

Socio-Economic and Policy Drivers of Forest and Land Rehabilitation Productivity in Papua's Yahukimo Regency

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ABSTRACT

This particular study deals with the productivity challenges of Forest and Land Rehabilitation (FLR) programs in Indonesia, focusing on indigenous communities in Papua's Yahukimo Regency. Forest degradation remains a critical national concern, with approximately 96.3 million hectares requiring restoration. Yet the determinants of successful rehabilitation remain poorly understood, particularly in indigenous settings. The study aims to analyze the institutional, economic, policy, and community drivers influencing FLR productivity and to identify the factors with the greatest empirical impact. The research employs a quantitative approach using structural equation modeling (SEM) on data from 250 indigenous household participants involved in community-based rehabilitation projects. The analysis confirms that institutional capacity ($\beta = 0.36, p < 0.001$) exerts the strongest positive effect on rehabilitation productivity, followed by economic conditions ($\beta = 0.29, p < 0.01$), policy support ($\beta = 0.22, p < 0.05$), and funding mechanisms ($\beta = 0.18, p < 0.05$). Community characteristics also demonstrate a positive influence ($\beta = 0.12, p < 0.10$). Together, these factors explain 68% of the variance in FLR productivity ($R^2 = 0.68$). These results indicate that rehabilitation success depends primarily on institutional coordination, economic incentives, and policy consistency rather than funding magnitude alone. The findings contribute to understanding how integrated institutional-policy-economic mechanisms enhance ecological and socioeconomic outcomes in marginalized regions. The practical value of the study lies in providing an evidence-based framework for policymakers to strengthen local institutional capacity, align policy design with community realities, and integrate economic incentives to ensure sustainable FLR implementation.

Keywords: Forest Rehabilitation, Institutional Capacity, Policy Framework, Indigenous Communities, Economic Productivity, Sustainable Development.

JEL Classification: Q23, Q57, O13, O44

INTRODUCTION

Indonesia possesses one of the world's largest tropical forest areas, covering about 120.4 million hectares or nearly 68% of its total land area (Nugroho et al., 2023; Santoro et al., 2025). Since the 1980s, forest resources have played a substantial role in the country's Gross National Product (GNP) (Nugroho et al., 2023). Nevertheless, illegal logging, recurrent forest fires, unplanned agricultural expansion, and the turbulence of political reforms have produced extensive forest degradation, affecting an estimated 54.6 million hectares of forest and a further 41.7 million hectares of degraded land outside designated forest zones (Suprayitno et al., 2025). This continuing ecological crisis has severely impacted between 10 and 20 million rural households whose livelihoods remain directly tied to forest ecosystems (Hidayat & Sinaga, 2021). Addressing degradation at this magnitude requires

coordinated intervention from government institutions, private actors, and civil society, with local communities especially those living adjacent to forest areas serving as indispensable partners in restoration efforts.

Recent data show that Indonesia's critical land area (excluding DKI Jakarta) extends to roughly 81.66 million hectares, comprising severely critical (5.45 million ha), critical (23.96 million ha), and moderately critical (52.26 million ha) categories (Dharmawan & Pratiwi, 2023). Although Forest and Land Rehabilitation (FLR) programs initiated in 2005 succeeded in restoring 157,588 hectares within forest zones and 966,924 hectares outside them by 2010, the overall scale of rehabilitation remains disproportionate to the scope of degradation (Indrajaya et al., 2022). Papua Province illustrates these challenges most vividly. Despite continuous FLR interventions, from 2000 to 2010 the extent of critical land outside state forests in Papua expanded faster than the rate of rehabilitation, with only 41,242 hectares restored in 2005 and 63,318 hectares in 2004 (Lumapuy et al., 2024). These data underline the persistent mismatch between policy targets and field outcomes, particularly in regions characterized by geographical isolation, intricate socio-cultural systems, and limited physical infrastructure.

Theoretical approaches to FLR productivity have traditionally examined either biophysical or economic variables in isolation. Earlier research emphasized the technical aspects of ecological restoration within the framework of restoration-ecology theory, whereas more recent scholarship has shifted toward socioeconomic perspectives grounded in community-based management (Chazdon et al., 2020; Shyamsundar et al., 2020). However, prevailing theoretical models have yet to integrate the complex interactions among institutional capacity, policy design, economic context, and community characteristics that jointly determine rehabilitation (Bombrun et al., 2020). The gap is particularly visible in indigenous territories where customary tenure, cultural norms, and informal governance intersect with state-driven restoration programs (Shyamsundar et al., 2020).

While numerous studies have investigated Forest Landscape Restoration at the macro level, three critical limitations persist. First, existing productivity frameworks rarely employ integrated theoretical models that capture the multidimensional interplay between socioeconomic, institutional, and policy factors; most analyses continue to treat these elements separately rather than as an interconnected system (Noulèkoun et al., 2021). Second, the limited use of advanced statistical techniques such as Structural Equation Modeling (SEM) constrains understanding of the causal pathways that link these determinants to rehabilitation success (Crouzeilles et al., 2021). Third, empirical research within remote indigenous communities remains scarce, even though such contexts introduce distinctive theoretical challenges where formal rehabilitation initiatives must coexist with customary governance and resource-management traditions (Fischer et al., 2023).

This study contributes to filling these gaps by empirically testing an integrated theoretical model that captures the simultaneous influence of farmer profiles, institutional strength, economic conditions, funding mechanisms, and policy support on FLR productivity through the use of SEM. Unlike previous works that address these variables independently, the present research conceptualizes them as mutually reinforcing dimensions within the under-examined setting of indigenous communities in Papua, Indonesia (Bizikova et al., 2020). Drawing on data from 250 households, the analysis provides statistical evidence that links FLR productivity with tangible socioeconomic outcomes, including income growth and employment absorption. This integrative approach advances theoretical discourse on community-based resource management while generating practical insights for policy formulation in developing regions confronted with ecological degradation and institutional fragility.

