

# Value Chain Transformation for Sustainable Pine Resin Production

A Case Study from Community Forestry in Agam, West Sumatra, Indonesia

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MSc Thesis in Environmental Sciences

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## Preface

Over the past few years, through my education and early career experiences, I have developed a deep interest in community and local development. During this time, I have worked with coastal and smallholder farming communities on clean energy and climate-tech programs. This thesis then gave me a new opportunity to explore a different field by working with a community of forest farmers in social forestry, which was both challenging and rewarding for me. I am truly grateful for this thesis experience, as it has broadened my perspective and deepened my passion for supporting sustainable development for communities.

I would like to extend my sincere gratitude to all individuals and institutions who made this thesis journey possible: the LPDP Scholarship for funding my master's thesis and entire master's program; my thesis supervisor, Dr. Aritta Suwarno, for her guidance and continuous support; UNEP Indonesia and PILI for their assistance in coordinating the fieldwork; and all the stakeholders involved in this study who warmly welcomed me to Agam, Indonesia, and generously dedicated their time to support the data collection.

My heartfelt thanks also go to my mom and sister, whose unwavering love has sustained me. I am also deeply grateful to all my dear friends for their generous care and thoughtful support, and to the many people I met along the way during my thesis journey, whose insightful conversations and encouragement offered inspiration.

Finally, I hope this thesis can make a small but meaningful contribution to Indonesia and be one step in my ongoing journey to support sustainable development for communities in Indonesia and beyond.

Wageningen, 24 October 2025

Graciella Merari

## Summary

Social forestry began globally in the 1970s as a response to the exclusion of the local communities from the profits of forest industries. After 2014, social forestry became a national priority in Indonesia, with community forestry as one of the schemes. Indonesian community forestry emphasizes local community empowerment while conserving forests. Pine forests, particularly *Pinus merkusii* in West Sumatra, are one example of social forestry. Resin from pine trees is a renewable source of gum rosin and turpentine with significant industrial applications, offering strong potential as a non-timber forest product (NTFP) for community development. In Indonesia, pine resin production is mostly managed by business license holders who often partner with local communities under the community forestry scheme. However, outcomes vary, with many practices leaning toward short-term goals rather than long-term sustainability. In Agam Regency, Indonesia, a Forest Farmer Group (FFG) in Padang Tarok Village received the 'Community Forestry' permit and now manages pine resin production by partnering with a private company. The partnership has created income opportunities but with limited community participation and no activities beyond pine resin value chain (VC). As the current VC is unsustainable and lacks participation from the local community, this study provides an optimal alternative scenario by identifying conditions and proposing sustainable improvements, focusing on the upstream part of the VC where communities are engaged and where participation is key to achieving sustainable community forestry.

This study employed a range of diverse methodologies to analyse the existing VC of pine resin production through a sustainable development lens, followed by an analysis of potential improvements for the optimal alternative scenario. The analysis included: comparative policy analysis (institutional aspect), VC analysis through main activities of VC mapping and stakeholder analysis (environmental aspect), economic valuation (socio-economic aspect), stakeholder perception analysis, and multi-criteria analysis (MCA). Stakeholder perception analysis emphasized the local community's perception to ensure that the improvements made align with the aspirations of the local community. The findings from this study indicated the immaturity of institutional, environmental, economic, and social aspects of the existing upstream pine resin VC in Padang Tarok Village, which required significant improvement to achieve sustainability and align with the goals of community forestry. The perception of stakeholders generally viewed pine resin VC in Padang Tarok Village in a positive light to support the local community. However, the local community itself showed no clear interest in the VC.

With the improvement narratives developed based on the existing pine resin VC for each sustainability aspect, four alternative scenarios were created: Business-as-Usual (BaU), Environmental Improvement, Eco-Governance Improvement, and Comprehensive Improvement scenarios. Based on the MCA results to assess the optimal alternative scenario, the Comprehensive Improvement scenario obtained the highest score among

the four alternatives. This scenario included improvements across all aspects of sustainability. However, this study did not suggest that the Comprehensive Improvement scenario should be immediately prioritized for implementation. Rather, it recommended a gradual progression from the BaU scenario to the Comprehensive Improvement scenario, providing stakeholders with options to improve the status quo step by step.

The difference found between what indirect stakeholders perceived as beneficial for the local economy (such as job opportunities in the pine resin VC) and the community's lack of interest reflected a gap between externally developed plans and on the ground realities. This gap stemmed from limited community participation in the existing VC, where the community's role had mostly been to be informed about decisions. In contrast, strong participation involves engaging the community throughout planning, implementation, and monitoring processes. Therefore, the MCA-based framework proposed in this study functioned as a participatory decision-making tool to address the wicked problem of VC transformation toward sustainable pine resin production within the context of community forestry. The framework integrated community perspectives to design tailored improvement scenarios, thereby guiding stakeholders in implementing optimal alternative scenarios. With the implementation of this framework, the main goal of Indonesian community forestry, to empower local communities while conserving the forest, could be achieved. Furthermore, this framework was adaptable to other community forestry cases in Indonesia and other tropical developing countries that faced similarly complex and interconnected sustainability challenges.

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# Chapter 1. Introduction

## 1.1 Background

Social forestry began globally in the 1970s as a response to the exclusion of the local communities from the profits of forest industries (van Noordwijk, 2020). The social forestry concept promotes sustainable management of forests by integrating local communities, governments, and the private sector. This concept has been especially important for tropical developing countries, where the livelihoods of local communities are heavily reliant on forest resources (Baynes et al., 2015; Wong et al., 2020). As a result, social forestry in developing countries has become increasingly popular where 31% of forests are now managed or owned by communities (Maraseni et al., 2019). By actively involving local communities, social forestry encourages forests protection, deforestation prevention, and the adoption of sustainable practices while improving rural communities' welfare (Fisher et al., 2018; Maraseni et al., 2019; Santika et al., 2017).

Indonesia's adoption of social forestry began slowly due to various challenges (van Noordwijk, 2020). A turning point came with the 1999 Forestry Law (No. 41/1999), which introduced 'Community Forestry', and replaced the earlier centralized system under Law No. 5/1967 (Pambudi, 2020). Social forestry gained further momentum after 2014, when it was elevated to a national priority under the new administration (Pambudi, 2020; Rakatama & Pandit, 2020). Since 2016, the government has aimed to allocate 12.7 million hectares (about 10% of state forests) to social forestry. The Indonesian Ministry of Environment and Forestry (MoEF) defines social forestry as community-led forest management in state, private, or customary forests, designed to improve well-being, maintain environmental balance, and strengthen socio-cultural dynamics (MoEF, 2016; Rakatama & Pandit, 2020). Among its schemes, community forestry (*Hutan Kemasyarakatan*) is distinct in its focus on job creation, poverty reduction, and conflict resolution, while conserving forests and maintaining their ecological functions (MoEF, 2016; Pambudi, 2020).

One example of social forestry in Indonesia involves pine forests, particularly *Pinus merkusii* (Sumatran pine), which has been extensively planted across the country, including in West Sumatra where Agam is located (Nurtjahjaningsih et al., 2007; Nawir et al., 2007; Imanuddin et al., 2020). Known locally as Tusam or Uyam, sumatran pine thrives at various elevations, making it valuable for restoration, rehabilitation, and production. Its ecological resilience and economic potential have positioned it as an important asset within national forestry efforts (Imanuddin et al., 2020). A key product derived from this species is pine resin, obtained by tapping trunks. Pine resin is a renewable resource and a major source of gum rosin and turpentine, widely used in industrial applications ranging from fragrances and flavoring compounds to paint solvents and pharmaceuticals (Rodrigues-Corrêa et al., 2012). The global pine chemicals market is projected to reach 4.69 million tons in 2025 and 5.71 million tons by 2030, with gum rosin and turpentine

accounting for half of this demand (Mordor Intelligence, 2025). This growing market highlights the strong potential of pine resin as a non-timber forest product (NTFP) to support community development in Indonesia. As such, pine forests provide a concrete example of how social forestry schemes can link ecological resilience with livelihood opportunities.

## 1.2 Problem Statement

Sustainable value chain (VC) transformations in developing countries pose difficulties and barriers for many stakeholders, particularly smallholders (Hidayati et al., 2023; Thorpe, 2018). This is especially true for community NTFP-based activities, where the path to sustainability is complicated by complex factors like governance, harvesting systems, economic viability, and sociocultural aspects (Pasaribu et al., 2021; Harbi et al., 2023). In these contexts, actors along the VC play a critical role in generating and delivering value by incorporating sustainability efforts at every stage, focusing on the interconnected economic, social, and ecological dimensions (Hidayati et al., 2023).

These challenges are especially relevant in Indonesia's community forestry context. Outside of Java, pine resin production is typically managed through partnerships between business license holders and local communities holding 'Social Forestry' permits under the community forestry scheme (Imanuddin et al., 2020; MoEF, 2016). While the intention of community forestry is to combine livelihood benefits with sustainable forest management, in practice, most schemes lean heavily toward short-term economic goals rather than long-term environmental sustainability (Latifah et al., 2023). This imbalance often results from limited or uneven participation by community members. Therefore, strengthening active community participation is essential to ensure that VC development could support both livelihood and forest conservation (Saraan et al., 2020).

The challenges described above are evident from many Indonesian regions, including the Agam Regency in West Sumatra Province. The 'Social Forestry' permit was granted to the Forest Farmer Group (FFG) Luhuang Sepakat (LS) in Padang Tarok Village, Agam, under the community forestry scheme. This permit has created opportunities to generate additional income through pine resin in partnership with a private company. However, only a small number of members have benefited, and no activities beyond resin taping have been developed.

The uneven benefits within this current partnership structure are related to complex stakeholder dynamics. As one of the possible holders of social forestry permits, FFG in Indonesia are entrusted with the management of forest territories, making them 'principally' the key players in the success of community forestry initiatives (Purnomo et al., 2022). However, in practice, other stakeholders (non-governmental organizations (NGOs), private companies, and political entities) play a significant role in social forestry through facilitating development programs for FFGs. The varying goals and motivations of these external actors can sometimes lead to differences in the nature and effectiveness of the programs implemented (Purnomo et al., 2022; Muhdar et al., 2022; Saraan et al., 2020).

Despite its importance, the pine resin VC under community forestry in Indonesia remains unsustainable, and there is only limited research addresses this issue in a comprehensive way. Existing studies mainly focused on commodity-level VC analysis, risks management in the pine resin supply chain, and the social sustainability evaluation of pine gum rosin production (Zakiyah et al., 2025; Rachmalia et al., 2022; Primaningtyas & Gheewala, 2025). However, they do not emphasize the equitable implementation of all sustainable aspects across the pine resin VC, nor do they place community participation at the center.

Given the lack of a holistic approach, there is no existing framework that can accommodate the complexities and interlinkages of sustainability needed to transform the pine resin VC. To address the gap mentioned above, this study is designed to provide an optimal alternative scenario to transform the current unsustainable VC into a sustainable one. Focusing on the upstream part of the VC where the communities are engaged, the study first provides a framework to identify existing conditions and then shows how to improve them. This is done while taking the community's voices into account, recognizing that community participation is the key to successful community forestry.

### 1.3 Research Objective

The objective of this study is to provide an optimal alternative scenario for the VC transformation for sustainable pine resin production in community forestry in Agam Regency, Indonesia. This objective is achieved by answering the general research questions and sub-research questions with detail as follows:

#### 1.3.1 General Research Question (GRQ)

How to improve the existing upstream pine resin VC in Agam, Indonesia?

#### 1.3.2 Sub-Research Questions (SRQs)

The GRQ is further divided into two primary parts. The first part investigates the current condition of the pine resin VC in Agam within the context of community forestry. Each SRQ mainly represents one of the sustainable development aspects as follows:

1. How has the community in Agam obtained the Social Forestry permit, and how does this process compare to the formal procedures? (Institutional aspect)
2. How is the existing upstream VC of pine resin in Agam, Indonesia, starting from sourcing in the forest to transporting to the manufacturing factory? (Environmental aspect)
3. What are the benefits of social forestry? (Socio-economic aspect)
4. How do the stakeholders perceive the existing pine resin VC? (Perception)

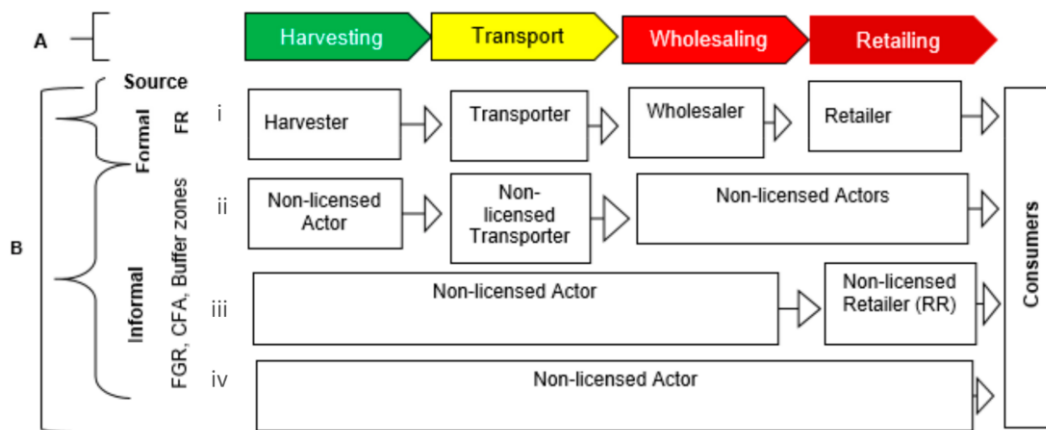
The second part of the SRQ consists of an analysis of potential improvements for the final optimal alternative scenario for the VC, addressed through the following question:

5. What is the optimal alternative scenario for the VC transformation for sustainable pine resin production?

## Chapter 2. Key Concepts

### 2.1 Value Chain

A value chain (VC) generally refers to a series of activities that add value from initial production to final customer, which are related to primary activities such as production, sales, distribution, and secondary activities such as planning, finance, and human resources (Fearne et al., 2012). The VC involves interconnected processes of material and information flows and relationships among chain stakeholders concerning control and power. Improving VCs is often viewed as an important way to support sustainable development, since it helps meet human needs while also bringing together different factors that drive environmental change (von Geibler et al., 2010). VC thinking is focusing on creating competitive advantages through better decision-making and collaborative development (Fearne et al., 2012). For NTFPs, the VC involves actors from collection to distribution, with a focus on how value is added at each stage (Magry et al., 2022). Figure 1 provides an example of a small-scale forest product VC. This VC is characterized by a shorter chain of main activities (typically comprising harvesting, transporting, wholesaling, and retailing) compared to more industrialized ones (Ali et al., 2023). The VC map includes a layer to map the stakeholders involved in each activity stage. Therefore, to fully understand the existing VC, identification is required not only through mapping the main activities, but also through identifying the involved stakeholders and analyzing the relationships among them, as addressed in SRQ 2.



**Figure 1.** An example of a forest product VC (Source: Ali et al., 2023)

Analyzing VC is done to examine the current state of the chain and identify opportunities for improvement, considering external factors such as environmental and social impacts (Fearne et al. 2012). The VC of NTFPs usually includes exploiters, collectors, and processing facilities. The activities of the exploiters involve harvesting the NTFPs by farmers and transporting the materials to the roadside, where they are later picked up by collectors. The collectors' step typically involves several collection points. Each collection

point often takes some time before the materials are transferred to another location. Finally, the processing facilities are where the crude NTFPs are manufactured into products that are ready to be sold to traders (Nguyen et al., 2021). Since this study focuses on community forestry, the analysis of the VC will stop at the collector level, before the products are processed. In VC terms, this part is commonly referred to as the upstream segment.

