Multidimensional Sustainability Analysis of Social Forestry Program in Mount Rakutak Protected Forest, West Java-Indonesia

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ABSTRACT

Social Forestry (Perhutanan Sosial) has been widely promoted in Indonesia as a dual strategy to enhance rural livelihoods while safeguarding forest ecosystems. This study assesses the sustainability of the Social Forestry Utilization Permit Scheme (IPHPS) implemented by the Mulya Tani Forest Farmer Group in Mount Rakutak Protected Forest, Bandung Regency, West Java. The RapSForest framework was employed to evaluate three dimensions of sustainability: ecological, socio-economic, and institutional. Data were obtained through household surveys (n=104), key stakeholder interviews, participatory observation, and secondary sources. Findings reveal that the overall multidimensional sustainability index is only 29.92%, classifying the program as "unsustainable" (<50%). Ecologically, the low Normalized Difference Vegetation Index (NDVI) and Shannon–Wiener diversity index (H') indicate limited forest recovery and reduced biodiversity. Socio-economically, household incomes remain below the regional minimum wage, constrained by inadequate access to finance and weak market integration. Institutionally, deficiencies in governance, low transparency, and limited trust in leadership undermine program effectiveness. Leverage analysis highlights NDVI, H', household income, and institutional trust as the most influential factors shaping sustainability outcomes. These results emphasize the need for multidimensional interventions: strengthening reforestation and biodiversity conservation, enhancing rural livelihoods through financial innovation and market access, and improving governance through transparency, accountability, and community participation. An integrated ecological–economic–institutional approach is essential to reconcile conservation objectives with local livelihood needs and ensure the long-term success of Indonesia's social forestry policy.

Keywords: social forestry, IPHPS, sustainability analysis, RapSForest.

INTRODUCTION

Forests are essential for global environmental sustainability, biodiversity conservation, and the livelihoods of communities living nearby. In Indonesia, forests play a vital role as a source of income, food security, and the provision of vital ecosystem services for a large portion of the population [1]. Recognizing the importance of sustainable forest management, the Indonesian government has implemented the Social Forestry program as a forest management approach.

One scheme developed in 2017 is the Social Forestry Forest Utilization Permit (IPHPS). This scheme is designed to provide local communities with opportunities to manage forest resources in protected areas, with the aim of balancing two main objectives: poverty alleviation and forest conservation. The Social Forestry Program, as a community-based initiative, aims to promote environmental sustainability and economic development by granting access rights and management responsibilities to local communities [2].

The first IPHPS pilot program was implemented through the Mulya Tani Forest Farmers Group, located in the Gunung Rakutak protected forest area, Bandung Regency, West Java, covering an area of approximately 1,888 hectares. This area serves important ecological functions, including water management, soil conservation, and biodiversity conservation [3], [4]. The program aims to

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enable local farmers to sustainably manage forest resources while generating income through agroforestry activities, thus contributing to conservation efforts. However, despite its potential to simultaneously achieve environmental and socio-economic goals, the IPHPS system still faces various challenges that limit its effectiveness.

This study highlights significant weaknesses in the economic, ecological, and institutional dimensions of the IPHPS program. Economically, participating farmers often earn below the regional minimum wage due to limited access to capital and weak market integration. This economic vulnerability reduces their ability to invest in sustainable practices, perpetuates poverty, and hinders long-term welfare improvements [5]. Ecologically, improvements in land cover remain limited, while intensive agricultural practices (e.g., excessive vegetable cultivation) burden the ecosystem [3], [6], [7]. Institutionally, institutional capacity for program management remains weak [8], [9], and community participation is low [10].

While a number of previous studies have highlighted specific issues within social forestry programs (such as institutional weaknesses, ecological degradation, or economic constraints), holistic analyses integrating all three dimensions of sustainability (economic, ecological, and institutional) are limited [26]. Most existing studies address these issues separately, failing to capture the complex interrelationships between these dimensions in forest management through the Social Forestry Utilization Permit scheme.