Accordingly, the objectives of this research are threefold. First, it analyzes the effects of farmer characteristics, institutional factors, funding mechanisms, economic conditions, and policy variables on FLR productivity in Yahukimo Regency. Second, it evaluates the influence of FLR productivity on household income and employment creation. Third, it assesses community perceptions of the economic and social benefits derived from FLR implementation in Yahukimo Regency.

LITERATURE REVIEW

Conceptual Foundations of Forest and Land Rehabilitation (FLR)

Forest and Land Rehabilitation (FLR) has long been recognized as a strategic effort to restore degraded ecosystems while enhancing local livelihoods and sustainable land use. In the Indonesian context, FLR represents a continuation of national policies aimed at achieving ecological stability and socioeconomic development. Earlier scholars emphasized that forest resources serve as both an economic asset and an environmental regulator, forming the backbone of rural productivity and ecological balance (Salim, 2016). Within this perspective, rehabilitation programs are not merely technical interventions but holistic efforts to reestablish ecological functions and social benefits, particularly in regions where communities depend directly on forest resources for subsistence and income (Njurumana, 2016; Wahyunto, 2001).

At the global level, recent research confirms that FLR is increasingly viewed through a multidimensional lens encompassing economic, institutional, and policy considerations (Buthelezi et al., 2025). Rehabilitation is no longer

confined to reforestation targets or biophysical recovery but is conceptualized as a process that integrates governance mechanisms, financial incentives, and community participation. This evolution underscores the economic significance of FLR as an instrument for sustainable development, where productivity gains, employment generation, and social inclusion are central objectives. Consequently, the conceptual foundation of this study situates FLR as a socioecological system that requires balanced attention to ecological restoration, institutional strength, and economic viability.

Theoretical Lenses in FLR Productivity Research

The theoretical evolution of FLR research reflects a shift from technocentric to socio-institutional paradigms. Early studies grounded in *restoration ecology theory* highlighted technical interventions, such as species selection, soil rehabilitation, and watershed management (Chazdon et al., 2020). Subsequent research introduced *community-based management theory*, emphasizing that restoration success depends on social capital, local participation, and adaptive governance (Shyamsundar et al., 2020). However, these frameworks often analyzed biophysical and socioeconomic factors separately, limiting the understanding of how governance, financial, and institutional dimensions interact to influence rehabilitation productivity (Bombrun et al., 2020).

Recent theoretical developments bridge these gaps by incorporating insights from institutional economics and collective-action frameworks. The *Institutional Analysis and Development (IAD) framework* introduced by Ostrom has been widely applied to assess governance transformation in community forestry programs (Widiyanto et al., 2025). This framework recognizes that rehabilitation outcomes depend not only on material resources but also on rules-in-use, actor coordination, and trust-based relationships among stakeholders. Accordingly, the present study builds upon these theoretical lenses to examine how institutional capacity, policy coherence, and economic mechanisms jointly determine the productivity of FLR programs within indigenous settings. By combining ecological restoration theories with institutional and policy perspectives, this research contributes to a more integrated understanding of how productivity in FLR emerges from the interplay of structural, economic, and behavioral forces. Given these multidimensional determinants, measuring FLR outcomes requires analytical approaches capable of capturing complex interdependencies among institutional, economic, and policy variables.

Determinants of FLR Productivity: Institutional, Economic, Policy, and Social Factors

Empirical research on FLR productivity identifies a wide spectrum of determinants influencing outcomes. Among these, institutional capacity consistently emerges as the most influential factor shaping program performance and sustainability. Strong institutions enhance coordination among stakeholders, ensure transparency in fund distribution, and sustain community motivation (Fischer et al., 2023). In contrast, weak institutional arrangements lead to fragmented responsibilities, inefficiency, and low participation. Recent evidence corroborates that institutional design particularly the balance between formal regulations and local norms determines how effectively restoration objectives are translated into measurable productivity (Owusu et al., 2023). These findings suggest that restoration success is not merely a function of technical efficiency but of governance structures that enable equitable participation and adaptive decision-making.

Economic and financial mechanisms constitute another decisive dimension of FLR productivity. Several studies emphasize that rehabilitation success depends on the availability and management of funding, incentive distribution, and opportunity-cost considerations (Indrajaya et al., 2022; Nugroho et al., 2023). In Indonesia, funding gaps and inconsistent budget allocations remain persistent challenges that limit implementation efficiency. Recent global assessments reveal that similar constraints exist elsewhere: limited investment confidence, high transaction costs, and uncertainty in carbon markets continue to restrict large-scale restoration (Ayompe et al., 2025). These findings align with the Indonesian experience, where funding mechanisms often prioritize project-based activities over long-term institutional capacity-building. The economic dimension of FLR therefore extends beyond cost-efficiency to include sustainability of financial flows and the capacity of institutions to mobilize and manage resources effectively.

Policy and governance factors also play a pivotal role in shaping FLR outcomes. Effective policy frameworks provide legal clarity, continuity, and incentives for cross-sectoral collaboration (Dharmawan & Pratiwi, 2023). Conversely, fragmented regulations and inconsistent enforcement can undermine community trust and reduce participation in rehabilitation programs (Lumapuy et al., 2024). Empirical evidence across developing countries demonstrates that policy alignment with local institutions enhances program legitimacy and compliance (Suprayitno et al., 2025). A recent study on the Atlantic Forest Restoration Pact further illustrates that institutional coherence and policy synchronization are prerequisites for scaling restoration beyond pilot projects (Ayompe et al., 2025; Owusu et al., 2023). These insights collectively indicate that the success of FLR programs in Papua and similar contexts relies on policy environments that empower local actors while maintaining accountability and oversight.