## 2.2 Community Forestry

The definition and implementation of social forestry may differ across countries, although there may be overlaps and similarities among them. In this study, social forestry' refers to the definition provided in the latest MoEF regulation No. 83 of 2016 about "Social Forestry" (MoEF, 2016). There are five schemes of social forestry that are recognized by the Indonesian government: Village Forests (*Hutan Desa*), Community Forests (*Hutan Kemasyarakatan*), Community Plantation Forests (*Hutan Tanaman Rakyat*), Forestry Partnership (*Kemitraan Kehutanan*), and Customary Forests (*Hutan Adat*) (MoEF, 2016). As mentioned in previous subchapters, the social forestry scheme applied in this study is the community forestry scheme.

As stated in MoEF Regulation No. 9 of 2021 about "Social Forestry Management," the primary goal of community forestry in Indonesia is to empower local communities (MoEF, 2021). Therefore, SRQ 4 serves as a foundation to understand their views on the current situation and their future aspirations. That being said, the improvements that serves as the basis for determining the optimum alternative VC scenario in SRQ 5 take into account how these improvements can ultimately empower the community with the details stated on the mentioned related MoEF's regulation. In order to arrange these improvement scenarios, the institutional processes experienced by the community, specifically FFG LS, were initially assessed through the first SRQ. Furthermore, the benefits received by the community so far and the potential benefits under the community forestry scheme are examined through the third SRQ. These assessments were conducted with reference to the two previously mentioned MoEF regulations.

## 2.3 Sustainable Development

Long-term success in VCs is believed to be achievable if the main stakeholders contribute significantly to sustainability. In VCs, the sustainability concept needs to be put into concrete recommendations that can serve as the guiding principles for the stakeholders involved (von Geibler et al., 2010). The definition of 'sustainability' itself has become ubiquitous, yet there is no widely accepted solid framework for its operationalization. However, social, economic, and environmental aspects are often considered the dominant interpretation of sustainability pillars in many studies (Purvis et al., 2018). As one of the first documents discussing sustainability, the Brundtland Report emphasized that no single model of sustainability can be applied universally by different

countries as economic, social, and ecological conditions vary. Yet despite the differences, sustainable development should be regarded as a global objective in order to achieve sustainability (World Commission on Environment and Development, 1987). Moreover, aside from how they are arguably considered as main aspects of sustainability and sustainable development, those three aspects are considered important to be integrated in developing VC analysis (Fearne et al., 2012).

According to the UN, sustainable development is achieved through integrating economic, social, and environmental aspects while recognizing their interlinkages. Moreover, the UN emphasizes that good governance and rules of law are essential, specifically highlighting institutions that are effective, transparent, accountable, and democratic (UN, 2012). Hence, the institutional aspect is considered an enabling condition for the three sustainable development dimensions. These four combined aspects are also recognized as both opportunities and challenges for social forestry in Indonesia (Rakatama & Pandit, 2020). The improvement of these four aspects was addressed in SRQ 5 by developing improvement narratives for each aspect, referring to the UN's global definition and social forestry literature. Subsequently, these four improvement narratives make the basis for developing alternative scenarios for the existing upstream VC of pine resin production, ultimately determining the optimum alternative. This outcome will serve as the guiding principle for stakeholders involved in sustainably transforming the current VC under the community forestry scheme.

### 2.3.1 Socio-Economic Aspect

The economic opportunities of social forestry lie in the generation of income for the people involved in the scheme (Rakatama & Pandit, 2020). However, the economic challenges of social forestry, particularly in Indonesia, often relate to the failure to lift local communities out of poverty while continuing to generate profit for external parties (Maryudi, 2012). On that account, the economic improvement narrative developed in this study considers income generation for all involved actors. However, the improvement specifically emphasizes income for the local community as the social forestry permit holders to help decrease poverty in the area.

A key social challenge of social forestry in Indonesia is reducing inequality by ensuring that support reaches marginalized and poorer groups (Race & Sumirat, 2015). Addressing this challenge is central to socio-economic improvement, which depends on generating income for the local community (the FFG) while ensuring the active participation of the group members. The existing socio-economic conditions of the VC were assessed using the third SRQ for economic aspect and the fourth SRQ which touched on certain elements of the social dimension.

### 2.3.2 Environmental Aspect

The environmental challenges of social forestry in Indonesia are related to biological changes in the forests as an effect of the activities (Arifin et al., 2009). Different

pine trees tapping methods to harvest resin not only could impact different yields but also affect the physiological changes to the trees. These changes affect growth ring width, the frequency and areal of axial canals, and the mean size of these canals (Rodríguez-García et al., 2016; Cunningham, 2012). Moreover, the use of chemical stimulants could also affect the biodiversity of the forest and lead to the rapid exhaustion of the forest resources (Cunningham, 2012). Therefore, the environmental improvements focus on how to suppress the biological changes in the area, especially towards the pine forests in harvesting activities, which came from the assessment of the second SRQ.

### 2.3.3 Institutional Aspect

The institutional challenges of social forestry in Indonesia are linked to the ineffectiveness of forest management systems in carrying out social forestry. While the institutional opportunities of social forestry in Indonesia are related to improving forest management by recognizing local communities as managers of state forests through the redistribution of control and responsibilities from the government to them (Santika et al., 2017; Rakatama & Pandit, 2020). To solve and support those, local institutions play an essential role through more coherent and integrated planning and decision-making to effectively coordinate and integrate the three aspects of sustainable development (UN, 2012). Therefore, the institutional scenario improvement in this study is making use of the existing policies on community forestry to empower community accountability in forest management by refining collaboration with local institutions and/or related stakeholders to increase the contribution and responsibilities of local communities, as well as increasing the effectiveness of community forestry itself. In this case, the local communities refer to FFGs. The existing condition of the institutional aspect of the VC was assessed through the first SRQ.

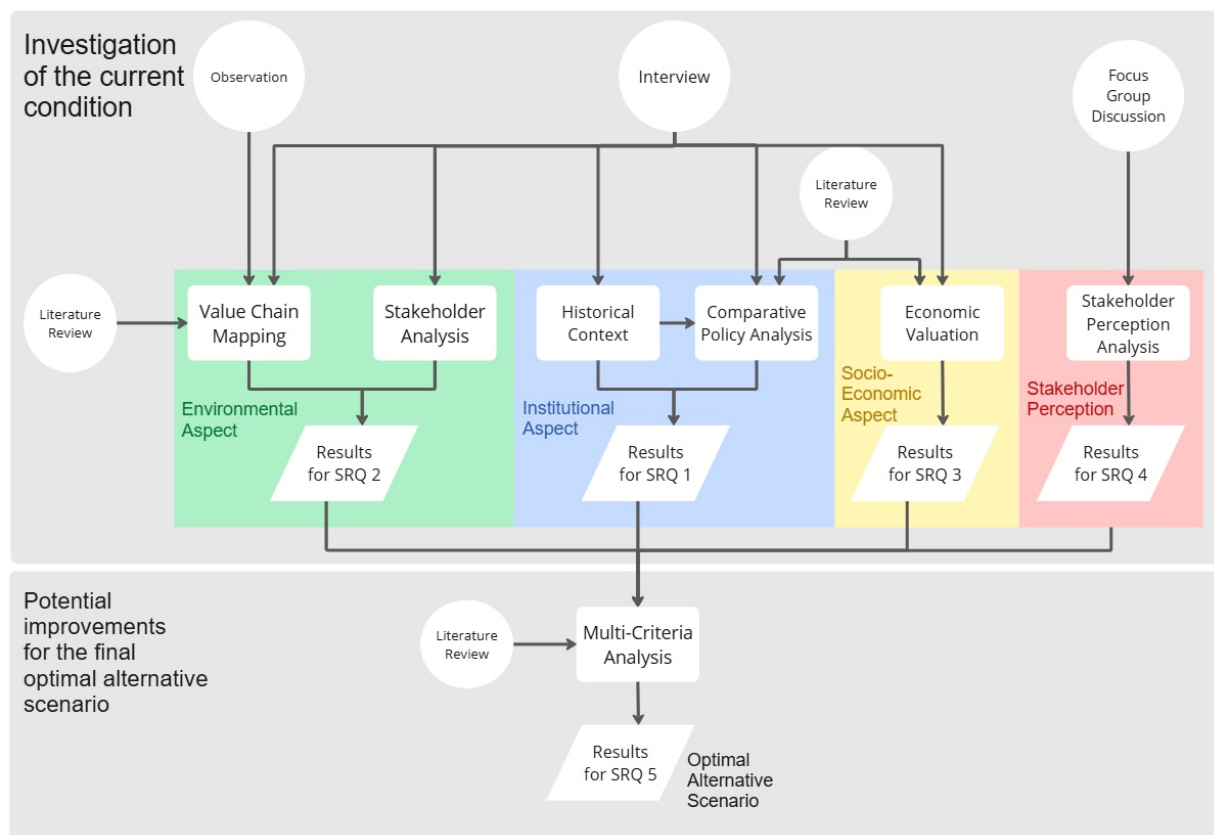
## Chapter 3. Methodology

### 3.1 Research Framework

The flow of data collection and analysis methods employed to answer the SRQs is visualized in Figure 2. To answer the SRQs, there were six methods of analysis this study employed: Comparative Policy Analysis, VC Mapping, Stakeholder Analysis, Cost-Benefit Analysis (CBA) as part of economic valuation, Stakeholder Perception Analysis, and Multi-Criteria Analysis (MCA). Primary data collection was conducted through observation, interviews, and focus group discussions (FGDs). Moreover, for some data analysis methods, such as VC Mapping, Comparative Policy Analysis, CBA, and MCA, secondary data collection through literature review was conducted to provide more information that was not obtainable through primary data collection.

The alternative scenarios in the MCA were made based on the improvements from the preceding SRQs results. Each SRQ represented one main aspect of sustainable

development that was analyzed to create improvement narratives. The first SRQ result, about the institutional process related to the social forestry permit, was used as the basis for institutional aspect improvement. The second SRQ result, about the bone of VC mapping, was used as the basis for environmental aspect improvement. The third SRQ, about economic valuation from the existing VC, was used as the basis for the socio-economic improvement scenario. Finally, the fourth SRQ, about stakeholders' perception, specifically about the public perception, was used as the basis for reasoning behind the improvement decision-making, considering what the local community said so that the alternative scenarios align with local conditions to achieve the goal of community participation in community forestry.



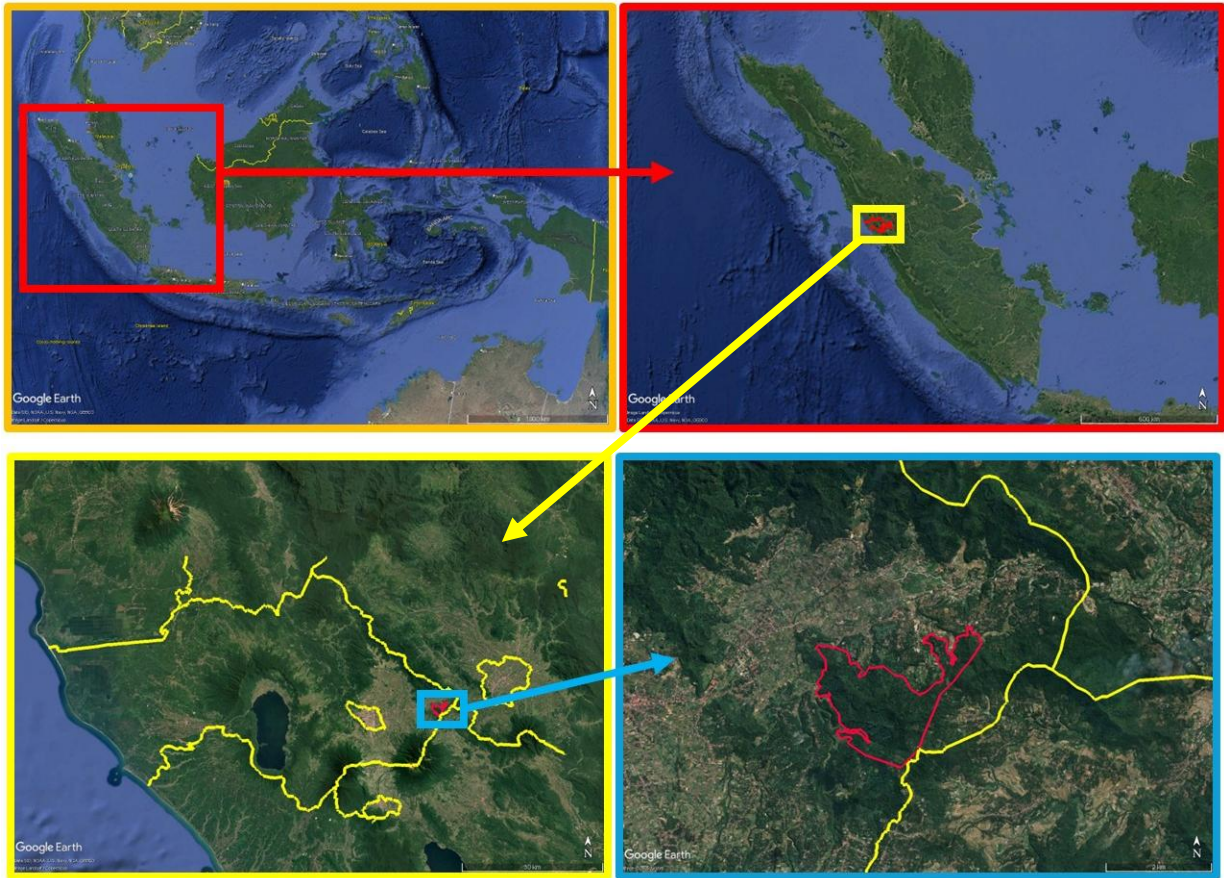
**Figure 2.** Flowchart of data collection and analysis methods used to answer the SRQs

## 3.2 Study Area

### 3.2.1 Geographical Location

The study was conducted in Padang Tarok Village, located in Agam Regency, West Sumatra, Indonesia, where the FFG LS operates. Figure 3 presents the boundary map of the study area within the broader context of Indonesia, Sumatra Island, and Agam Regency in West Sumatra province. The site is geographically located at coordinates -0.288622, 100.507572 (Google Earth, 2025). The total area for FFS LS's social forestry activities is 360 hectares. As of 2024, Padang Tarok Village had a population of approximately 8,430 people.

As of 2023, 59 heads of households from Padang Tarok Village were members of FFG LS (MoEF, 2023).



**Figure 3.** Location and boundary maps of the FFG LS social forestry area, shown at four scales: Indonesia, Sumatra Island, Agam Regency in West Sumatra Province, and the FFG LS site (Source: Google Earth, 2025)

### 3.2.2 Local Community

FFG LS has the right to manage the forest, including in deciding with whom they want to partner in managing the forests area. This is done in accordance with the specific rules and requirements regulated in Chapter 6 of MoEF Regulation No. 9 of 2021 (MoEF, 2021). However, the utilization of the social forestry area under FFG LS remains limited, with only one farmer group business unit (FGBU), which sole activity is pine tapping. Members of the FFG LS and the local community are not yet heavily involved in the existing pine VC, as pine resin tapping requires specific techniques they have not yet mastered. Furthermore, the pine tapping activity is not managed by the leaders of the FFG but is predominantly managed by the private company that partners with the FFG. The private company pays a premium to the FFG for every kilogram of pine resin harvested.

## 3.3 Data Collection

### 3.3.1 Primary Data

Primary data was collected in Padang Tarok Village. There were three main types of primary data collection methods employed in this study capturing observation, interviews, and FGDs. This data collection was carried out in coordination with the United Nations Environment Programme (UNEP) in Indonesia. The FFG LS is the direct beneficiary of one of UNEP's programs, with a local implementing NGO and a private pine resin company serving as the program's direct grantee. Therefore, the observations and interviews were mostly conducted alongside representatives from both the NGO and the company, who were simultaneously collecting data for their baseline study.