To date, social forestry programs still face various obstacles, such as illegal logging, unsustainable land use, and weak institutional structures that hinder the achievement of program objectives [5], [11], [25]. Furthermore, the low ecological improvement and minimal increase in participating farmers' incomes further emphasize the need for a redesign of the management approach. These challenges demonstrate the urgency of an integrated and sustainable approach to social forestry management.

Recent research emphasizes the importance of improved governance, increased community participation, and stronger ecological interventions to address these pressing issues [12], [13], [14]. Based on these issues, a comprehensive, multidimensional sustainability analysis is needed to assess the level of sustainability and ensure the long-term success of the Social Forestry Program.

RESEARCH METHODS

Research Location

This research was conducted from June 2022 to January 2023 in the IPHPS area of the Gunung Rakutak Protected Forest, Perum Perhutani Divre III West Java, which is administratively located in seven villages and two sub-districts in Bandung Regency, West Java. The number of respondents selected for this study was 104 respondents spread across Ibun District (Ibun, Dukuh, Neglasari, Sukarame Villages), Pacet District (Mandalahaji, Nagrak, Cikawao Villages), and Pacet District (Mandalahaji, Nagrak, and Cikawao Villages).

Data Collection, Types, and Data Sources

Data Types

This study uses two types of data: primary and secondary data. Primary data were obtained through: Interviews and Observations. Structured interviews with farmers who are members of the IPHPS, forest farmer group administrators, local government officials, and related non-governmental organizations (LSM). Semi-participatory direct observation at the study site (Mount Rakutak Protected Forest Area) to gain an in-depth understanding of ecological conditions, agroforestry practices, and socio-institutional dynamics. The data collected covered ecological aspects (vegetation cover, biodiversity, land degradation), socio-economic (income, benefit distribution, participation, gender), and institutional (governance, leadership, transparency, trust among members).

Secondary data was obtained from various related agencies, such as: the Ministry of Environment and Forestry (KLHK), Perum Perhutani, the Forestry Service of West Java Province and Bandung Regency, research institutions and universities, as well as academic literature related to social forestry policies.

Method of collecting data

To meet the data criteria relevant to the RapSForest (Rapid Appraisal for Social Forestry Sustainability) application, the data collection process is carried out through:

Collection of Reports and Related Literature

This activity includes social forestry policies, IPHPS documents, forestry statistics, and previous research findings. It draws on the Rapfish approach adapted to the forestry sector (RapSForest).

Collecting Similar Data from Different Sources (Triangulation)

Data was obtained from various sources (farmers, government, NGOs, Perhutani) for cross-checking. The goal was to clarify data accuracy and reduce bias.

Field Verification

Direct observation and confirmatory interviews with key informants (farmer group members, farmer group administrators, local community leaders, village officials, and Perhutani managers) were conducted to ensure the accuracy of ecological, socio-economic, and institutional data.

Preparation of Questionnaires

The research instrument was developed based on RapForest attributes, which include ecological, socio-economic, and institutional indicators (Table 1). The questionnaire was used for structured interviews with selected respondents.

Analysis Techniques

The RapForest method was used as a rapid appraisal tool to evaluate sustainability across three main dimensions: economic, ecological, and institutional. The data analysis method used in this study is shown in Table 1. The analysis was complemented by Monte Carlo simulations to test the reliability of the results and minimize bias [15]. Validation was performed at a 95% confidence interval with a low error rate, thus ensuring the reliability of the research findings.

To assess the ecological dimension, the results of the satellite imagery-based Normalized Difference Vegetation Index (NDVI) analysis were used using previous research. This index measures vegetation health, canopy density, and land cover. NDVI is a quantitative indicator of the success of the forest rehabilitation program. The Shannon-Wiener biodiversity index (H') is applied to measure: Species richness (the number of species in an area) Species evenness (the even distribution of species). The H' value is used as an important ecological indicator to assess the resilience of forest ecosystems and the contribution of the IPHPS program in maintaining biodiversity.