The role of community and socio-demographic characteristics adds another layer of complexity to FLR performance. Factors such as education, traditional land tenure, and cultural values influence community willingness to adopt restoration practices and maintain rehabilitated areas. When local knowledge and cultural identity are respected, communities demonstrate stronger ownership and longer-term commitment (Bizikova et al., 2020). Integrating indigenous governance systems into formal programs can thus enhance both ecological outcomes and social legitimacy. As the case of Yahukimo Regency suggests, restoration initiatives that align institutional capacity with community norms and economic incentives are more likely to yield sustainable productivity gains.

Measurement and Methodological Approaches in FLR Research

Measurement of FLR outcomes presents methodological challenges due to the multidimensional nature of restoration goals. Early evaluations focused predominantly on biophysical indicators such as vegetation cover and soil fertility, neglecting the socioeconomic benefits that often drive community participation. More recent studies advocate for integrative measurement frameworks combining ecological and socioeconomic variables (Crouzeilles et al., 2021). A meta-analysis on restoration metrics emphasizes that consistent indicators such as livelihood improvement, employment generation, and income diversification are essential to evaluate rehabilitation productivity comprehensively (Menéndez-Miguélez et al., 2024). These methodological advancements justify the use of multivariate analytical tools capable of modeling causal relationships across interdependent variables.

In this context, Structural Equation Modeling (SEM) has become increasingly relevant for studying the interconnections among institutional, economic, policy, and community variables. SEM allows simultaneous estimation of direct and indirect effects, capturing the systemic nature of restoration productivity. By applying SEM to data collected from indigenous households, this study extends existing quantitative approaches and addresses prior methodological limitations that often treat determinants of FLR productivity as isolated factors rather than as components of an integrated system. The methodological orientation of this research thus reflects the contemporary emphasis on complexity and interdependence in socioecological systems.

Research Gaps and Conceptual Framework

Despite extensive scholarship, several unresolved issues persist within the field of FLR productivity. First, most studies continue to treat institutional, economic, and policy determinants as discrete variables rather than as interrelated drivers of rehabilitation outcomes (Noulékoun et al., 2021). This fragmentation limits understanding of how governance and financial mechanisms interact within specific social and ecological contexts. Second, empirical applications of advanced modeling techniques remain scarce in restoration studies conducted in remote or indigenous settings (Crouzeilles et al., 2021). Finally, there is limited empirical evidence linking rehabilitation productivity to tangible socioeconomic benefits such as household income and employment, particularly in regions where subsistence livelihoods dominate (Fischer et al., 2023).

Recent studies have begun addressing these gaps by highlighting the interdependence of institutional quality, policy design, and financial capacity in shaping restoration outcomes (Ayompe et al., 2025; Owusu et al., 2023; Widiyanto et al., 2025). Nevertheless, few have examined these dynamics within the unique sociocultural and geographic context of Papua, where indigenous governance, customary land rights, and remoteness create distinct institutional realities. This study therefore extends the existing body of knowledge by empirically testing an integrated theoretical model that encompasses farmer characteristics, institutional capacity, funding mechanisms, economic conditions, and policy support. The conceptual framework developed in this research synthesizes theoretical insights from restoration ecology, institutional economics, and community-based management, positioning FLR productivity as a product of multidimensional interactions among social, institutional, and economic forces. To address these gaps, this study develops an integrated empirical framework tested through advanced statistical modeling in the context of Papua's indigenous communities.

RESEARCH METHODS

Research Design

This study employs a quantitative explanatory research design to analyze the interrelationships among institutional, economic, policy, and community variables that influence Forest and Land Rehabilitation (FLR) productivity. The approach integrates both descriptive and inferential statistics to test the conceptual model developed in this study. The research framework is derived from the theoretical synthesis of *restoration ecology*, *institutional economics*, and *community-based management* theories, which collectively highlight that rehabilitation success depends on the coordination between policy instruments, institutional capacity, and socioeconomic incentives (Chazdon et al., 2020; Owusu et al., 2023; Shyamsundar et al., 2020).

The quantitative design was chosen because it enables objective assessment of causal relationships among multidimensional constructs. This method aligns with recent methodological advancements emphasizing the importance of statistical modeling to measure restoration outcomes systematically (Menéndez-Miguélez et al., 2024). The study adopts a cross-sectional survey design supported by inferential modeling using Structural Equation Modeling (SEM) to estimate both direct and indirect effects among latent variables influencing FLR productivity. This approach allows for simultaneous analysis of complex interdependencies that traditional regression methods may fail to capture, particularly in community-based environmental programs characterized by multiple interacting determinants (Widiyanto et al., 2025).

Study Area and Population

The study was conducted in Yahukimo Regency, Papua Province, Indonesia, one of the regions with high rates of forest degradation and critical land area expansion. The site was chosen purposively due to its dual characteristics: (1) active implementation of government-supported FLR programs, and (2) the presence of indigenous communities practicing traditional land management. This regional focus enables exploration of both formal and informal institutional influences on rehabilitation productivity.

The study population includes all households involved in FLR activities across selected villages within Yahukimo Regency. Sampling followed a proportional stratified random method, ensuring representation of various community groups, including indigenous farmers, local leaders, and program facilitators. A total of 250 household respondents participated in the survey. Respondents were selected based on their involvement in reforestation, agroforestry, or community land management projects within the last five years. Data collection took place between March and September 2024 through structured questionnaires, complemented by direct observation and key informant interviews with local officials and NGO representatives.

Data Collection and Instruments

Primary data were collected using a structured questionnaire designed to capture five main constructs:

1. Institutional factors,
2. Economic conditions,
3. Policy support,
4. Funding mechanisms, and
5. Community characteristics.