#### 3.3.1.1 Observation

The observation was conducted daily from 13 to 17 April 2025 at all points along the upstream VC to capture activities from the pine forest through to the warehouse. As the fieldwork of this study was supported by the TLGF project, the observation was carried out alongside officers from the pine resin company and the implementing NGO, who introduced and guided the main activities involved in upstream pine resin production. There were no strict predetermined rules for observing the existing upstream VC. The findings were written as a detailed narrative description, and a few photos were taken.

#### 3.3.1.2 Interview

The interviews were done semi-structured to ensure the collection of specific types of information needed while still allowing room to identify unexpected elements that could enrich the analysis. Questions were prepared in advance, combining open-ended and closed-ended formats, and tailored to the purpose of each interview and the specific stakeholders involved. The guiding questions were developed in Indonesian to align with local knowledge and cultural sensitivities. To ensure accurate capture of the interview's content and data inventory purposes, the interviews were recorded with the interviewee's verbal consent. The interviews were primarily, but not limited to, focused on the details of each activity in the upstream VC of pine resin production, the existing benefits-sharing mechanism within the current VC, and each stakeholder group's role, capacity, and perceptions of these while considering sustainability aspects. Table 1 shows the stakeholders interviewed, and the details of the purpose of each interview are specified in Table A in the Appendix. Purposive sampling was used to select interview participants. Some interviewees were predetermined, while others were selected by the organizations based on who they considered most suitable to provide relevant responses. Additionally, certain stakeholders were interviewed more than once to follow up and confirm new findings that emerged from other interviews.

**Table 1.** Lists of interviewed stakeholders

Type of stakeholders	Stakeholders	Number of Participant(s)	Date of interview
Administrative Government Bodies	Village Government ( <i>Nagari</i> )	5	13 April 2025
		1	17 April 2025
Government forestry authorities	Forest Management Unit (FMU - <i>Kesatuan Pengelola Hutan</i> )	1	12 April 2025
	Forestry Extension Worker ( <i>Penyuluh Kehutanan</i> )	1	15 April 2025
	Forest Ranger ( <i>Polisi Hutan</i> )	1	
NGO	Implementing NGO	3	15 May 2025
	Inter-governmental Organization/Funding Agency	1	15 April 2025
Tappers	Local Tapper	1	17 April 2025
	Outside Tapper	1	14 April 2025
Business Venture	Pine Resin Company	2	13 April 2025
		2	15 April 2025
		2	1 May 2025
Forest Farmer Organization	Community FFG ( <i>Kelompok Tani Hutan</i> )	1	14 April 2025
		2	17 April 2025
	Nagari Forest Management Institution ( <i>Lembaga Pengelola Hutan Nagari</i> )	3	14 April 2025
		3	16 April 2025

### 3.3.1.3 Focus Group Discussion (FGD)

A total of three FGDs were conducted on 14, 16, and 17 April 2025, each involving 9–10 participants. Efforts were made to ensure balanced representation of gender and age. Each FGD consisted of two sessions and lasted between 2 to 3 hours in total. The FGDs aimed to explore local communities' perspectives on the pine resin VC and their potential involvement. The FGD methods and analysis were adapted following methods from Adekola & Olumati (2023). Participants were representatives of local communities in the village, sampled through stratified snowball sampling.

The first session was an open session to explore participants' knowledge and information on social forestry and the existing pine resin VC. In the second session, participants wrote their thoughts on sticky notes for more specific topics, which the facilitator then collected and grouped by similarity. The facilitator subsequently guided participants in elaborating their responses and explaining their reasoning. The second session explored the following topics:

1. Current Needs: Related to their present occupation or to the type of work they would like to do if they were currently unemployed.
2. Current Challenges: Challenges faced in pursuing their current livelihood.
3. Concerns: Regarding involvement in the pine resin VC.

4. Expected Benefits: In the context of the social forestry scheme, what kind of support would they hope to receive if external assistance were available. This was kept open to both pine resin-related or unrelated responses, since not all participants viewed pine resin activities positively.

### 3.3.2 Secondary Data

This study elaborated secondary data to support the analysis and strengthen the findings. Details of the secondary data used in this study are shown in Table 2.

**Table 2.** Details of secondary data

Type of secondary data	Topics and/or type of documents	Source of documents
Scientific Paper	Social forestry, community forestry, pine resin VC, and sustainable NTFP productions.	<ul style="list-style-type: none"> <li>• Browse through sites such as Scopus, Google Scholar, Neliti, and search engines.</li> </ul>
Government-related Documents	<ul style="list-style-type: none"> <li>• Ministerial Decree</li> <li>• Ministerial Regulation</li> </ul>	<ul style="list-style-type: none"> <li>• Local government stakeholders interviewed in this study</li> <li>• FFG LS</li> <li>• Government's online repository</li> </ul>
FFG-related Documents	<ul style="list-style-type: none"> <li>• Memorandum of Understanding (MoU) of partnership</li> <li>• Shapefile data of the local area</li> </ul>	<ul style="list-style-type: none"> <li>• FFG LS</li> <li>• FMU</li> </ul>

## 3.4 Data Analysis

### 3.4.1 Comparative Policy Analysis

The comparative policy analysis was conducted to answer the first SRQ. This was adapted from the conceptual framework of Radin and Weimer (2018) to suit the specific needs and scope of this study and comprised the following steps:

1. Identified the documents to compare based on the needs of this study. This was done by comparing the regulations from the MoEF No. 83 of 2016 concerning Social Forestry” for the national-level regulation, and “Community Forestry Permit” which was received by FFG (MoEF, 2016; MoEF, 2023).
2. Identified individuals related to the documents in order to understand the local context of implementation and to highlight relevant document attributes. This was achieved through interviews with government stakeholders and the FFG board of management. Therefore, before the comparison, the historical context of pine reforestation and tapping was done by describing primary data obtained from interviews with those stakeholders.
3. Conducted an in-depth analysis of the documents, considering variables and context provided by stakeholders. Given the focus on the community-level context, a gap between the regulations from MoEF (national-level regulation) and local

realities was expected. The comparison results were presented in a tabular form, by comparing certain related variables from both regulations, followed by the key findings.

### 3.4.2 Value Chain Analysis

The VC analysis was conducted in this study to investigate the existing VC and identify areas of improvement from the upstream pine resin VC in terms of environmental aspect. The VC analysis comprises two main methods as follows:

#### *3.4.2.1 Main activities of VC Mapping*

Mapping of the VC main activities was done to answer the second SRQ about the existing VC of pine resin in Agam, Indonesia. This study only considered main activities in the upstream phase comprising a network of suppliers and sub-suppliers as suggested by Mubarik et al. (2021). The steps in main activities of VC mapping involved identification of point activities in the upstream stage followed by visualizing those steps in supporting software (MacCarthy et al., 2022). The resulting VC activities map became the backbone for the later analyses, including stakeholder analysis, economic valuation, and additional information such as FFS legal documents and FFS additional activities. The results from these analyses were placed under the related activity stages, creating a layered map that connects each analysis to the main VC activities, resulting as a final value chain map.

#### *3.4.2.2 Stakeholder Analysis*

This study adopted a stakeholder analysis method from Reed et al. (2009) to identify stakeholders' needs, interests, capacities, and any historical conflicts or alliances related to the VC of pine resin under the community forestry. The stakeholder analysis was done under three steps: stakeholders' identification, stakeholders' differentiation and categorization, and relationships between stakeholders' investigation.

##### *Stakeholder Identification*

Stakeholder identification was conducted using a combination of semi-structured interviews and snowball sampling. Initial interviews were held with the implementing NGO and the pine resin company responsible for the pine resin VC program in the area. In addition to discussing the program and addressing other SRQs, these stakeholders helped identify individuals and organizations to interview. Snowball sampling was then used to include new stakeholders mentioned in subsequent interviews.

##### *Stakeholders' Differentiation and Categorization*

The identified and interviewed stakeholders were categorized using a top-down analytical categorizations approach based on their levels of interest and influence in the existing VC. Their interest and influence were analyzed based on their perspectives regarding the VC of pine resin production. This interest analysis considered their views on each aspect of sustainable development: environmental, social, economic, and institutional. Influence was assessed by examining their instruments of power: condign power, compensatory power, and conditioning power. Condign power was derived from

threats and punishments; compensatory power came from offering rewards to gain influence; and conditioning power involved shaping people's beliefs and perceptions. The accumulation of interest in the sustainable development aspects determined their level of interest, while the accumulation of their instrument of power determined their level of power. The results of this stakeholder categorization are translated into the 'Interest-Influence' Matrix. To provide a clearer visualization of each stakeholder's level of influence and interest, a stakeholder matrix was created, with influence on the x-axis and interest on the y-axis. The stakeholders' levels of interest and influence are represented by their distance from the origin (the zero point) in the matrix. The higher their level of interest or influence, the farther they will be from the origin.

#### *Relationships Between Stakeholders' Investigations*

By capturing the relationships each stakeholder has with others through the interviews, a summary of the key relationship was created to explain how their interests and influence shape interactions among stakeholders. These key relationships were then summarized and presented in a tabular format.

### 3.4.3 Economic Valuation

The benefits from the upstream VC of pine resin were assessed to answer the third SRQ by analysis of both existing and potential benefits. The monetary benefits were analyzed using a CBA, followed by a detailed breakdown in benefit-sharing among stakeholders. In addition, a descriptive analysis was used to capture potential benefits that are often overlooked and have not yet been fully utilized by the FFG.

#### a. Existing benefits

CBA was conducted to assess the economic benefits of the pine resin VC, both at the existing condition and for the alternative scenarios in MCA by following the approach from Boardman et al. (2018). The main steps of CBA were capturing identification and calculation of the benefits and costs, and economic viability analysis. The analysis was conducted over 35 years, following the time frame of the Social Forestry Management Plan that was prepared by the FFG.

##### 1) Costs and Benefits Identification

The source for benefits and costs details of the existing pine resin VC was obtained mainly, but not limited to, interview results with people from FFG, the company involved in the VC, the current tappers, the implementing NGO, and the related local government. This was also further supported by a literature review of cost components which details were not mentioned during the interviews. The details of the cost component were comprising capital, operational, and maintenance, which can be found in Table B, C, and D respectively in the Appendix.

The benefit from the upstream VC was the price of crude pine resin harvested, which was usually sold by middlemen to the buyer, who then sent it to the end buyer. The price used was the lowest price identified from interviews. The final value of the benefit component was calculated by multiplying the average quantity of crude pine resin

harvested by the total harvest volume. Moreover, the benefit distribution to the stakeholders involved was presented in a tabular form.

## 2) CBA

To assess the economic viability of the existing VC and the benefit sharing, some variables were applied to the CBA calculation. The calculation was done in  $n$  years of the project life,  $B_t$  and  $C_t$  are the benefits and costs in year  $t$ ,  $s$  is the real discount rate. The discount rate of 10% was adopted based on common practice in Indonesian socio-economic projects conducted in collaboration with the Indonesian government. The following are the formulas used in the CBA:

Present value of benefit ( $PV(B)$ ) components:

$$PV(B) = \sum_{t=0}^n \frac{B_t}{(1+s)^t}$$

Present value of cost ( $PV(C)$ ) components:

$$PV(C) = \sum_{t=0}^n \frac{C_t}{(1+s)^t}$$

Net present value ( $NPV$ ):

$$NPV = PV(B) - PV(C)$$

Benefit-cost ratio ( $BCR$ ):

$$BCR = \frac{PV(B)}{PV(C)}$$

## b. Potential Benefits

The monetary and non-monetary potential benefits were analyzed qualitatively using a descriptive analysis of the interview results with relevant stakeholders. The interview data, in which potential non-monetary benefits were mentioned, were reviewed and transformed into a descriptive analysis to support socio-economic improvement at a later stage. The results were presented in a tabular format.

### 3.4.4 Stakeholders Perception Analysis

#### a. Stakeholders other than local people perception

The stakeholders' perception was analyzed as a further extension of the stakeholder analysis conducted previously in 3.4.2.2. Their perceptions were assessed based on their interest in VC, as revealed through the interview results.

#### b. Community perception

The community's perceptions were analyzed to understand their potential involvement in the pine resin VC and to inform future considerations on how the improvements of VC should be made and how FFG should be managed to achieve both sustainability in the pine resin sector and community empowerment under the social forestry scheme. The analysis followed the thematic approach by Adekola & Olumati (2023), applying an inductive method to identify patterns of meaning from the data. The

focus was on exploring participants' current needs, challenges, concerns regarding involvement in the pine resin VC, and expected benefits from VC participation. Responses from the FGDs were coded and grouped into key themes using ATLAS.ti to tag quotations and organize emerging themes. As a result, four central themes were identified that reflect the community's potential roles and interests in the pine resin VC.

### 3.4.5 Multi-Criteria Analysis (MCA)

The method used for the MCA was adapted from Macharis et al. (2012) and its summary is shown in Figure 4. The steps were as follows:

- Step 1: Define the alternative scenarios

The development of improvement narratives served as the foundation for alternative scenarios development in the subsequent MCA assessment. This process employed a mix of quantitative and qualitative analysis by using results from the preceding methods and an iterative approach to the collected data:

#### *a. Identification of Sustainability-Focused VC Improvement Components*

Each of the three SRQs, from SRQ1 to SRQ3, represents one of the sustainability aspects: SRQ1 addresses the institutional aspect, SRQ2 focuses on the environmental aspect, and SRQ3 relates to the socio-economic aspect. Components for improvement based on each SRQ result were selected through an iterative process with the findings from SRQ4 on public perception, to ensure that the selected improvements align with community needs, address public concerns, or respond to the benefits expected by the community. However, in line with the UN's view of sustainable development, these aspects are strongly interlinked (UN, 2012). As a result, even when one aspect was prioritized in the improvement narrative, the improvement would still naturally connect with the other sustainability aspects.

#### *b. Improvement Narratives Development*

After selecting the components for improvement from each SRQ result, the development of the improvement narratives was carried out using quantitative and/or qualitative approaches. For each sustainability aspect, the steps in developing the narrative were as follows:

- **Institutional aspect from SRQ1:**

As in the previous case, an iterative process was carried out using the results from SRQ4 to ensure that the selected areas for improvement aligned with public perception. In addition to SRQ4, the iterative process also referred to the results of interviews with other stakeholders, particularly those related to the targeted institutional improvements.

With regard to governance, the development of the narrative was also conducted through a literature review, but with a stronger emphasis on government documents to identify opportunities for maximizing potential benefits. This was done while still referring to the UN's definition of governance support roles, adapted to the local context.

- **Environmental aspect from SRQ2:**

An iterative process with the results of SRQ4 was conducted to ensure that the components identified for improvement aligned with public perception. Following this, the narrative for the proposed environmental improvement was developed through a literature review to explore the feasibility of implementing such improvements. The literature review aimed to identify ways to enhance environmental friendliness. This was done while referring to the UN’s definition of environmental sustainability and other relevant literature.

- **Socio-economic aspect from SRQ3:**

Similar to the other aspects, an iterative process was also applied to SRQ 4 to ensure that the selected areas for improvement were appropriate. After that, the development of narratives was guided by literature review. Moreover, a CBA was also conducted by adjusting to the developed narrative. The basis for the calculations referred to the CBA analysis conducted in SRQ 3. During the development process, it was also important to ensure that the developed scenario remained aligned with the UN’s sustainable development principles, while adapting to the local context.

*c. Alternative Scenarios Development*

The total number of alternative scenarios used as management options for the MCA was four, one of which was the business-as-usual (BAU) scenario. All four alternative scenarios were presented as a value chain map. The arrangement of improvement narratives applied for the four scenarios is shown in Table 3.

