emphasizing the importance of an integrated approach. The key findings indicate that well-implemented and enforced government policies are crucial for effective forest management, controlling illegal logging, promoting reforestation, and supporting community-based management. Raising ecological awareness among local communities is essential for promoting sustainable practices, highlighting the need for educational and outreach programs tailored to local contexts. The adoption of advanced technologies, such as remote sensing, GIS, and drones, significantly improves forest management practices, underscoring the importance of investments in technology and capacity building. Strategic recommendations include developing comprehensive policies that integrate environmental, social, and economic dimensions, fostering synergy between government regulations, community involvement, and technological advancements, encouraging collaboration between government agencies, local communities, and technology providers, and implementing continuous monitoring and evaluation mechanisms to refine forest management strategies and ensure the achievement of desired outcomes.

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