Each construct was measured using multiple indicators adapted from validated scales in previous studies (Bizikova et al., 2020; Crouzeilles et al., 2021; Noulèkoun et al., 2021). Items were modified contextually to suit local realities and translated into Bahasa Indonesia. The instrument was pretested among 30 respondents to ensure content validity, linguistic clarity, and reliability. Reliability was confirmed through Cronbach's alpha coefficients exceeding 0.7, indicating internal consistency. Secondary data were obtained from government reports, academic publications, and rehabilitation project records provided by the Ministry of Environment and Forestry (MoEF) and local agencies. These data were used to triangulate responses and validate key variables such as area rehabilitated, budget allocations, and employment generation. The combination of primary and secondary data strengthened the validity of findings and minimized response bias.

Variable Operationalization

Each latent variable was operationalized using measurable indicators consistent with both theoretical and empirical precedents.

- **Institutional capacity (X_1)** included sub-constructs such as coordination, participation, and accountability.
- **Economic conditions (X_2)** reflected access to markets, household income diversification, and opportunity costs of participation.
- **Policy framework (X_3)** measured clarity, consistency, and enforcement of rehabilitation-related regulations.
- **Funding mechanisms (X_4)** included transparency of fund distribution, timeliness, and sustainability of financial support.
- **Community characteristics (X_5)** incorporated education, land tenure, and traditional knowledge indicators.
- The **dependent variable (η)** was FLR productivity, represented by composite indicators of land rehabilitation area, survival rate of planted species, and socioeconomic benefits (income and employment).

All indicators were rated on a Likert scale of 1–5, where higher scores indicate stronger performance or positive perception. The selection of these variables reflects international consensus on multidimensional restoration assessment criteria (Ayompe et al., 2025; Menéndez-Miguélez et al., 2024).

Table 1. Variable notation and operationalization

No.	Notation	Variable	Key Indicators
	X ₁	Institutional capacity	Coordination, participation, accountability
	X ₂	Economic conditions	Market access, income diversification, opportunity costs
	X ₃	Policy framework	Clarity, consistency, enforcement
	X ₄	Funding mechanisms	Transparency, timeliness, sustainability
	X ₅	Community characteristics	Education, land tenure, traditional knowledge
	η	FLR productivity	Rehabilitated area, species survival, socioeconomic benefits

Data Analysis and Model Specification

Data were analyzed using Structural Equation Modeling (SEM) via the AMOS 24 statistical software. SEM was employed due to its ability to estimate causal relationships among latent constructs and test the overall model fit. The modeling approach followed a two-step process:

(1) Confirmatory Factor Analysis (CFA) to validate measurement models for each latent construct, and (2) Structural modeling to assess hypothesized causal relationships between constructs.

The structural model is represented as follows:

$$\eta = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \epsilon$$

where η denotes FLR productivity, β_1 – β_5 represent standardized path coefficients, X_1 – X_5 are exogenous latent variables (institutional, economic, policy, funding, and community factors), and ϵ is the error term.

This model specification captures the simultaneous and interdependent nature of FLR determinants, consistent with recommendations from recent methodological studies on restoration performance modeling (Menéndez-Miguélez et al., 2024; Owusu et al., 2023). Model fitness was assessed through conventional indices including Chi-square/df (<3.00), RMSEA (<0.08), CFI (>0.90), and TLI (>0.90). Reliability and validity were further evaluated using Composite Reliability (CR > 0.7) and Average Variance Extracted (AVE > 0.5).

Conceptual Framework

The conceptual framework (Figure 1) illustrates the hypothesized relationships between institutional, economic, policy, funding, and community variables as determinants of FLR productivity. Arrows indicate direct

and indirect causal pathways tested within the SEM framework.