**Table 3.** Arrangement of improvement narratives for each scenario

Alternative Scenarios	Improvement narratives applied		
	Environmental	Institutional	Socio-economic
BaU	Not applied	Not applied	Not applied
Environmental Improvement	Applied	Not applied	Not applied
Eco-Governance Improvement	Applied	Applied	Not applied
Comprehensive Improvement	Applied	Applied	Applied

- Step 2: Define criteria and weights

- a. Criteria

The criteria that were used to assess the alternative scenarios were the three sustainability aspects, along with the institutional aspect. The sub-criteria of each criterion were designed adapting to the UN documents, the related Indonesian government documents, and ‘The FSC National Forest Stewardship Standard of Indonesia’ document by Forest Stewardship Council (FSC) (2020). The document from FSC was chosen as one of the main sources to complement the elements that are not widely covered in an operational granularity manner by the other aforementioned documents. Compared to the other relevant Criteria & Indicators (C&I) documents, such as the ITTO Criteria and Indicators for the Sustainable Management of Tropical Forests, the FSC standard offers several distinct advantages for the detailed assessment required,

including provides a highly detailed hierarchy of principles and criteria, strong emphasis on social aspects and community forestry, context-specific adaptation, and action oriented practice framework (FSC, 2020). Table 4 shows the criteria and sub-criteria used to assess the scenarios. The criteria and indicators were adapted from MoEF Reg. No. 9 of 2021 and from FSC document with the details explained in the Appendix (MoEF, 2021; FSC, 2020). The source details for each sub-criteria is presented in Table E in the Appendix.

**Table 4.** Criteria, sub-criteria, and Indicators for MCA

Criteria	Sub-criteria	Indicators
Environmental	Biodiversity is maintained or enhanced.	Pine resin is extracted through low impact tapping techniques that minimize tree wounding and damage, thereby maintaining, enhancing, or restoring the structural and ecological features of pine forests and safeguarding the diversity of all naturally occurring species and their genetic diversity.
	Effective measures to avoid negative impacts of management activities on environmental values	All community forest management activities are planned and implemented to prevent negative impacts and to protect environmental values.
Social	Representation of stakeholders, particularly women, youth, and marginalized groups.	Culturally appropriate engagement processes where all stakeholders (Particularly women, youth, elderly, and marginalized groups), are identified as appropriate representatives, and are represented and engaged in community forestry management decision-making processes.
	Job-specific training and oversight are provided to workers to support the safe and effective execution of the Management Plan and associated operations	Training programs are planned and implemented to ensure all workers has the adequate knowledge and skills related to the job to safely execute Management Plan activities.
	Community Free, Prior, and Informed Consent (FPIC) in resin VC decisions	Community FPIC processes are planned and implemented for all resin VC decisions and activities, to ensure communities receive comprehensive information about their rights and obligations.
	Effectiveness of community engagement and participation in resin VC management.	Culturally appropriate engagement processes are established and implemented to inform communities about specific Management Plan activities and benefit distribution arrangements, with active invitations for local community involvement.
Economic	The capacity to use resources efficiently and access financial institutions and markets.	Financial planning shows efficient resource allocation and sufficient Management Plan funding by leveraging external organizational aids.
	Economic viability and profitability of the pine resin VC for the community	Diversification of local economic sources by enabling alternative economic activities other than pine resin extraction in community forestry areas, with active community participation.

	Contribution of the activities under the social forestry permit to local employment and livelihood diversification	Prioritizing the employment of local people, where local and non-local options show equivalent cost, quality and capacity, preference is given to local people.
Institutional	Availability of the necessary administrative documentation.	Minimum documents such as RKPS and AD/ART are available, and transparency from all stakeholders involved is realized through accessible documentation and open communication processes.
	Compliance with national and local laws and regulations governing social forestry and resin production.	All follow-up documents, regulations, and administrative are developed according to the national and local laws demonstrate full compliance with legal recommendations and requirements.
	Clarity and community involvement in long-term management planning under the social forestry permit.	A clear plan for community involvement in long-term management is documented in the Management Plan and related materials, aligned with the social forestry permit.

b. Weight

The criteria were weighted to determine the relative importance of each one. Stakeholders were asked to assign a percentage to each criterion, with the total adding up to 100% per stakeholder. The final weights were calculated by first averaging the percentages for each criterion within each stakeholder group, then averaging the results across all stakeholder groups.

- Step 3: Performance Matrix

The criteria in each alternative scenario were assigned scores using a scale of 1 to 5. A score of 1 indicates that the criterion in the alternative scenario performs very poorly in fulfilling the indicator, while a score of 5 indicates that the criterion performs very well in fulfilling the indicator. The scores for every alternative scenario were assigned based on the relative performance compared to the other alternative scenarios.

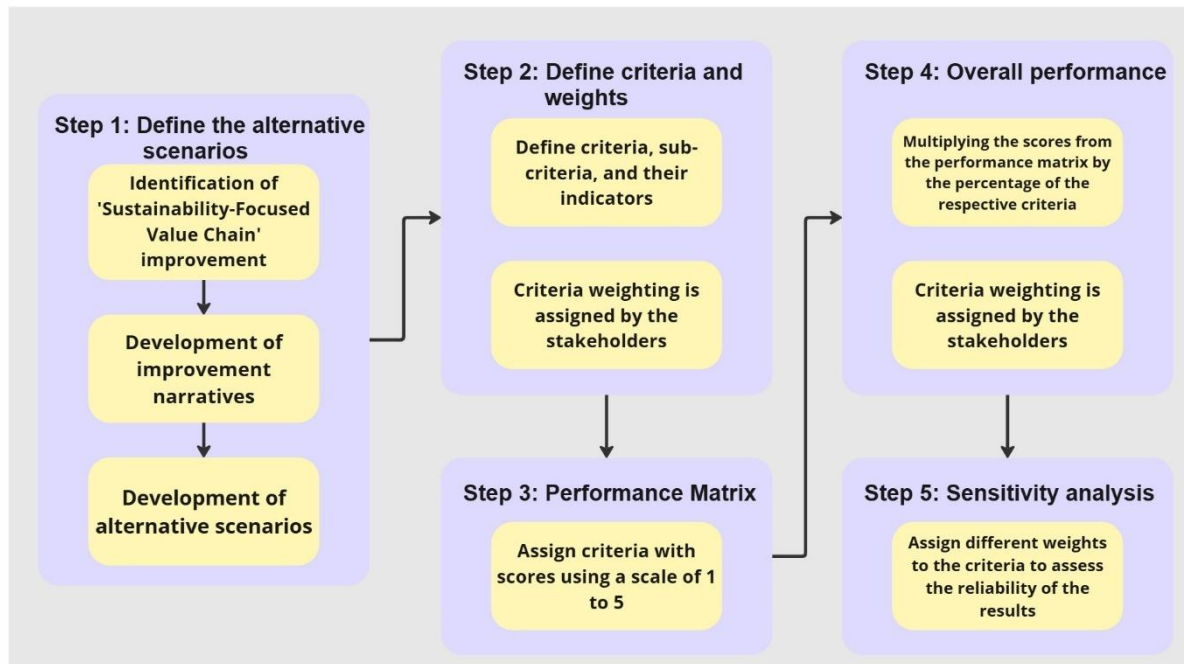
- Step 4: Overall Performance

After both performance matrix and weighting criteria were finalized, all the scores in each criterion were multiplied by the percentage of the respective criteria. The final overall performance for each alternative scenario was the sum of the multiplied performance matrix. While the highest scored alternative scenario represents the optimum VC, the best alternative scenario for each stakeholder could be assessed by only multiplying the performance matrix by the original criteria weight made by respective stakeholders.

- Step 5: Sensitivity Analysis

Finally, sensitivity analysis was conducted to determine the reliability of the results obtained from the overall performance of alternative scenario. This was done to assess

whether different criteria of weighing would produce different results, which then provided new insights of the alternative scenarios. The sensitivity analysis involved three different criteria arrangements for weighing alternatives: (1) equal weighting across all criteria, (2) reassigned weighting based on reverse ranking order, and (3) adding 5% to the two lowest weighted criteria and subtracting 5% from the two highest weighted criteria.



**Figure 4.** Steps of multi-criteria analysis to determine the optimal alternative VC

## Chapter 4. Results

### 4.1 Institutional Process of Social Forestry in Agam

#### 4.1.1 Historical Context of Pine Reforestation and Tapping

Pine trees in Agam were planted in the 1970s as part of a forestation program initiated by the central government. In the early 2000s, pine resin tapping activities began, carried out by a state-owned enterprise based in Sumatra and a large private company. In 2017, the village forest came under local management through the establishment of the Nagari Forest Management Institution (*Lembaga Pengelola Hutan Nagari* – LPHN), formed under the authority of the village government. Later, in 2022, a Forest Farmer Group (FFG) was formed and applied for a social forestry scheme with support from another private company and a forest extension officer. The details are as shown in Figure 5.



**Figure 5.** Historical context of pine reforestation and tapping in Agam, Indonesia

#### 4.1.2 Social Forestry Application Process in Agam by FFG

The private company has played a key role since the establishment of FFG. In general, the process from the application for community forestry to the issuance of the Community Forestry permit for FFG aligns with the national-level documents from the MoEF as well as the documents received by FFG. However, supporting documents such as the Business Plan or Social Forestry Management Plan have not been officially approved, although NTFP utilization activity within the community forestry area has already begun. This activity is carried out by the private company as FFG’s partner, which was not selected through a formal selection process by FFG’s members. The comparison of each step is summarized in Table 5.

**Table 5.** Comparison between national-level regulations and local social forestry documents

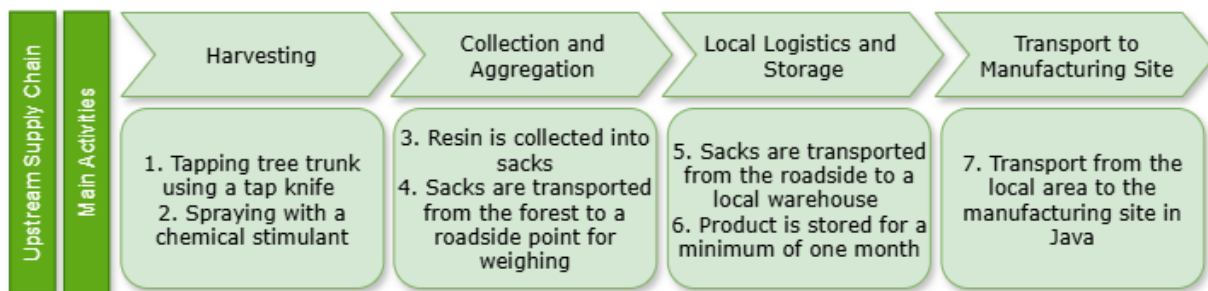
Steps	Regulation from MoEF concerning Social Forestry (MoEF, 2016)	Community Forestry Permit received by the FFG (MoEF, 2023)	Key Findings
Application for Community Forestry	<b>Article 19 – Application for Community Forestry:</b> An application for a Community Forest Utilization Permit may be submitted by the chairperson of the joint FFGs (Clause 1). The application must be accompanied by a list of local community members who will become members of the Community Forestry group, acknowledged by the village head, a general description of the area, and a proposed location map (Clause 5).	The chairperson of the FFG submitted an application for Community Forest Management Approval.	The application fulfilled one of the possible applicant categories and met the requirement of collecting the membership list.  Although not stated in the permit, the process of collecting the local community list, verified by obtaining copies of their ID cards, was assisted by the private company.
Verification of Administrative and Technical Requirements	<b>Article 21 and 22:</b> The verification is carried out by the Directorate General of Social Forestry through an assessment of the completeness of administrative requirements. Once the administrative documents are considered compliant, technical verification is conducted under the mandate of the Ministry of Environment and Forestry.	The Technical Verification Report is issued by BPSKL, providing details of the proposed working area, which will serve as the basis for the subsequent process of issuing the Community Forest Management Approval	The technical verification carried out by the community followed the steps outlined in the MoEF regulation.  All the back-and-forth communication involving the submission of required documents and updates between the relevant forestry government bodies and the FFG was assisted by the forest

			extension worker, and occasionally by the private company as well.
Issuance of the Social Forestry permit by the Ministry of Forestry	<p><b>Article 23:</b> After fulfilling the verification requirements, the Community Forest Utilization License is issued by the Minister through the Director General</p>	Permit of the 'Minister of Environment and Forestry on the granting of Community Forest Management Approval' to the FFG through the Secretariat of the Directorate General of Social Forestry and Environmental Partnership	The verification duration was not clearly specified in the permit.
Availability of supporting documents	<p><b>Article 51:</b> The administration of NTFPs is regulated by a separate Ministerial Regulation, unlike timber forest products, which are required to have a Business Plan under this regulation.</p> <p><b>Article 59:</b> Community forestry holders are required to prepare a Business Plan and submit an implementation report to the grantor or licensor, which may be assisted by other parties in a non-binding manner.</p>	Approval for Community Forest Management, especially for the use and harvesting of NTFPs, should be in line with the management zones outlined in the Social Forestry Management Plan.	Currently, FFG LS does not have an officially approved Business Plan or Social Forestry Management Plan, but NTFP utilization in partnership with a private company is already underway.
	<p><b>Article 46:</b> The community forestry permit holders, together with the potential partner, prepare a draft of partnership agreement involving village institutions and the chosen other parties, and agreed upon by the local community.</p>	There are no details regarding the required documents related to the partnership. However, FFG is entitled to receive support for the partnership in developing its business.	The existence of the partnership agreement could not be confirmed due to time constraints during data collection. However, the private company selected to carry out pine resin activities under community forestry scheme was not chosen through a bidding process or tender by FFG

			members, as the company has been involved since FFG's formation.
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## 4.2 Existing Pine Resin VC

The upstream VC process of crude pine resin production in Agam involves four main units, which are harvesting, collection and aggregation, local logistics and storage and transport to manufacturing site, as shown in Figure 6. After that, crude pine resin is processed in the factory for downstream manufacturing into products such as rosin and turpentine in another area.



**Figure 6.** Main activities of the upstream pine resin VC

Based on the observation of the site, the overall operations are relatively simple and do not involve complex mechanical or digital systems. The whole process of the upstream VC is considered traditional as the equipment used is manual or semi-manual, without the use of automation or advanced technologies. At present, pine resin production is managed by a private company through a partnership with the FFG, which holds the community forestry permit. The existing upstream VC and the stakeholders involved are presented as follows:

### 4.2.1 Upstream VC Process

#### a. Harvesting Crude Pine Resin

The first main activity in the upstream pine resin VC is harvesting crude pine resin performed by the tappers. The pine resin harvesting is done through two primary tasks: (1) tapping the tree trunk and (2) spraying stimulants. Tapping is dominated by workers from outside the region. Most workers involved in this VC have limited education, usually only up to elementary school, which makes it difficult for them to operate more sophisticated equipment and technology. At present, there are three tappers from outside Padang Tarok Village and two local people who work as tappers as a side job. They are paid based on the number of kilos of crude pine resin they collect and lack both insurance and job security.

Decades ago, when forest management was still under the state-owned forestry enterprise, tapping workers used poor practices that in some cases led to the death of pine trees. Today, organizations granted with pine tapping permits are required to follow a Standard Operating Procedure (SOP) issued by MoEF, titled “SOP for the Evaluation System of Pine Resin Tapping for Permit Holders and Partnerships within Forest

Management Units”. This document serves as the primary guideline for managing the pine forest, including in conducting tapping activities and stimulant spraying (MoEF, 2020).