This research methodology adopts a policy analysis framework to ensure the results can be used as a basis for policy recommendations. Integration is carried out through the following stages: Identification of policy issues from ecological, socio-economic, and institutional dimensions. Analysis of alternative solutions and policy recommendations: Developing a multidimensional strategy to strengthen the sustainability of IPHPS.

Table 1. Data Analysis Methods

Criteria	Indicator	Reference
Ecology	Greenness Level /NDVI	– Annisa et al (2023)
	Diversity Index	– Almaghfirah (2023)
	Precious Species	– Kavanagh & Pitcher, (2004);
	Diversity Index	– Kavanagh & Pitcher, (2004);
	Classification based on the life stage of species	– Pitcher & Preikshot (2001)
Socio-Economi	Social Forestry Income Contribution	– Yunus (2015); Yunus et al., (2010)
	Income Distribution	– Spieth et al. (2019)
	Farming Management	– Pujo et al (2023)
	Revenue Management	

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Criteria	Indicator	Reference
Institutional	Subjective Well-being	
	Local Wisdom	
	Women's participation	
	Public Perception of Forests	
	Policy implementation	
	Leadership	
	Institutional Management	
	Transparency	
	Attitude of Trust towards Stakeholders	

RESULTS AND DISCUSSION

Analysis of Sustainability Index and Leverage Based on RapForest Evaluation of IPHPS Sustainability Index

The sustainability analysis of the IPHPS program began with testing using Monte Carlo analysis based on established criteria and indicators. The evaluation results showed that the Monte Carlo value had a sustainability index range of 0.93–2.50%. This finding indicates that the RapSForest method used in this study has a high level of accuracy. With a 95% confidence interval, the small difference in values indicates a relatively low level of analysis error, so this method can be used as a quick tool to evaluate the sustainability of IPHPS management. This is in line with the findings of, [16] who stated that Monte Carlo values can function as indicators of random error. According to [17], Monte Carlo analysis can be used to identify errors, differences in assessments, and potential data input errors due to variability in attribute scoring.

Validity testing was performed using the goodness of fit coefficient of determination (R^2) value. An R^2 value approaching 1 indicates that the data used increasingly fits the model, thus increasing the model's validity [18]. Based on the research results, the R^2 value for multicriteria analysis reached 0.95, which means that 95% of the data variability can be explained by the model, while the remaining 5% is influenced by other factors not included. According to [16], an R^2 value exceeding 80% indicates that the sustainability index prediction model is reliable for use in sustainability analysis. Thus, the R^2 value of 0.95 in this study confirms that the RapForest method is highly valid and suitable for use in assessing the sustainability of IPHPS management at the research site.

In addition, the model representation was tested based on the stress value level (measurement inconsistency). The results showed a stress value of 12.82% (0.1282). A stress value close to 0 (zero) indicates that the model output is close to the actual condition. In general, the tolerance for stress values is below 25% [19]. Therefore, the value of 12.82% obtained in this study indicates that the model has a good level of suitability. In other words, the smaller the stress value, the better the model is in representing the actual conditions of the system under study [23], [24]. The test results are explained in Table 2.

Table 2. Sustainability index values and statistical parameters of RapSForest analysis results

Criteria	Sustainability Index (%)	Monte Carlo (%)	Difference (%)	Stress Value (%)	Coefisien Determinant (R^2)
Ecology	28,21	29,14	0,93	16,32	0,93
Social-Economi	29,70	30,81	1,11	14,13	0,95
Institutional	26,73	29,23	2,50	14,29	0,93
Multicriteria	29,92	31,29	1,37	12,82	0,95

Source: Research result, 2025 (Processed)

Based on the table above, the RapSForest test yielded a sustainability index value for Mulya Tani's IPHPS management of 29.92%. This value falls into the less sustainable category (≤50%), indicating that the system under study requires significant intervention to achieve sustainability. A

visualization of the Mulya Tani IPHPS sustainability index based on three main dimensions is presented in Figure 1.