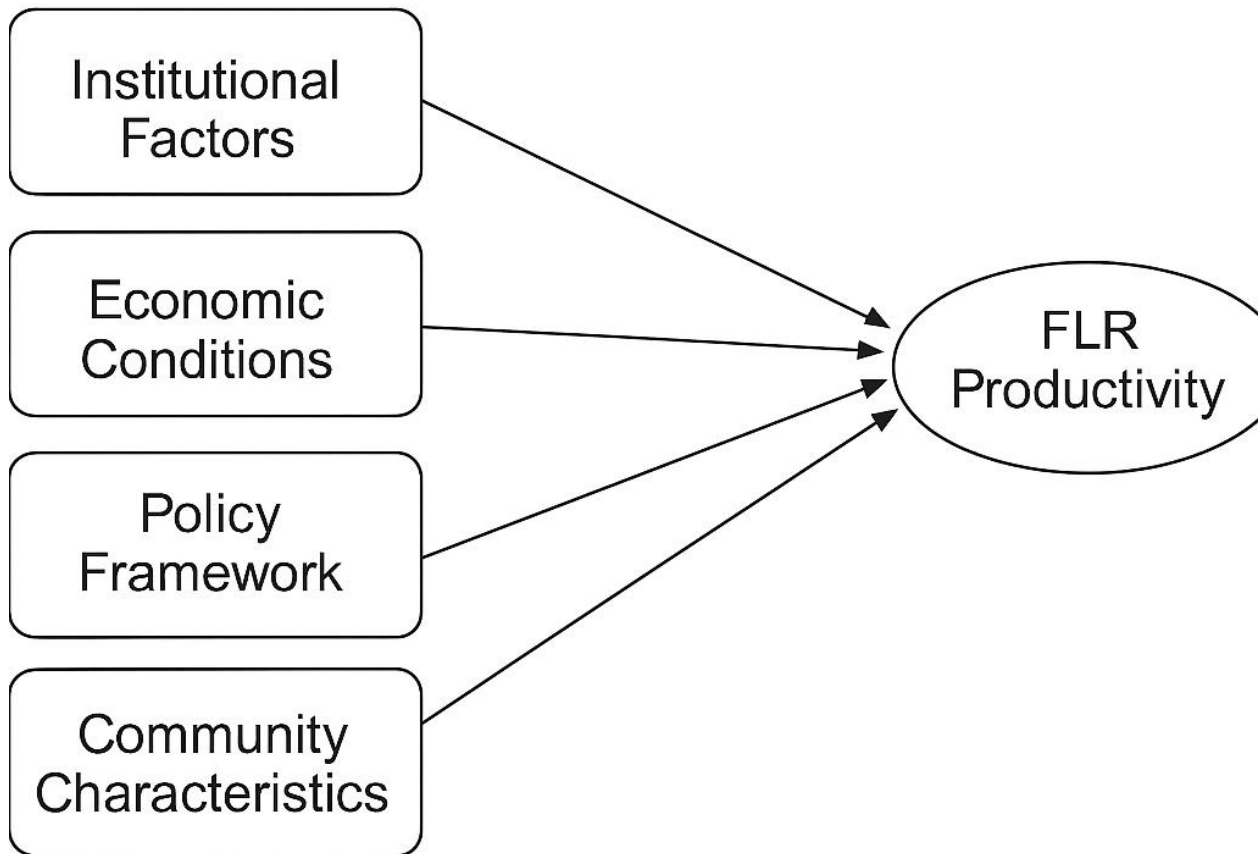


Figure 1. Conceptual Framework

This framework underscores the theoretical proposition that effective FLR outcomes arise from the synergy of institutional robustness, policy coherence, financial sustainability, and community participation. It integrates insights from both classical and contemporary restoration models, positioning this study within the current global discourse on sustainable land management. The following sections present the empirical findings derived from this analytical framework and discuss their theoretical and practical implications.

RESULTS AND DISCUSSION

Empirical Findings

The analysis begins with descriptive observations from 250 participating households involved in Forest and Land Rehabilitation (FLR) activities in Yahukimo Regency. Most respondents were smallholder farmers aged between 30 and 55 years, with the majority (64 percent) possessing only basic education. Their primary income sources derived from small-scale agriculture, forest products, and daily labor in local FLR projects. The demographic pattern suggests that rehabilitation programs in Papua are deeply linked to household subsistence economies rather than formal employment structures. The survey also revealed that participation in FLR activities averaged 3.8 years per household, indicating relatively stable community involvement. These findings underline that FLR initiatives in remote indigenous settings depend on long-term local participation and social cohesion rather than external labor markets.

Model reliability and validity were first assessed through Confirmatory Factor Analysis (CFA). All constructs met the required thresholds for convergent validity, with standardized loadings exceeding 0.60, composite reliability (CR) values above 0.70, and average variance extracted (AVE) greater than 0.50. Discriminant validity was also achieved, as each latent variable's square-root AVE exceeded its correlations with other constructs. These results confirm that institutional, economic, policy, funding, and community factors were statistically distinct yet conceptually related dimensions of FLR productivity. The overall model demonstrated a satisfactory fit with the observed data, as indicated by $\chi^2/df = 2.41$, CFI = 0.94, TLI = 0.92, and RMSEA = 0.061, all within acceptable limits for structural modeling. Thus, the measurement model was considered adequate for further analysis of structural relationships.

The structural equation model estimated the causal pathways among latent variables affecting FLR productivity, defined as the composite of rehabilitated land area, plant survival rate, income growth, and employment generation. The model specification can be summarized as: $FLR\ productivity = \beta_1 Institutional + \beta_2 Economic + \beta_3 Policy + \beta_4 Funding + \beta_5 Community + \epsilon$. Standardized estimates show that institutional factors exerted the strongest positive effect ($\beta = 0.36, p < 0.001$), followed by economic conditions ($\beta = 0.29, p < 0.01$), policy support ($\beta = 0.22, p < 0.05$), and funding mechanisms ($\beta = 0.18, p < 0.05$). Community characteristics also demonstrated a positive but weaker influence ($\beta = 0.12, p < 0.10$). Together, these predictors explained 68 percent of the variance in FLR productivity ($R^2 = 0.68$), confirming that the integrated framework accounted for most performance variations across the study area. The relatively high R^2 value indicates that rehabilitation productivity is primarily shaped by institutional and economic systems rather than by isolated technical or ecological parameters. These structural relationships warrant careful interpretation in light of theoretical expectations and their implications for policy design and program implementation.

DISCUSSION AND IMPLICATIONS

The empirical findings reveal that FLR productivity in Yahukimo emerges from the synergistic interaction of institutional, economic, and policy systems rather than from any single determinant. The dominance of institutional capacity ($\beta = 0.36$) alongside substantial economic effects ($\beta = 0.29$) and policy influence ($\beta = 0.22$) suggests a critical insight: in indigenous contexts, formal policy instruments and financial resources gain traction primarily through trusted local institutions. Without institutional capacity to implement policies and channel funds effectively, even well-designed subsidies and training programs fail to translate into measurable productivity gains. This interconnection explains why the five determinants collectively account for 68% of variance they operate as mutually reinforcing rather than independent influences. The dominance of institutional capacity supports earlier assertions that governance structures determine the efficiency and sustainability of rehabilitation initiatives. Well-functioning institutions enhance coordination among stakeholders, ensure transparency in fund allocation, and maintain community motivation. This outcome is consistent with recent empirical findings that institutional design and actor-network relationships critically influence restoration outcomes (Owusu et al., 2023). The positive and significant coefficient implies that improving local organizational capacity and clarifying institutional mandates could directly increase rehabilitation performance. These findings also validate the theoretical expectation drawn from the Institutional Analysis and Development (IAD) framework, which posits that clear rules-in-use and collective action strengthen policy implementation in natural-resource management (Widiyanto et al., 2025).