### *Tapping Tree Trunk*

The harvesting of crude pine resin is done by tapping the tree trunk using a tapping knife, as shown in Figure 7a. The SOP document does not provide or mention a specific name for the method used to create the groove on the pine tree trunk. Regarding tapping, the SOP mainly specifies the spacing between grooves, the frequency of tapping on the same wound, and other related technical details (MoEF, 2020). Figure 7b shows pine tree trunks in the social forestry area allocated to FFG LS that have been tapped. The resin is collected in a renewable and more eco-friendly container, which is a coconut shell, as shown in Figure 7c. One coconut shell can hold 250 to 300 milliliters of crude pine resin per month and can be used for over a year. It is replaced only when it becomes too worn to hold resin effectively. Additionally, one tapper from outside the area stated that coconut shells are a cheaper alternative for collecting resin.



**Figure 7.** (a) Tap knife; (b) Wounded pine tree trunks; (c) Pine resin collected in the coconut shell (Courtesy: PILI)

Although most tapping techniques follow the SOP, the FMU officer emphasized that the SOP is often ignored in practice. Tappers tend to rely on outdated and improper techniques. Despite this, guidance from the FMU continues to be provided. However, technical monitoring is now rare compared to previous years when it occurred more frequently. No specific training is offered by FMU to tappers or businesses, as all technical standards are outlined in the permit documents and the SOP. If these standards are not followed, the license or permit granted can be revoked. Forest rangers do patrol the area to ensure compliance with forest management regulations, although they do not specifically inspect the tapping wounds made one by one.

While the techniques currently used by tappers generally align with the SOP, the tappers themselves reported not being aware of the existing SOP. Regarding the frequency of tapping, one local tapper explained that he can tap between 10 and 20 pine trunks per day during initial tapping, depending on how hard or soft the bark is and how high the tapping point is on the tree (MoEF, 2020). A detailed comparison between the SOP regulations and field practices is presented in the Appendix.

### *Stimulant spraying*

The stimulant is applied by spraying a solution onto the freshly wounded tree trunk to enhance optimal resin flow. As acidic chemicals are involved, care should be taken

when handling them, as they may cause skin irritation. The SOP from MoEF provides suggestions regarding the type of stimulant and its composition that can be used for spraying, based on the altitudes of the pine forests. The main ingredients are either an organic solvent or sulfuric acid. However, the current field practices followed by the tappers, as suggested by the company, involve a mixture of nitric and sulfuric acids, with no differentiation in treatment for different altitudes. The stimulant used, its composition, and the dosage recommended by the company to the tappers differ from what is stated in the SOP document. Further details of differences are shown in Table F and G in the Appendix.

A mixture of nitric acid and sulfuric acid is provided by the company, and the tappers mix it themselves. Although the composition of the chemical stimulant suggested by the company already differs from the SOP, the company stated that each tapper may use different compositions and dosages depending on their style and personal experimentation.

One tapper mentioned that when mixing the chemicals, it is acceptable to add more water, as long as it is not too little. Moreover, another tapper stated that he does not know the names of the chemicals used. He identifies them by the color of the gallon caps and recognizes the mixing ratio from experience. Typically, chemical spraying is done the day after the tapping cut is made. This process is repeated roughly every 10 to 15 days, depending on the season, with the average being once every 10 to 12 days.

b. Transport to Roadside Collection and Regional Warehouse

After the pine resin is harvested, the collected resin is poured into sack-sized plastic bags and then covered with actual sacks. These sacks filled with pine resin are then transported to the warehouse through several stages: first from the pine forest to the roadside, and then from the roadside to the warehouse. The workers that transport sacks of crude pine resin from forest to roadside are outside workers and non-tappers as it is hard to find local people who are able and willing to do this. The detailed process is shown in Table 6.

**Table 6.** Details of transporting activities

<b>Activities</b>	<b>Sub-activities</b>	<b>Details</b>
<b>Transport to Roadside Collection</b>	From forest to roadside	<ul style="list-style-type: none"> <li>• Tappers pour resin from coconut shells into:               <ul style="list-style-type: none"> <li>○ Plastic bag (sack-sized).</li> <li>○ Covered with sack.</li> </ul> </li> <li>• Transport through steep terrain:               <ul style="list-style-type: none"> <li>○ Terrain: steep, unstable forest slopes.</li> <li>○ Workers use motorcycles to reach the weighing point at the roadside.</li> </ul> </li> </ul>
	Weighing & documentation	<ul style="list-style-type: none"> <li>• Done once a month and takes 1 full day.</li> <li>• A worker from the private company weighs sacks at roadside</li> </ul>

		<ul style="list-style-type: none"> <li>• Each sack is labeled with weight, order number, and unique code (also recorded on paper).</li> <li>• The copies of these papers are given to the truck driver and the tappers.</li> </ul>
<b>Transport to Regional Warehouse</b>	N/A	<ul style="list-style-type: none"> <li>• The sacks containing crude pine resin then being transported to the regional warehouse storage with a pickup truck by a local resident who is also a member of KTH.</li> </ul>

c. Warehouse Storage and Transport to Manufacturing Site

The waiting time to ship from the regional warehouse in Agam to the downstream site on Java Island usually depends on the type of vehicle that will be rented to transport it. It usually takes about a month. Before the sacks are sent to Java, the truck driver usually double-checks the number and weight of the sacks and then makes a loading list and signs it as proof. These papers with the weight and number of sacks details will be sent to the regional coordinator through WhatsApp before the delivery from Sumatra to Java begins. Therefore, the headquarters management can only trace the results of harvest sent through communication with the regional coordinator.

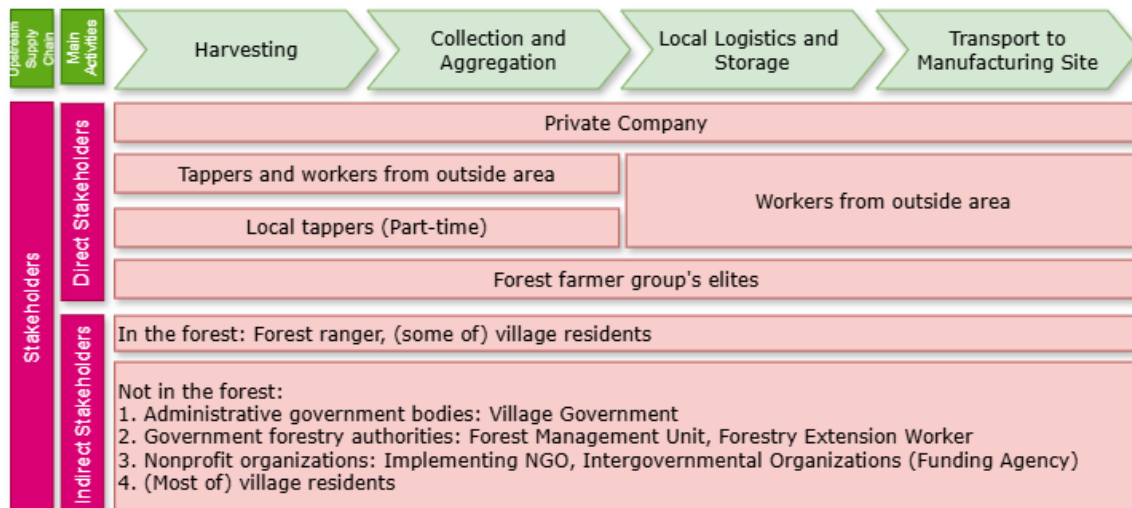
d. Transport to Manufacturing Site

The pine resin sacks are transported to the manufacturing site on Java Island by an external service provider that is paid based on the number of kilograms of resin transported. Tronton trucks are not allowed to enter the small roads leading to the warehouse due to the risk of road damage and breakage. As a result, shipments to the manufacturing site on Java Island are often delayed for several months. This delay occurs while waiting for enough stock from nearby areas to accumulate in order to fill large truckloads efficiently. The upstream VC of pine resin ends after transportation to the manufacturing site, as the stages after are no longer part of the community forestry process.

#### 4.2.2 Stakeholders Involved in the Upstream VC

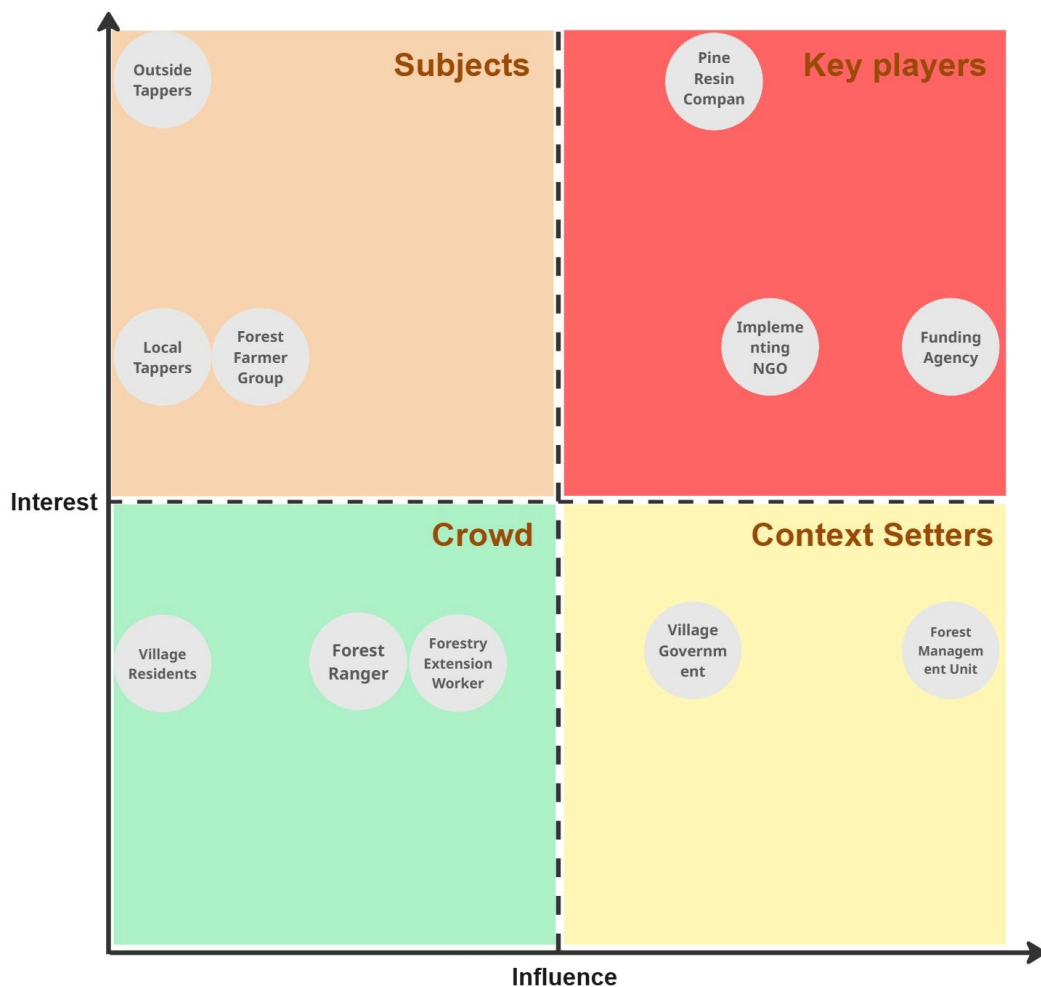
a. Stakeholders involved

The direct and indirect stakeholders involved in the upstream pine resin VC are as explained in Figure 8, which comprises of the pine resin company, the implementing NGO, the funding agency, the village government, FMU, outside tappers, local tappers, FFGs, village residents, forest rangers, and forestry extension workers. Moreover, their position in the Influence-Interest matrix is shown in Figure 9, with further details and reasoning of their position is provided in Table H in the Appendix.



**Figure 8.** Stakeholders of the upstream pine resin VC

The “Key Players” in the VC are the pine resin company, the implementing NGO, and the funding agency; these stakeholders need to be actively managed to maximize their support in leveraging community forestry and to minimize potential risks arising from their influence (Reed et al., 2009). The implementing NGO runs programs aimed at environmental conservation and improving the socio-economic capacity of local communities. Depending on the program, they can provide both monetary and non-monetary benefits, though the distribution of these benefits is limited by conditions set by the funding agency, in partnership with the pine resin company during implementation. The funding agency decides the flow of funds channeled through the implementing NGO. They hold authority in determining whether a program should continue, through a monitoring and evaluation mechanism, and maintain direct connections with national-level government institutions. The pine resin company has the potential to provide greater income for residents who become tappers. However, they are vulnerable to partnership termination with FFG or being replaced by another business venture, especially if FFG becomes more empowered in making decisions related to the pine resin VC under their social forestry permit. The company strives to implement programs that improve community welfare and capacity while ensuring environmentally friendly pine resin tapping processes by applying for a development program and grant (jointly with the implementing NGO) to the funding agency for programs.



**Figure 9.** Stakeholders' Influence-Interest Matrix

The “Context Setters” are the village government and the forest management unit; they require monitoring and management due to their significant potential to affect the VC despite limited engagement (Reed et al., 2009). The village government acts as an intermediary institution for nearly all activity permits in the village, including those related to the pine resin VC. Moreover, they provide village funds as external financing for FFG through a monitoring and evaluation mechanism and offer organizational technical guidance and mentoring to FFG. The Forest Management Unit acts as a monitor and facilitator for FFG, starting from its formation, supporting FFG in obtaining social forestry designation and legal permission for pine resin tapping, and providing capacity building for FFG. Although almost all forestry-related activities should get permission through them, their direct involvement in the field is low to none.

The “Subjects” include outside tappers, local tappers, and FFGs; although they individually lack strong influence, they are considered important because of their potential to form alliances and collectively affect outcomes (Reed et al., 2009). Both local and outside tappers are prone to being replaceable; however, this affects outside tappers more, as tapping in the area is their main job. The community FFG is institutionally the highest decision-making body for activities and management under the community forestry permit.

However, currently, its leadership is not yet fully capable of independently managing the FFG or forest-related matters tied to the permit. Especially in the pine resin VC, they have a much lower influence compared to the private company.

Finally, the “Crowd” consists of village residents, forest rangers, and forestry extension workers; these stakeholders require minimal attention or detailed engagement (Reed et al., 2009). The village residents (also called local communities here) have an insignificant influence on the VC. Most FFG members can be considered merely village residents due to their minimal involvement in FFG activities and decision-making. While they are aware of the pine resin VC, they are not actively involved. As well as the forest ranger, who is an individual who directly patrols the forest to monitor violations and compliance, including pine resin tapping activities, and holds the authority to impose sanctions if any violations occur. Lastly, the forest extension worker, who is an individual from the FMU who works hands-on to assist with any legal matters needed by FFG, typically by going through the village institution first. If there are any administrative or forestry legality issues, the Forestry Extension Worker directly steps in to resolve them.

b. Relationships between stakeholders

Table 7 provides further details on the reasons behind the power matrix, explaining the relationship between stakeholders. The results show that the village government is an institution that interacts with most stakeholders. While for the other stakeholders, the active relationships with the other stakeholders mostly only involve around two or three other stakeholders.