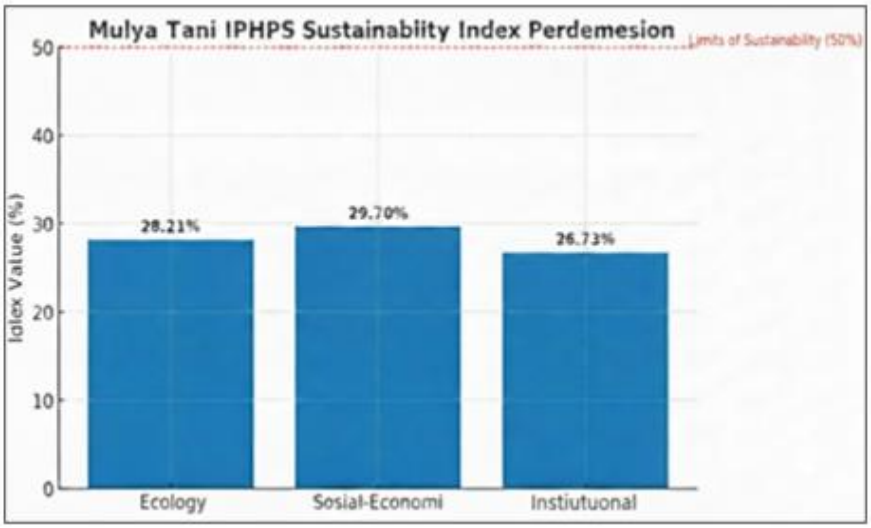

Figure 1. Radar diagram (spider chart) of IPHPS Sustainability Source: Research Result, 2025 (Processed)

It is clear that all dimensions are below the 50% threshold, categorizing it as unsustainable and requiring significant intervention. This condition reflects an unbalanced forest management strategy across various social, economic, and ecological dimensions, and serious obstacles to achieving sustainable management exist. This is reinforced by the analysis using a radar diagram (spider chart) in Figure 2.

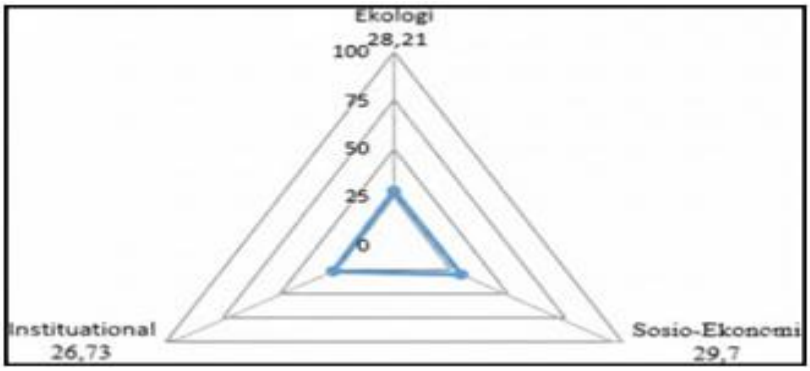

Figure 2. Radar diagram (spider chart) of IPHPS Sustainability Source: Research Result, 2025 (Processed)

Based on Figure 2, the radar diagram (spider chart) shows a comparison of sustainability indices across three main dimensions (Ecology, Socio-Economic, and Institutional). This graph shows that all three dimensions are relatively equal (26–30%), but all are below the sustainability threshold (50%), thus categorizing the Rakutak IPHPS program as unsustainable.

Sustainability evaluations for each of the ecological, socio-economic, and institutional dimensions require special attention, appropriate policy improvements, and targeted programmatic interventions. These results indicate that all three dimensions of sustainability are in a relatively similar range, at 26–29%, and are all categorized as unsustainable. Therefore, no single dimension is dominant; all require significant improvements to achieve a more sustainable state. A detailed explanation of each dimension of sustainability is outlined below.