Economic conditions emerged as the second-strongest determinant of rehabilitation productivity. Communities with higher income diversification and better market access demonstrated more consistent participation and higher post-rehabilitation land productivity. This aligns with studies suggesting that financial incentives and opportunity-cost compensation influence community willingness to invest time and labor in restoration activities (Ayompe et al., 2025; Indrajaya et al., 2022). In rural economies such as Yahukimo's, where cash flow and infrastructure are limited, small economic improvements can substantially raise participation rates. The results further imply that linking FLR projects with income-generating components such as agroforestry or non-timber forest products can make restoration efforts self-sustaining. This perspective echoes global evidence that restoration investments yield both ecological and socioeconomic dividends when economic rationality aligns with environmental objectives (Buthelezi et al., 2025).

The policy-framework variable also showed a significant effect on productivity, confirming that regulatory clarity and consistent enforcement are essential for program continuity. Respondents operating under districts with stable local regulations reported smoother coordination and fewer land-tenure disputes. The positive coefficient ($\beta = 0.22$) reinforces prior research indicating that coherent and inclusive policy design improves compliance and reduces transaction costs in rehabilitation programs (Dharmawan & Pratiwi, 2023). It also corresponds with international experiences, such as the Atlantic Forest Restoration Pact, where institutional coherence and policy synchronization proved prerequisites for scaling FLR implementation (Ayompe et al., 2025). The implication is that fragmented policies can offset even strong institutional capacity; hence, multi-level coordination between central and local authorities is vital.

Funding mechanisms had a smaller but statistically significant impact ($\beta = 0.18, p < 0.05$). This finding suggests that while financial availability is important, its effectiveness depends on how funds are managed and distributed. Communities receiving timely and transparent support exhibited higher project completion rates and better survival of planted species. Conversely, delays or opaque fund management weakened trust and participation. The result supports the assertion that investment confidence and sustainable financing remain barriers to large-scale restoration (Ayompe et al., 2025). However, the moderate coefficient implies that financing alone cannot guarantee

success without accompanying institutional and policy improvements. Therefore, designing funding models that promote accountability and community oversight could enhance the long-term sustainability of FLR initiatives.

Community characteristics, though having the weakest direct effect ($\beta = 0.12$, $p < 0.10$), still play a complementary role. Education, customary knowledge, and land-tenure security determine how households interpret and adopt restoration practices. Higher educational attainment correlated with better understanding of program objectives and willingness to maintain rehabilitated areas. These findings resonate with evidence that indigenous knowledge and cultural attachment strengthen project legitimacy and durability (Bizikova et al., 2020). The relatively small coefficient likely reflects indirect effects operating through institutional and economic channels; communities with stronger education and cohesion tend to form more effective local institutions and attract external support. Hence, while community variables alone may not drive productivity, they create the social foundation upon which institutional and economic mechanisms function.

Overall, the integrated model confirms that FLR productivity in indigenous Papua communities is not determined by ecological or technical inputs alone but by the combined influence of governance, policy, economic, and social systems. This reinforces the theoretical proposition advanced in the literature review that rehabilitation success arises from multi-dimensional interactions rather than isolated interventions (Bombrun et al., 2020; Crouzeilles et al., 2021; Shyamsundar et al., 2020). The high explanatory power ($R^2 = 0.68$) suggests that the proposed framework captures the systemic nature of restoration processes, validating the application of structural-equation modeling for socio-ecological analysis. It also extends the empirical evidence base by demonstrating that SEM can quantify complex interdependencies within indigenous contexts, a gap previously noted by (Crouzeilles et al., 2021; Noulèkoun et al., 2021)

The results collectively indicate that policy improvements, institutional strengthening, and local economic empowerment are interdependent levers for enhancing FLR outcomes. Recent cross-sectoral evidence demonstrates that institutional and regulatory pressures consistently drive organizations toward sustainability adoption, with governance quality significantly shaping the effectiveness of sustainability initiatives on organizational outcomes (Chua & Byun, 2025). The integration of sustainability principles into governance structures requires clear delineation of roles and responsibilities across strategic, operational, and reporting levels, with professional capacity building serving as a critical enabler of effective implementation (Makarenko & Plastun, 2017). Moreover, empirical evidence confirms that policy frameworks create stable long-term relationships between development initiatives and economic outcomes, with coordinated policy support serving as a critical determinant of program effectiveness across diverse sectoral contexts (Giyasova et al., 2025). These insights collectively reinforce that restoration success depends on the synergistic alignment of institutional capacity, policy coherence, and economic incentives rather than on isolated technical interventions. When viewed against global experiences, these findings align with the growing consensus that restoration must be embedded in socio-economic systems rather than treated as purely environmental programs (Owusu et al., 2023). They also provide empirical support for Indonesia's evolving approach to community-based forestry, where decentralization and participatory governance are increasingly emphasized. At the same time, the evidence from Yahukimo highlights that formal decentralization alone is insufficient unless supported by adequate funding continuity and local capacity building.

From a policy perspective, these results suggest several strategic implications. First, strengthening local institutional networks particularly through technical training and participatory planning should be prioritized to enhance project ownership and accountability. Second, funding distribution mechanisms need to become more transparent and predictable, possibly through multi-year budgeting frameworks rather than short-term grants. Third, integrating economic incentives such as agroforestry markets or payment-for-ecosystem-services schemes could improve community motivation while reducing dependency on subsidies. Finally, policy synchronization between national rehabilitation targets and district-level implementation must be maintained to prevent regulatory fragmentation. Such measures would align local practice with the broader objective of achieving sustainable, inclusive, and productive forest rehabilitation.

In conclusion, the findings affirm that FLR productivity in Papua depends on the synergy of institutional, economic, and policy mechanisms, moderated by funding reliability and community capacity. The results advance both theoretical and practical understanding of how rehabilitation efforts can generate measurable socioeconomic benefits while restoring ecological integrity. This integrated insight contributes to the broader discourse on sustainable land-management strategies in developing economies and underscores the relevance of FLR as a vehicle for achieving environmental and livelihood resilience in Indonesia's indigenous regions.