**Table 7.** Relationship between stakeholders

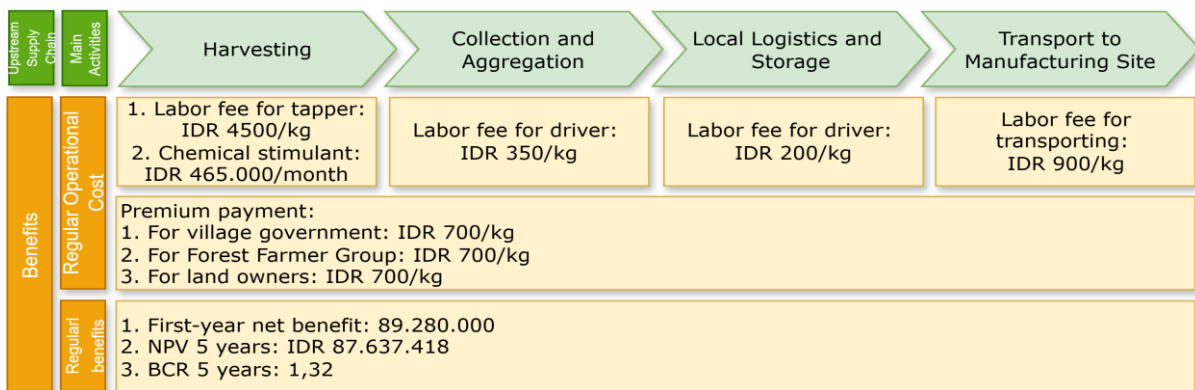
Type of Stakeholder	Stakeholders	Key relationships with other stakeholders
Administrative government bodies	Village Government	Basically, they act as a bridge between all organizations or institutions with KTH.
Government forestry authorities	Forest Management Unit	<ul style="list-style-type: none"> <li>• Functions as an intermediary institution at the regency level between regional forestry bodies (such as the Social Forestry and Environmental Partnership Agency for Sumatra) and national-level bodies (Ministry of Forestry), especially regarding administrative legality matters with FFG.</li> <li>• Does not directly engage with external organizations such as business ventures or NGOs, but is always informed about related activities.</li> </ul>
	Forestry Extension Worker	The individual who physically interacts with all parties, especially between the FMU, village government, and FFG.
	Forest Ranger	A member of the FMU who goes directly into the forest and interacts with field workers. Will report to the FMU if any violations occur.
Nonprofit Organizations	Implementing NGO	<ul style="list-style-type: none"> <li>• Works closely with FFG to build their capacity and improve their welfare as a group.</li> </ul>

		<ul style="list-style-type: none"> <li>Depending on the project, can act as a negotiator between FFG and non-governmental external institutions such as business ventures.</li> <li>Sustainability program depends on funding from the funding agency.</li> </ul>
	Inter-governmental Organization (Funding Agency)	<ul style="list-style-type: none"> <li>Actively communicates with implementing NGOs and business ventures as funding recipients for transforming the pine resin VC.</li> <li>If challenges arise during implementation in the field, has the authority to contact regional or national institutions for the greater good.</li> </ul>
Local People	Village residents	Mostly interact directly with the village government and may communicate with FFG members, but this depends on the proactiveness of each individual.
Field workers	Local tapper	Closely connected with the private company and has a voice that can influence FFG.
	Outside tappers and worker	Closely connected with the private company. Generally accepted by the community, although they do not actively integrate.
Business Ventures	Pine resin company (private company)	<ul style="list-style-type: none"> <li>Closely connected with FFG leaders and the forestry extension worker for legal matters.</li> <li>Strong relationship with the implementing NGO and funding agency in preparing and implementing programs for the community through FFG.</li> </ul>
Forest Farmer Organization	FFG	<ul style="list-style-type: none"> <li>Strongly connected with business ventures for activities related to the pine resin VC.</li> <li>Closely related to hamlet leaders and the village government for administrative needs.</li> </ul>

## 4.3 Benefits from Social Forestry

### 4.3.1 Existing benefits

As shown in Figure 10, the regular operational costs include labor fees, chemical stimulant, and premium payments to certain stakeholders, with more detailed calculations explained in Table 8. The monetary benefits, indicated by an NPV of IDR 87.64 million over five years and a BCR of 1.32, show that the current VC is economically viable.



**Figure 10.** Existing benefits of the upstream pine resin VC

Table 8 shows the calculation of the costs and benefits of the entire pine resin VC over the course of 35 years, starting from 2025. The detailed calculation of the existing VC capital, operational, and maintenance costs used can be found in Table B, C, and D respectively in the Appendix.

**Table 8.** Costs and benefits of the entire pine resin SC over the course of 35 years

Time (year)	2025	2030	2035	2040	2045	2050	2055	2060
<b>Cost Component (IDR)</b>								
Capital Cost	20.790.000	0	0	0	0	0	0	0
Operational Cost	290.330.000	290.330.000	290.330.000	290.330.000	290.330.000	290.330.000	290.330.000	290.330.000
Maintenance Cost	31.600.000	31.600.000	31.600.000	31.600.000	31.600.000	31.600.000	31.600.000	31.600.000
<b>Benefit Component (IDR)</b>								
Crude pine resin	432.000.000	432.000.000	432.000.000	432.000.000	432.000.000	432.000.000	432.000.000	432.000.000
PV Cost	342.720.000	199.893.202	124.117.951	77.067.482	47.852.843	29.712.851	18.449.343	11.455.590
PV Benefit	432.000.000	268.238.012	166.554.701	103.417.365	64.214.047	39.871.871	24.757.295	15.372.332
<b>Nett PV Benefit</b>	<b>89.280.000</b>	<b>68.344.810</b>	<b>42.436.750</b>	<b>26.349.883</b>	<b>16.361.204</b>	<b>10.159.021</b>	<b>6.307.952</b>	<b>3.916.742</b>
<b>NPV 5 years</b>	87.637.418							
<b>BCR 5 years</b>	1,32							
<b>NPV 35 years</b>	32.880.359							
<b>BCR 35 years</b>	1,33							

The NPV results suggest that the pine resin VC under community forestry is profitable both in the short term (5 years) and long term (35 years). In the initial 5 years, the project shows a BCR of 1.32, indicating that the benefits outweigh the costs during this period. Even after 35 years, the BCR remains above 1, signaling that the project still generates more benefits than costs. However, when considering the 35-year timeframe, the NPV decreases significantly, from IDR 87.64 million for the first 5 years to IDR 32.88 million for the 35-year period. This drop suggests a smaller margin of benefit relative to costs over the long term as the result of discounts over a longer period.

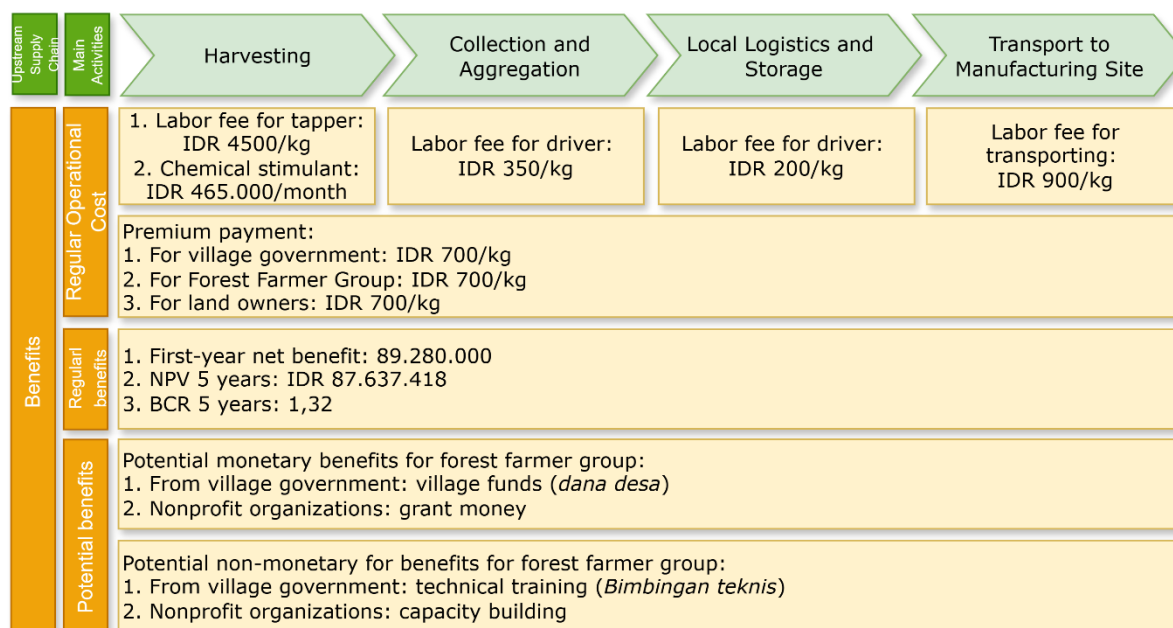
The net benefit is distributed to several stakeholders, such as FFG, local people entitled to manage the forest, village government, and private company. Table 9 shows the benefit distribution from the first year, reflecting the existing allocation. The benefit distribution is calculated based on the premiums received by each stakeholder, except for the company, whose benefit stems from the indirect benefit gained by sourcing resin without involving a middleman. However, the use of the premiums by these stakeholders and the responsibilities that come with it are not clear yet.

**Table 9.** Benefit distribution from the upstream pine resin VC

Stakeholders	Value per year (IDR)	Remarks
FFG	25.200.000	Each stakeholder is entitled to receive IDR 700 per kilogram of crude pine resin harvested. This is based on a total monthly harvest of approximately 3,000 kilograms
Local people entitled to manage the forest	25.200.000	
Village government	25.200.000	
Company	13.680.000	Although the amount is smaller than that received by other stakeholders, they will still gain greater benefits from processing the crude pine resin into final products through downstream processes. This figure represents the externalities of benefit obtained from the upstream process by sourcing the resin directly, rather than purchasing it from farmers, considering a total production cost of IDR 12,000 per kilogram of crude pine resin harvested in the upstream process.
<b>Total</b>	<b>89.280.000</b>	

#### 4.3.2 Potential benefits

In addition to the existing benefits, there are also potential benefits from social forestry, both monetary and non-monetary. These potential benefits come from the village government and NGOs, which integrated to the VC layer of benefits as shown in Figure 11. The details of these potential benefits are provided in Table I and J in the Appendix.



**Figure 11.** Overall benefits of the upstream pine resin VC

## 4.4 Stakeholders Perception on Pine Resin Production

### 4.4.1 Stakeholders other than local people’s perception

Table 10 shows the perceptions of stakeholders regarding the pine resin VC. The overall perception of stakeholders, except for the local people whose views are presented in 4.4.2, is positive. Most believe that VC activities can increase community welfare as most of them believe that it could increase community welfare while protecting the forest. However, the details vary, as presented in the table.

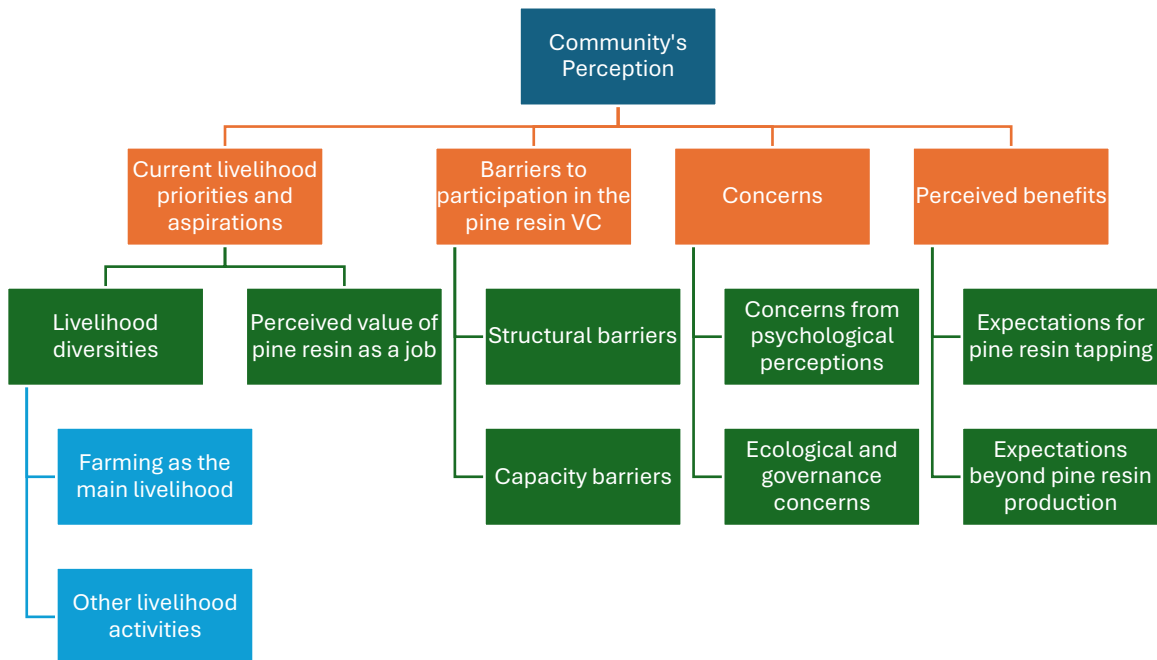
**Table 10.** Stakeholders’ perception of pine resin VC

Type of Stakeholder	Stakeholders	Perception of the pine resin VC within community forestry
Administrative government bodies	Village Government	<ul style="list-style-type: none"> <li>• Strongly supports the pine resin VC activities as a way to generate more income for the community and hopes that residents will be more open to trying it.</li> <li>• Sees that most people are still not eager to try new things, especially becoming pine resin tappers.</li> </ul>
Government forestry authorities	Forest Management Unit	<ul style="list-style-type: none"> <li>• Sees social forestry as a solution to forest area farming practices within local communities.</li> <li>• With social forestry in place, the responsibility to protect the forest, including the pine forest, is shared with FFG, which makes FMU feel supported.</li> </ul>
	Forestry Extension Worker	<ul style="list-style-type: none"> <li>• Views social forestry as a way to improve community welfare by maximizing forest potential.</li> </ul>
	Forest Ranger	<ul style="list-style-type: none"> <li>• Believe that as long as all activities follow existing rules and SOPs, there is nothing to worry about.</li> </ul>
Nonprofit Organizations	Implementing NGO	<ul style="list-style-type: none"> <li>• More open to exploring other professions that could improve community welfare and does not pressure people to become tappers.</li> <li>• Tends to see that all aspects of the VC must be balanced (environmentally, socio-economically, and institutionally).</li> </ul>
	Inter-governmental Organization (Funding Agency)	<ul style="list-style-type: none"> <li>• Support for the pine resin VC program was approved in part because of its potential to increase women's involvement. Their support is not limited to the pine resin VC but also extends to areas like literacy improvement.</li> </ul>
Local People	Village residents	Varies with detailed explanation in section 4.4.2
Tappers	Local tapper	As a local, questions why outside tappers earn income in their village through tapping, which leads to personal interest in

		becoming a tapper and strongly encourages others to follow the same path.
	Outside tapper	Engages in tapping purely out of economic necessity and is capable of doing the work.
Business Ventures	Pine resin company	View exclusive cooperation in pine resin tapping within FFG's social forestry area as a potential for stability in their pine resin business, but they still do not feel fully secure about long-term partnership guarantees.
Forest Farmer Organization	Community FFG	The leaders of the group see this as a positive opportunity to improve both the members' and the community's economy. However, at present, they are still too focused on the pine resin VC and are not yet able to manage it independently, as the FFG is still very new and the leadership has not fully utilized its available capacities. Meanwhile, the members have little to no involvement, so their perception differs from that of the leaders and is closer to that of ordinary village residents as local people.

#### 4.4.2 Community perception

Four main themes emerged from the FGDs regarding local people's perception, as the local community, related to their current condition and pine resin production: current livelihood priorities and aspirations, barriers to participation in the pine resin VC, concerns, and perceived benefits. These are summarized in Figure 11.



**Figure 12.** Summary of community's perception on the upstream pine resin VC

- 1) Current Livelihood Priorities and Aspirations
  - a. Livelihood diversities

### *Farming-related as the main livelihood*

Most of the responses about current needs were mainly related to farming. Based on the three FGDs, the most frequently mentioned needs were related to access to better seedlings, fertilizers, and other farming support, with 41% of participants identifying these as their current needs. Most of the seeds they currently use are local seeds, but these do not produce good results. For example, some types of plants like cinnamon are seen as less promising because they take too long to harvest, which creates economic challenges during the waiting period.