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Determining Factors of IPHPS Sustainability Using Leverage Analysis

The analysis results show that each criterion (ecological, socio-economic, and institutional) exerts a nearly equal relative influence on the management of the Rakutak IPHPS. The magnitude of each criterion's influence can be seen from the Root Mean Square (RMS) value, which represents the relative role of an indicator in influencing the sustainability index [16]. The higher the RMS value, the stronger the indicator's contribution in determining sustainability. The results of the Leverage Analysis are explained as follows:

Ecological Dimension

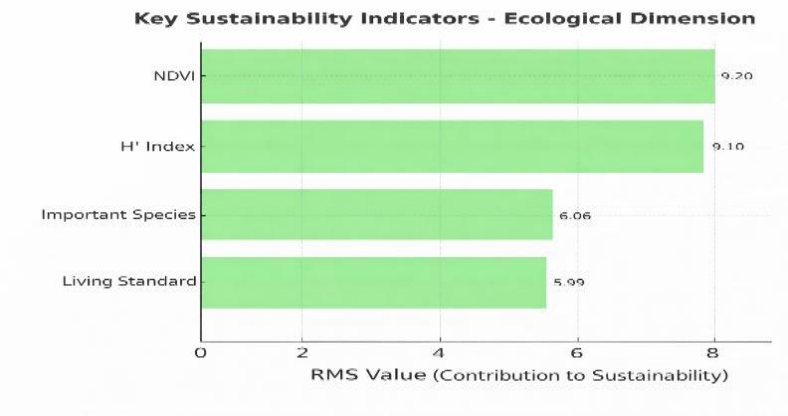

Figure 3. Attribute Sensitivity of Ecological Dimension Dimension Source: Research Result, 2025 (Processed)

The sensitivity analysis results for this dimension show an NDVI value of 9.20 and a Shannon-Wiener Index of 9.10. This indicates that these two indicators have the greatest influence on ecological sustainability. This means that the NDVI and H' values emphasize the need for more effective forest rehabilitation and biodiversity conservation strategies. The sensitivity analysis shows that the NDVI value of 9.20 and the Shannon-Wiener Index (H'; 9.10) are the most influential indicators on ecological sustainability. This underscores the need for more effective forest rehabilitation and biodiversity conservation strategies.

Socio-Economic Dimension

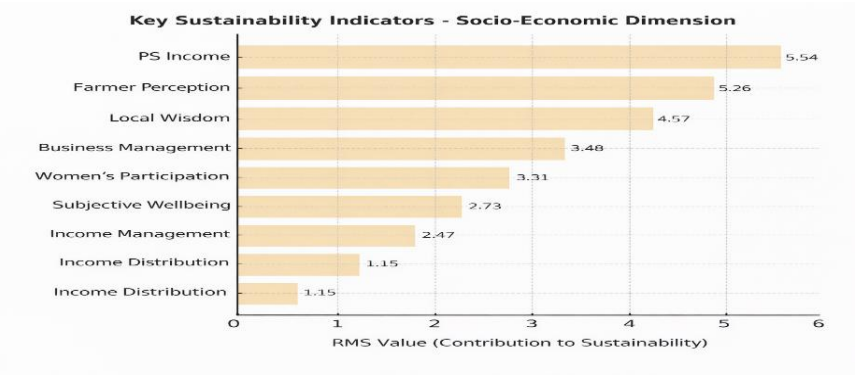

Figure 4. Attribute Sensitivity of Socio-Economic Dimensions Source: Research Result, 2025 (Processed)

In the socio-economic dimension, the most dominant factors are the contribution of income from IPHPS (5.54) and farmers' perceptions of forests (5.26). This means that improving community economic well-being and changing farmers' perceptions/awareness of the importance of sustainability are key to strengthening this dimension. Other indicators such as local wisdom, women's participation, and income distribution play additional, albeit lesser, roles. Empirical

findings indicate that the contribution of income from IPHPS (5.54) and farmers' perceptions of forests (5.26) are dominant factors in the socio-economic dimension. This confirms that improving economic well-being and changing farmers' perceptions are key to strengthening this dimension. Additional indicators such as local wisdom, women's participation, and income distribution do play a role, albeit with a lower weight.