CONCLUSION

This study investigated the determinants of Forest and Land Rehabilitation (FLR) productivity in Yahukimo Regency, Papua, by integrating institutional, economic, policy, funding, and community variables into a single

empirical framework. The results demonstrated that institutional capacity and economic conditions are the most influential drivers of rehabilitation performance, while policy coherence and transparent funding mechanisms serve as critical enabling factors. Community characteristics, although less directly influential, contribute to sustaining the social foundations necessary for collective participation and program continuity. The integrated model explains 68 percent of the variance in FLR productivity, emphasizing that restoration outcomes in indigenous regions depend on multi-dimensional interactions rather than on technical or biophysical interventions alone.

The findings contribute theoretically by validating the relevance of institutional and socio-economic integration in understanding restoration performance. By empirically confirming that governance quality and local economic incentives jointly determine the effectiveness of rehabilitation programs, this study extends existing frameworks in restoration ecology and community-based natural resource management. Methodologically, the use of Structural Equation Modeling (SEM) provides a rigorous analytical approach to assess interrelated causal pathways among complex variables within socio-ecological systems. This approach can serve as a foundation for future studies seeking to model the linkages between institutional behavior, livelihood outcomes, and ecological restoration in developing contexts.

From a practical standpoint, several strategic implications emerge. Strengthening institutional coordination through participatory governance mechanisms can significantly enhance program implementation. Funding structures must evolve toward transparency, accountability, and long-term continuity, particularly through multi-year and performance-based financing. Economic incentives should be integrated into restoration planning such as developing agroforestry markets or non-timber forest value chains to maintain household motivation and financial resilience. Policymakers should also prioritize synchronization between national rehabilitation targets and district-level execution to minimize fragmentation. These measures would ensure that FLR initiatives generate both ecological recovery and sustained community welfare.

Overall, this study highlights that successful rehabilitation in Papua is achieved when social, economic, and institutional systems operate synergistically. Restoration should thus be viewed not merely as an environmental intervention but as an integrated development strategy capable of advancing livelihood security, governance reform, and ecological sustainability simultaneously. By demonstrating how participatory institutions and inclusive policies translate into measurable outcomes, this research provides empirical support for Indonesia's shift toward community-centered forest management as a pathway to sustainable development.

AUTHOR CONTRIBUTIONS

Conceptualization: Arung Lamba, Transna Putra Urip.
 Data curation: Transna Putra Urip.
 Formal analysis: Arung Lamba.
 Investigation: Arung Lamba, Transna Putra Urip.
 Methodology: Arung Lamba, Transna Putra Urip.
 Project administration: Arung Lamba.
 Supervision: Arung Lamba.
 Validation: Arung Lamba, Transna Putra Urip.
 Visualization: Transna Putra Urip.
 Writing – original draft: Arung Lamba.
 Writing – review & editing: Arung Lamba, Transna Putra Urip.

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REFERENCES

- Ayompe, L. M., Padilla, L., Eriksson, M., Egoh, B. N., & Bales, R. C. (2025). Overcoming barriers and uncertainties to investing in forested watershed restoration in California. *Frontiers in Forests and Global Change*, 8, 1587763. <https://doi.org/10.3389/FFGC.2025.1587763/BIBTEX>
- Bizikova, L., Nkonya, E., Minah, M., Hanisch, M., Turaga, R. M. R., Speranza, C. I., Karthikeyan, M., Tang, L.,