Besides seedlings, good quality fertilizer is also a key need, especially for paddy rice. Some participants mentioned that there has been no assistance related to fertilizer so far. Many farmers end up choosing cheaper fertilizers that are subsidized by the government. However, they need to apply for the subsidy in advance, and many of them are not confident or familiar with the process.

In addition to seedlings and fertilizer, they also mentioned the need for tools, land, capital, and training to support their farming activities. This includes both basic farming tools for beginners and more advanced equipment like grass cutters and plowing tools. Beyond tools and equipment, they also expressed the need for agriculture-related training, including how to negotiate prices with middlemen.

*“We have land, but nothing to plant. And if we do plant, of course we need fertilizer. That’s it. We have land, but we need seeds. If the government gives seeds, they also need to provide fertilizer.”*

Participant 2, FGD 2.

### *Other livelihood activities*

People whose jobs were unrelated to farming, or who sought a side job outside of it, expressed little to no interest in working with pine resin. There were 9 types of sectors other than general farming and pine resin harvesting mentioned throughout 3 FGDs, including small businesses or household-level industries that could grow with better access to machines, equipment, or capital. For example, the women involved in home-based cassava cracker production mentioned the need for cassava grinders and cracker molding machines to improve their production. The most mentioned was sewing, which was mentioned 5 times throughout the FGDs, as they hoped to start their own sewing businesses at home. The other professions include sand mining, motorcycle repair workshop, small trading, and hospitality.

#### b. Perceived value of pine resin as a job

Throughout the entire discussion, none of the participants expressed a clear interest in becoming pine resin tappers for their main job, even after discussing the potential benefits. The women agreed that it is not feasible for them, and they prefer jobs that require less effort but offer higher pay. They have heard about pine tapping, especially

for the past ten years, but remain uninterested. Most of the men expressed a similar point of view. They have met and seen outside tappers at work but are still uninterested and feel physically incapable. Only one participant mentioned having experience as a taper but had to stop due to physical strain. However, there were a few participants who expressed skepticism about the entire pine resin activity in their area, despite the information at the beginning of the session about the potential benefits.

*“People here just are not interested in collecting the resin. [...] We do not even know how much profit there is. We do not know what the benefits are. So honestly, the people here do not have any concerns. They are just not involved in the pine resin collection. That is why they picked people from Java, they are willing to do it. [...] Seems like it (No matter the profit, people here are still uninterested). The system is not clear. If you ask people one by one, no one here understands it. [...] So, it is difficult.”*

Participant 8, FGD 2.

Based on their comments, none of the participants had any objections to the outside tappers. They view outside tappers as more diligent and used to climbing hills. There are no feelings of anger or resentment toward outside tappers, as they view them as fellow human beings seeking a job. The younger participants had concerns about non-local people might take over their land. Despite these worries, the younger people still expressed no desire to become tappers themselves.

## 2) Barriers to participation in the pine resin VC

### a. Structural barriers

The difficulty of accessing the pine forest was one of the main barriers most mentioned by participants, which was also confirmed during a site visit to the pine forest. This was mentioned at least six times throughout the whole FGDs. The road to the pine forest is covered with bushes that need to be cut down while walking up to where the pine trees grow. This is different from the access to forest farming areas, which are regularly cleared and safer for anyone, even those with less skill in cutting bushes to pass through.

Besides poor road access, steep terrain was frequently mentioned as a barrier, along with the risks that come with it. One participant said that as paddy farmers, they usually work on flat land like rice fields, not on slopes like in the pine forest. Another mentioned that the path is harder because thick undergrowth must be cleared. Most participants agreed that the pine forest terrain is more difficult, so they are not very interested in working as tappers themselves. One participant emphasized their fear of going to the pine forest during strong wind because of the risk of trees falling. However, one participant agreed that if the road was cleared and built properly, activities related to the pine resin VC might become more interesting.

Besides these physical barriers, limited access to specific tools and equipment for tapping was also a problem. One participant mentioned that from a logistics point of view,

pine resin tapping needs special tools and supplies, and if these were provided, more people might be interested in joining.

#### b. Capacity barriers

One of the reasons why most people are not really interested in pine resin activities is because they do not really know how to do it.

*“The issue is knowledge. Because the local people here do not have the knowledge.”*

Participant 7, FGD 3.

Not only lack of knowledge related to pine tapping activities, knowledge in general was also mentioned as the challenge when it comes to the human resources in the area, such as for farming.

*“Maybe it is knowledge. About farming, applying for aid, the processes needed to improve farming or plantations. Right now, people only know the traditional ways.”*

Participant 8, FGD 1.

### 3) Concerns

#### a. Concerns from psychological perceptions

When asked about concerns on being involved in pine resin activities, especially as pine resin tappers, concerns about pests and wild animals were mentioned at least five times throughout the FGDs. The animals mentioned included monkeys, bees, snakes, bears, and wild boars. Incidents related to these animals have never happened, except for being stung by bees. A few participants mentioned how it usually happens once every few years.

Other than that, natural disasters and weather were also mentioned, with at least five times mentioned throughout the FGDs. These included mostly landslides and volcanic eruptions. It was also mentioned that some parts of the road around the forests used to be good but collapsed after the landslides. It was also mentioned that lots of landslides usually happen when it rains too often.

*“Another issue is the volcano eruption. There was an eruption this past week.”*

Participant 9, FGD 1

*“Almost every day, really.”*

Participant 1, FGD 1.

#### b. Ecological and Governance Concerns

During FGD 3, the ecological concerns on the effect of pine tapping on the trees and the other living beings around were discussed the most and mentioned how outsiders manage this.

*“Because from what I have seen and experienced, I have checked their work. They use acid. And the way they tap also damages deep into the tree to extract the resin. So, the percentage of trees dying is higher. One day someone could be walking through the forest, and a branch might suddenly snap. [...] If outsiders manage the resin, they might not care about the environment here. This is not their home.”*

Participant 7, FGD 3.

Additionally, another participant also mentioned their concerns with the pine trees might die if tapped excessively.

*“If we over-tap the pine trees, the resin will be depleted, and the trees will die. So, what comes next?”*

Participant 2, FGD 3.

#### 4) Perceived Benefits

##### a. Expectations for Pine Tapping Training

When discussing the expected benefits if there were to be a related program provided, training related to pine tapping only mentioned twice from the whole FGD, with one of them mentioning the training would be not for herself.

*“If there is a (pine tapping) training for the community, that is fine. [...] I don’t know yet (why it is perceived as needed).”*

Participant 6, FGD 3.

The other person who mentioned being interested in pine resin training also emphasized that it would not necessarily be for himself.

*“I am interested, but lazy (with pine resin training). Because there are other things that are more interesting. Mostly personal needs. But if there’s training in pine resin, that would be good too because there are a lot of unemployed people in this village. And with more unemployed people, there would be more crime. So, it would help to expand job opportunities.”*

Participant 2, FGD 3.

##### b. Expectations Beyond Pine Resin Production

“Training” was mentioned fourteen times throughout the FGDs. However, most of these mentions were not related to pine tapping. The sectors in which training was desired included farming-related, sewing, hospitality, and money management for small businesses. Participants also expressed expectations of receiving benefits such as capital and equipment related to mentioned trainings, each of which was mentioned four times.

## 4.5 Optimal Alternative Scenario for Upstream VC

### 4.5.1 Alternative Scenarios

The components identified from the environmental aspect that require improvement are the tree trunk tapping method using a tap knife and the use of chemical stimulants. The existing methods for both components are not only harmful to the long-term health of the trees but are also a concern raised by the local community (López-Álvarez et al., 2023; Cunningham, 2012). The recommended improvement is to apply a measured tapping thickness using a borer without chemical stimulants (Du et al., 2021).

Furthermore, the components identified from the institutional aspect that require improvement are related to the FFG documents and the clarity of stakeholder involvement in existing regulations. These components were selected based on the MoEF regulations on Social Forestry, which specify the documents that must be completed by community forestry groups but are still missing in the current FFG, as shown in Table 5 (MoEF, 2016). The existing governance lacks a Management Plan, Articles of Association, and detailed premium distribution documents. Moreover, greater clarity regarding the involvement of both the community and other stakeholders is also necessary. Therefore, institutional improvement should focus on addressing these missing documents and enhancing the transparency of stakeholder roles.

Lastly, the components identified from the socio-economic aspect that require improvement are pine resin management within the social forestry area, FFG operability, and tapper welfare. The current conditions of these components still indicate a lack of FFG accountability and underutilization of the socio-economic potential associated with being a community forestry decree holder. In addition, the welfare of tappers remains insufficiently addressed. Improvements for these components include utilizing the full range of potential benefits identified in Section 4.3.2, such as establishing a new farmer group business unit to generate additional income. Moreover, tapper welfare can be enhanced through more training opportunities and the provision of health insurance.

Details of the selected improvement components mentioned above, and their corresponding narratives are provided in Table K, L, and M in the Appendix. Based on these selected components and their associated improvement narratives, four alternative scenarios for the pine resin VC were developed, with the arrangement of improvements applied according to the instructions in Table 3, with further details also provided in the Appendix. The VC maps for the BaU, Environmental Improvement, Eco-Governance Improvement, and Comprehensive Improvement scenarios are presented in Figures 13, 14, 15, and 16, respectively. Moreover, the CBA calculations for Environmental-Improvement and Eco-Governance scenarios and Comprehensive scenarios are provided in Table N and O respectively in the Appendix.