Institutional Dimension

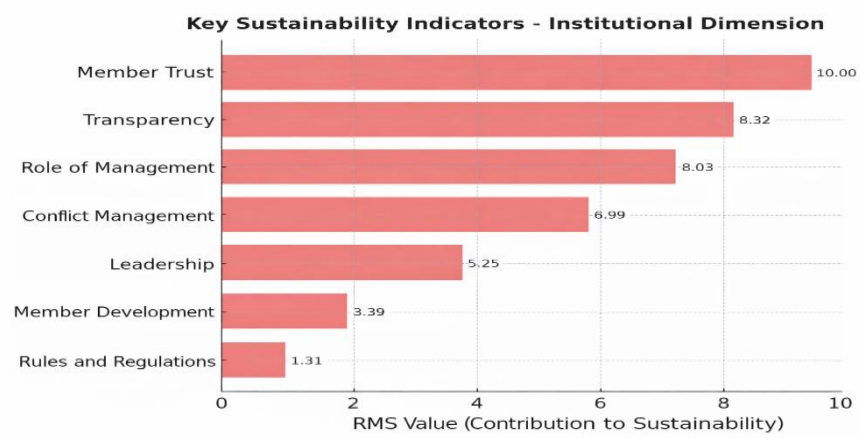

Figure 5. Sensitivity of Attribute Dimension Institutional Dimension Source: Research Result, 2025 (Processed)

In the institutional dimension, the most influential factor is member trust in the management (10.00), followed by transparency (8.32) and the role of the management (8.03). The IPHPS institution will only be sustainable if governance is strengthened, the management is perceived as credible by members, and there is transparency in program management. Conflict management (6.99) and leadership (5.25) are also important in preventing institutional disintegration. In the institutional dimension, the most influential factor is member trust in management (10.00), followed by transparency (8.32), and the role of management (8.03). Trust has been shown to be an institutional legitimacy that mediates collaboration and community performance [20]. Transparency in governance is also a crucial prerequisite for accountability and accountability in natural resource management [21], [22]. The IPHPS institution will only be sustainable if governance is strengthened, management is seen as credible, and there is transparency in program management. Furthermore, conflict management (6.99) and leadership (5.25) play significant roles in preventing institutional disintegration. Conflict resolution mechanisms and participatory leadership are essential for effective community-based forest management. The sensitivity analysis results show that the Institutional dimension is the most critical factor (highest RMS), especially in the aspects of trust, transparency, and management governance. Sustainability in the Ecological dimension is strongly influenced by vegetation conditions (NDVI) and biodiversity levels (H'). In the Economic dimension, sustainability is strongly influenced by farmer income and perceptions of the forest, indicating that sustainability is only possible if community welfare increases while awareness of conservation improves. Thus, the Rakutak IPHPS program requires a multidimensional intervention approach: ecological through increased reforestation and conservation activities, economic through increased income and access to capital, institutional through increased strong governance and community participation.

CONCLUSION

The research results confirm that the Mulya Tani Social Forestry Utilization Permit (IPHPS) program on Mount Rakutak remains unsustainable, with a multidimensional index score of 29.92%. The three analyzed dimensions ecology, socio-economics, and institutions each exhibit fundamental, interrelated weaknesses that require significant intervention. The Ecological Dimension indicates low vegetation cover and biodiversity, and forest rehabilitation and biodiversity conservation efforts are suboptimal. Stronger ecological interventions are needed through

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reforestation, habitat restoration, technology-based monitoring, and the preservation of local wisdom. The Socio-Economic Dimension indicates that farmer incomes remain below the welfare standard. Limited access to capital limits the ability to invest in sustainable practices. Economic strengthening strategies need to focus on increasing access to financing, diversifying farming businesses, and strengthening the market for IPHPS products. The institutional dimension shows weak governance, characterized by a lack of oversight, low farmer capacity, and suboptimal land use. Member trust in management still needs to be strengthened, along with improvements in transparency, leadership, and conflict management. Community participation in governance and community-based oversight are key to long-term success. Overall, the sustainability of the IPHPS program can only be achieved through an integrated, multidimensional approach. Strengthening ecological, socio-economic, and institutional aspects must be integrated within a single strategic framework to increase the program's effectiveness.

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