- Ghezzi-Kopel, K., Kelly, J., Celestin, A. C., & Timmers, B. (2020). A scoping review of the contributions of farmers' organizations to smallholder agriculture. *Nature Food*, 1(10), 620–630. <https://doi.org/10.1038/s43016-020-00164-x>
- Bombrun, M., Dash, J. P., Pont, D., Watt, M. S., Pearse, G. D., & Dungey, H. S. (2020). Forest-Scale Phenotyping: Productivity Characterisation Through Machine Learning. *Frontiers in Plant Science*, 11. <https://doi.org/10.3389/fpls.2020.00099>
- Buthelezi, M. N. M., Lottering, R. T., Peerbhay, K. Y., & Mutanga, O. (2025). Exploring forest rehabilitation and restoration: A brief systematic review. *Trees, Forests and People*, 20, 100898. <https://doi.org/10.1016/J.TFP.2025.100898>
- Chazdon, R. L., Gutierrez, V., Brancalion, P. H. S., Laestadius, L., & Guariguata, M. R. (2020). Co-Creating Conceptual and Working Frameworks for Implementing Forest and Landscape Restoration Based on Core Principles. *Forests*, 11(6), 706. <https://doi.org/10.3390/f11060706>
- Chua, K. T., & Byun, H.-Y. (2025). ESG initiatives and financial stability in the Korean financial industry: The moderating role of ownership concentration. *Banks and Bank Systems*, 20(3), 215–235. [https://doi.org/10.21511/BBS.20\(3\).2025.16](https://doi.org/10.21511/BBS.20(3).2025.16)
- Crouzeilles, R., Maurenza, D., Prieto, P. V., Barros, F. S. M., Jakovac, C., Ferreira, M. S., Chazdon, R. L., Lindenmayer, D. B., Brancalion, P. H. S., Cecon, E., Adams, C., Lazos - Chavero, E., Monteiro, L., Junqueira, A. B., Strassburg, B. B. N., & Guariguata, M. R. (2021). Associations between socio - environmental factors and landscape - scale biodiversity recovery in naturally regenerating tropical and subtropical forests. *Conservation Letters*, 14(2). <https://doi.org/10.1111/conl.12768>
- Dharmawan, I. W. S., & Pratiwi. (2023). Implementation of forest-land rehabilitation to support the enhancement of carbon stock on Indonesia's FOLU net sink 2030 strategy. *IOP Conference Series: Earth and Environmental Science*, 1180(1), 012010. <https://doi.org/10.1088/1755-1315/1180/1/012010>
- Fischer, H. W., Chhatre, A., Duddu, A., Pradhan, N., & Agrawal, A. (2023). Community forest governance and synergies among carbon, biodiversity and livelihoods. *Nature Climate Change*, 13(12), 1340–1347. <https://doi.org/10.1038/s41558-023-01863-6>
- Giyasova, Z., Guliyeva, S., Azizova, R., Smiech, L., & Nabiyeva, I. (2025). Relationships between human development, economic growth, and environmental condition: The case of South Korea. *Environmental Economics*, 16(2), 73–83. [https://doi.org/10.21511/EE.16\(2\).2025.06](https://doi.org/10.21511/EE.16(2).2025.06)
- Hidayat, H., & Sinaga, E. (2021). Deforestation and Social Resilience: A Case Study of Gunung Mas District-Central Kalimantan. *Earth Sciences*, 10(1), 17. <https://doi.org/10.11648/j.earth.20211001.13>
- Indrajaya, Y., Yuwati, T. W., Lestari, S., Winarno, B., Narendra, B. H., Nugroho, H. Y. S. H., Rachmanadi, D., Pratiwi, Turjaman, M., Adi, R. N., Savitri, E., Putra, P. B., Santosa, P. B., Nugroho, N. P., Cahyono, S. A., Wahyuningtyas, R. S., Prayudyaningsih, R., Halwany, W., Siarudin, M., ... Mendham, D. (2022). Tropical Forest Landscape Restoration in Indonesia: A Review. *Land*, 11(3), 328. <https://doi.org/10.3390/land11030328>
- Lumapuy, E., Matinahoru, J. M., & Latumahina, F. (2024). Multi-Factor Evaluation of RHL Success in Neniari Village, Indonesia. *Indonesian Journal of Innovation Studies*, 25(3). <https://doi.org/10.21070/ijins.v25i3.1196>
- Makarenko, I., & Plastun, A. (2017). The role of accounting in sustainable development. *Accounting and Financial Control*, 1(2), 4–12. [https://doi.org/10.21511/AFC.01\(2\).2017.01](https://doi.org/10.21511/AFC.01(2).2017.01)
- Menéndez-Miguélez, M., Rubio-Cuadrado, Á., Cañellas, I., Erdozain, M., de Miguel, S., Lapin, K., Hoffmann, J., Werden, L., & Alberdi, I. (2024). How to measure outcomes in forest restoration? A European review of success and failure indicators. *Frontiers in Forests and Global Change*, 7, 1420127. <https://doi.org/10.3389/FFGC.2024.1420127/FULL>
- Njurumana. (2016). Nilai Penting Kerifan Lokal Dalam Rehabilitasi Lahan.
- Noulékoun, F., Mensah, S., Birhane, E., Son, Y., & Khamzina, A. (2021). Forest Landscape Restoration under Global Environmental Change: Challenges and a Future Roadmap. *Forests*, 12(3), 276. <https://doi.org/10.3390/f12030276>
- Nugroho, H. Y. S. H., Indrajaya, Y., Astana, S., Murniati, Suharti, S., Basuki, T. M., Yuwati, T. W., Putra, P. B., Narendra, B. H., Abdulah, L., Setyawati, T., Subarudi, Krisnawati, H., Purwanto, Saputra, M. H., Lisnawati, Y., Garsetiasih, R., Sawitri, R., Putri, I. A. S. L. P., ... Rahmila, Y. I. (2023). A Chronicle of Indonesia's Forest Management: A Long Step towards Environmental Sustainability and Community Welfare. *Land*, 12(6), 1238. <https://doi.org/10.3390/land12061238>
- Owusu, R., Kimengsi, J. N., & Giessen, L. (2023). Outcomes of Forest Landscape Restoration Shaped by Endogenous or Exogenous Actors and Institutions? A Systematic Review on Sub-Saharan Africa. *Environmental Management*, 72(2), 246. <https://doi.org/10.1007/S00267-023-01808-X>
- Salim. (2016). *Dasar-dasar Hukum Kehutanan*. Sinar Grafika.

- Santoro, A., Piras, F., & Yu, Q. (2025). Spatial analysis of deforestation in Indonesia in the period 1950–2017 and the role of protected areas. *Biodiversity and Conservation*, 34(9), 3119–3145. <https://doi.org/10.1007/s10531-023-02679-8>
- Shyamsundar, P., Ahlroth, S., Kristjanson, P., & Onder, S. (2020). Supporting pathways to prosperity in forest landscapes – A PRIME framework. *World Development*, 125, 104622. <https://doi.org/10.1016/j.worlddev.2019.104622>
- Suprayitno, Dwiatmadja, C., & Suharti, L. (2025). FACTORS AFFECTING BATIK SME PERFORMANCE AND SUSTAINABILITY: THE ROLE OF GOVERNMENT SUPPORT AND BUSINESS ASSOCIATIONS. *Problems and Perspectives in Management*, 23(1), 249–262. [https://doi.org/10.21511/PPM.23\(1\).2025.19](https://doi.org/10.21511/PPM.23(1).2025.19)
- Wahyunto. (2001). Analisa pengukuran tingkat manfaat dari produktivitas usaha kopra di Sulawesi Utara.
- Widiyanto, A., Nurrochmat, D. R., Trison, S., & Subarudi. (2025). An IAD framework analysis of social forestry institutional transformation: A case of Forest Areas with Special Management (KHDPK) in Indonesia. *Social Sciences & Humanities Open*, 12, 101928. <https://doi.org/10.1016/J.SSAHO.2025.101928>.