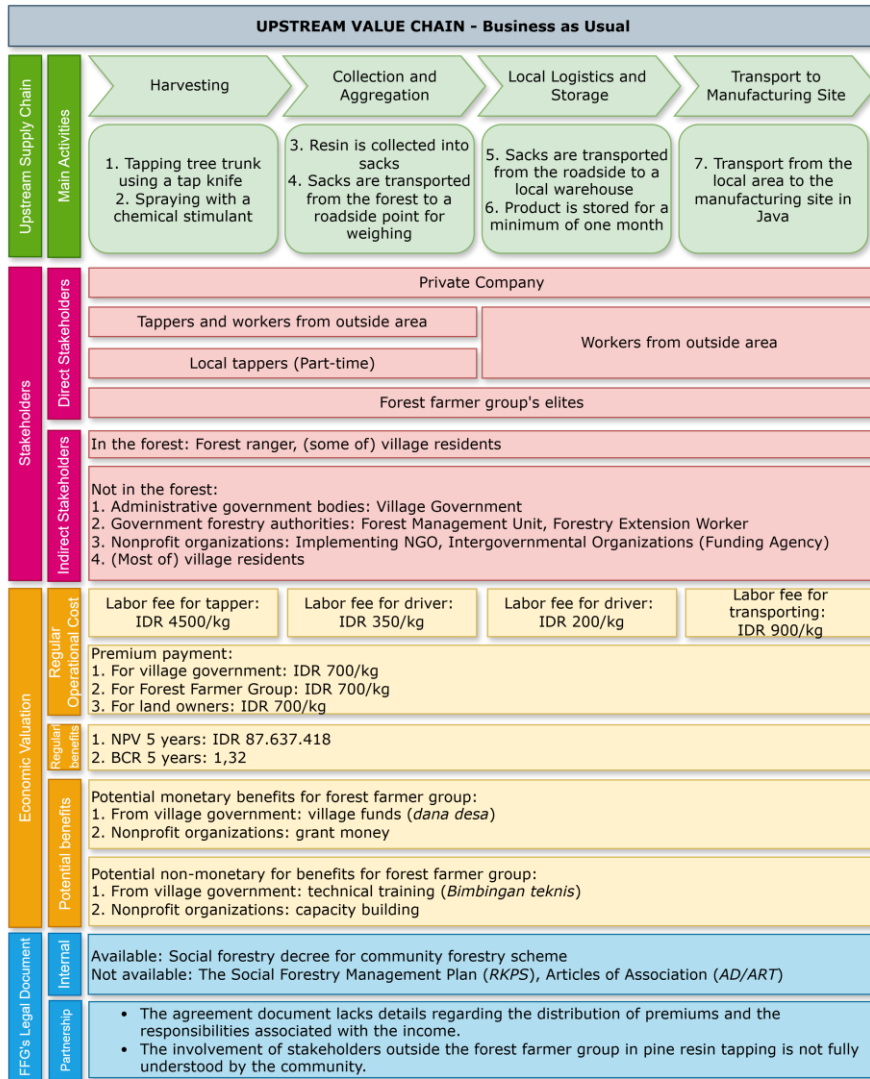


Figure 13. Upstream VC of BaU Scenario

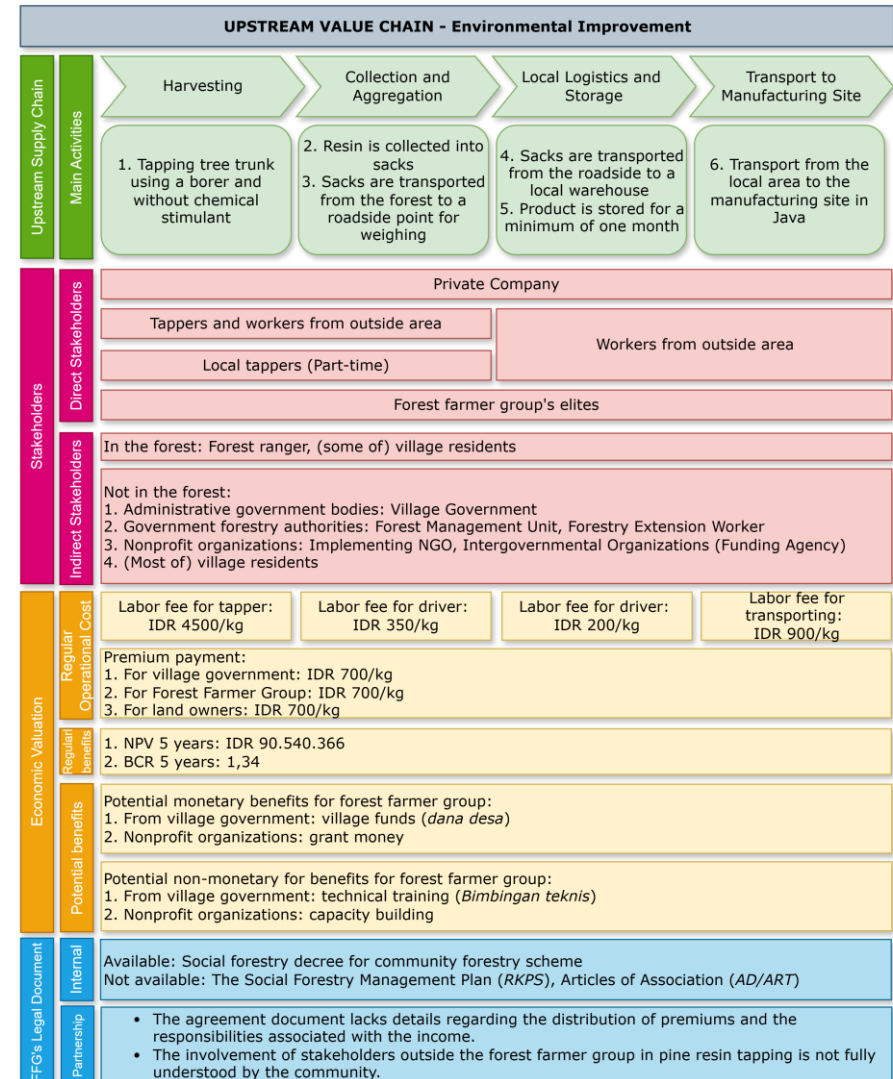


Figure 14 Upstream VC of Environmental Improvement Scenario

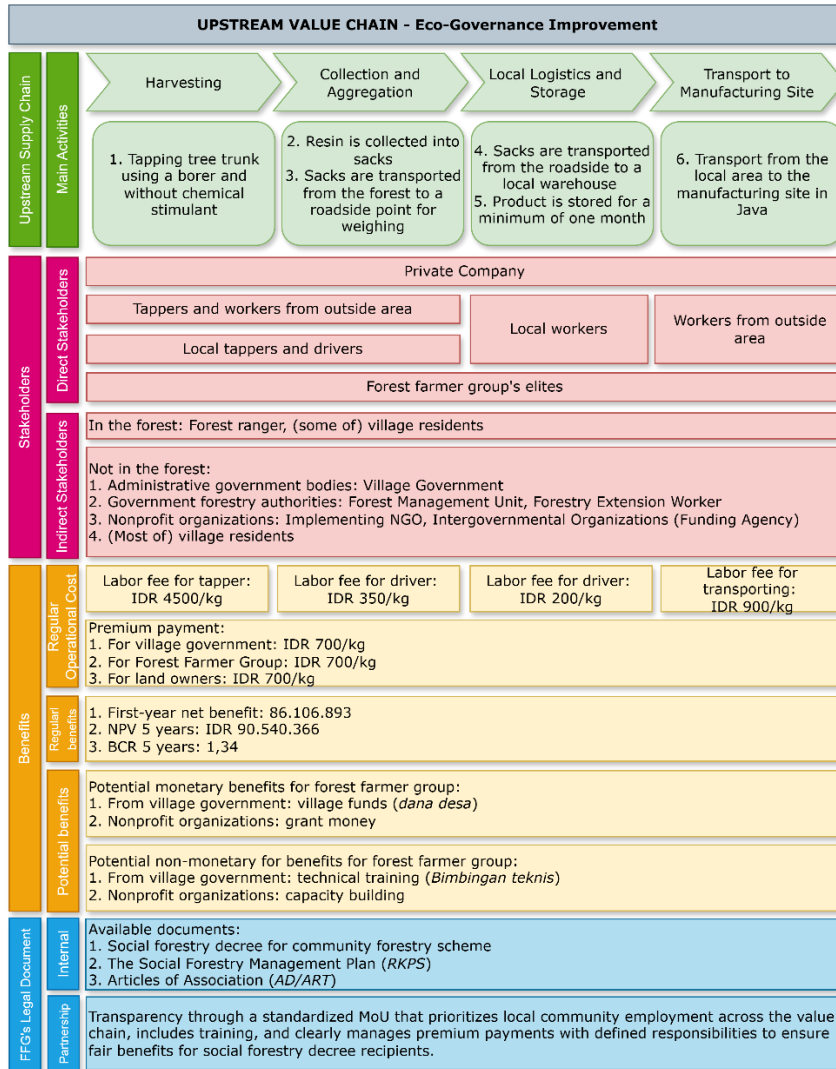


Figure 15. Upstream VC of Eco-Governance Improvement Scenario

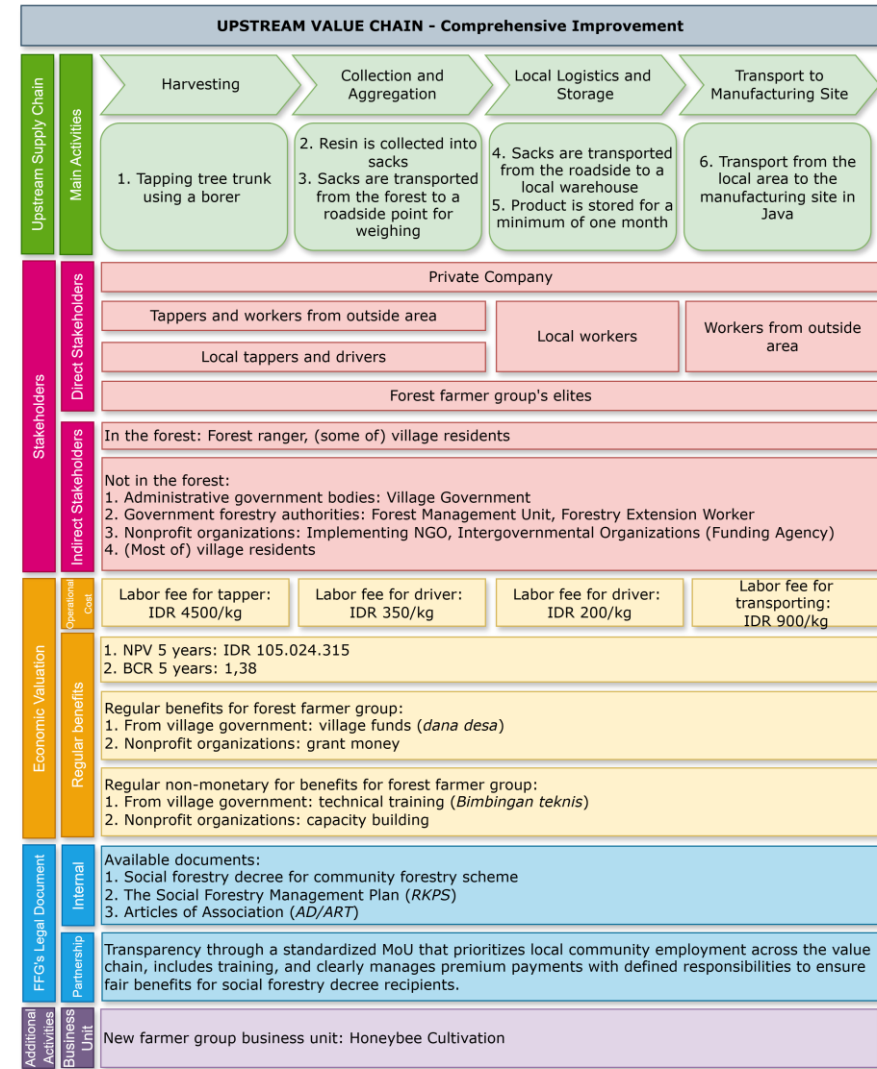
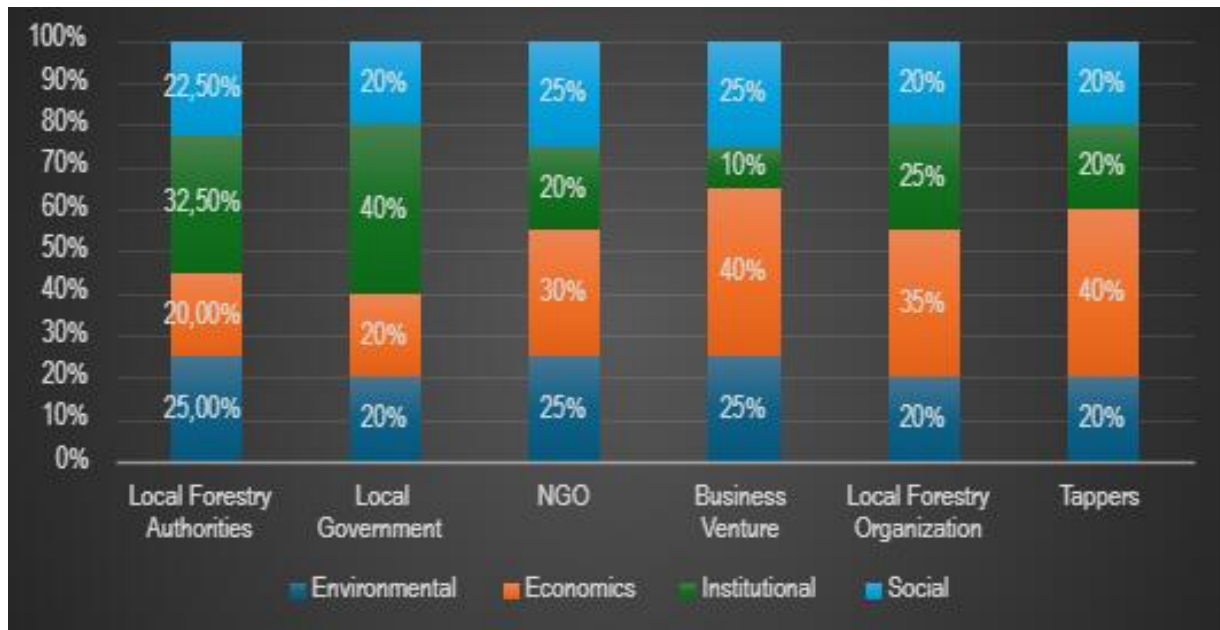


Figure 16. Upstream VC of Comprehensive Improvement Scenario

#### 4.5.2 Optimal alternative scenario based on the scenarios' performance

The four sustainability aspects were used as the main criteria to assess the alternative scenarios. Those criteria were assigned with different weights based on the stakeholders' perception of importance as shown in Figure 17. The highest average weight is for the economic criterion, while the weights of the other criteria are relatively close to each other.



**Figure 17.** Weights for each criterion by the stakeholders

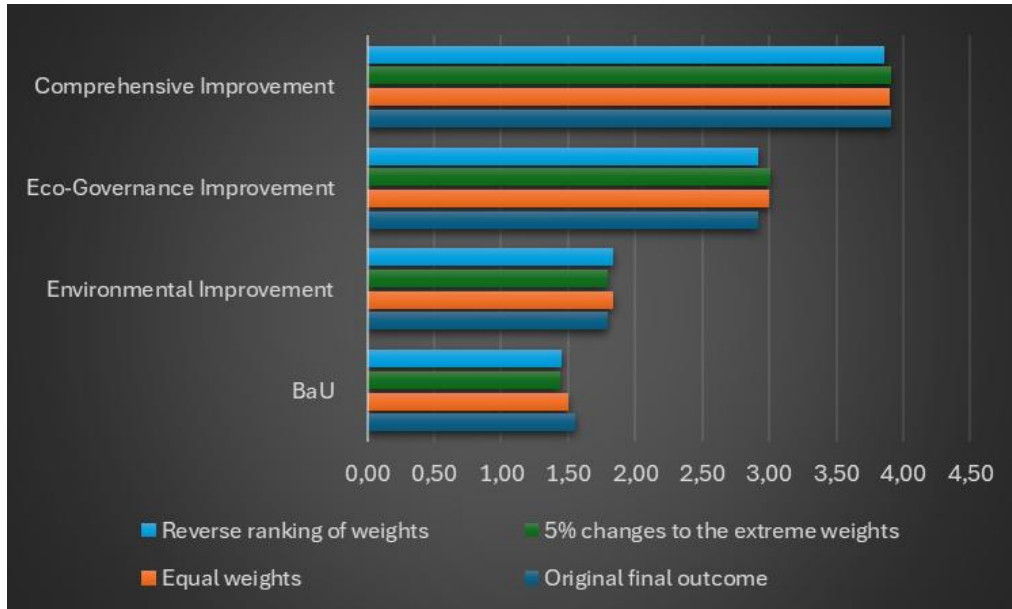
The detailed assigned scores for all criteria and sub-criteria across the four alternative scenarios are presented in Table P in the Appendix. After combining the results of the criteria weights with the performance of each sub-criterion in every scenario, Table 11 presents the results of the optimal alternative scenario for the upstream VC of pine resin production in Agam. The results indicate that the Comprehensive Improvement scenario is the most optimal to implement in Agam, with a final score of 3.91. This score is one point higher than the second-highest scenario and 2.36 points higher than the lowest-scoring scenario.

**Table 11.** Overall performance of the scenarios

Criteria	Weight (%)	Alternative Scenarios Average Overall Performance			
		BaU	Environmental Improvement	Eco-Governance Improvement	Comprehensive Improvement
Environmental	22,50%	0,23	0,68	0,68	0,68
Social	22,08%	0,22	0,22	0,66	0,94
Economic	30,83%	0,62	0,41	0,51	1,23
Institutional	24,58%	0,49	0,49	1,07	1,07
Overall Total		1,55	1,80	2,92	3,91
Preference Rank		4	3	2	1

### 4.5.3 Sensitivity Analysis

The sensitivity analysis results shown in Figure 18 indicate that the MCA results were robust, as the ranking order remained unchanged even after adjusting the weights of the criteria. This demonstrates that the performance outcomes leading to the final results were stable and insensitive to changes in the weight assignments.



**Figure 18.** Sensitivity analysis for the overall performance

## Chapter 5. Discussion

This study aimed to provide an optimal alternative scenario for transforming pine resin VC toward sustainability within the context of community forestry. Specifically, at the lower level of governance, which in this case is a village in Agam Regency. The results are intended to offer a decision-making approach through an integrated framework to guide the investigation of potential improvements. In this discussion chapter, the implications of this study for community forestry in Agam, community participation, and broader implications are discussed. The effectiveness of the proposed approach as a decision-making tool is also examined. Furthermore, this chapter discusses the limitations and uncertainties identified in the study.

### 5.1 Evaluating the Pine Resin VC within Community Forestry in Agam

The current VC is unsustainable due to institutional dependency and limited community engagement. While the institutional framework defines the foundation of community forestry, its weaknesses cascade into environmental and socio-economic dimensions. The findings reveal that although the Community Forestry permit has provided access and income opportunities, the existing VC remains institutionally immature, environmentally vulnerable, and socially unequal. These outcomes reflect the broader challenges of Indonesia's social forestry implementation, where empowerment objectives often remain aspirational due to structural dependency on external actors (Fisher et al.,

2018; Rakatama & Pandit, 2020; Purnomo et al., 2022). Together, these dimensions reveal that achieving sustainability in the pine resin VC requires addressing both structural governance constraints and local participation barriers.

### 5.1.1 Institutional Dimension

The comparative policy results revealed that the establishment and functioning of the FFG LS were heavily influenced by external intermediaries, particularly the private company and supporting NGOs. The FFG lacks independence from the start as the group's formation and social forestry application were initiated by the private company, primarily with the intention of securing a supply for its own pine resin production through a partnership with the FFG. While such facilitation accelerated permit acquisition and initial operations, it created a dependency that limited the FFG's managerial autonomy and decision-making power. Moreover, the partnership with the private company results in an exclusive pine resin supply to the company, which prevents the FFG from participating in more open market opportunities. This condition exemplifies the "top-down facilitation trap," where community organizations become implementers rather than leaders of social forestry (Maryudi, 2012).

But without the help of an external party, such as the private company, it would not have been guaranteed that the local people would have been able to both form the FFG and obtain the Community Forestry permit. This is especially true when compared to the study by Fisher et al. (2018), which shows that obtaining social forestry permits remains a challenging process for local communities, often necessitating assistance from external actors to complete the required documentation. However, it is important for the village government, as the institutional body with the strongest connection to all stakeholders, to exercise greater caution when granting permission for external parties to engage with local groups. The government is expected to act as a protector of the FFG as "Subjects" in the VC, which remains vulnerable due to limited knowledge and capacity. This role is essential to prevent overexploitation and potential abuse of community forestry resources. This is especially true for the village government classification as the "Context Setters," where, despite their limited direct engagement in the regular activities of the VC under community forestry, their power to allow external stakeholders to be involved in the local organization could pose a risk to the community if not managed carefully (Reed et al., 2009).

A study by Purnomo et al. (2022) shows that if outsiders wish to access the forest area, a permit must be obtained through the elites in the area, such as village government and leaders of the FFG, which could create opportunities for bribery. While no clear evidence of bribery was found in this study, establishing a clear and transparent partnership through a partnership agreement document, as suggested in this study, would help prevent it. This is particularly important to avoid the illegal transfer of management rights in later years (Purnomo et al., 2022). The precaution is especially important considering that during the weight assignment for the criteria in MCA by the private company, they assigned institutional aspect (10%) as far less important than the economic

aspect (40%), even though the overall weight of the institutional aspect across all stakeholders averaged 24.58% out of four aspects. When arranging a partnership agreement document, it is important for both the private company and the FFG to pay attention to the contract length, ensure fair compensation for laborers, and consider benefit-sharing (Permadi et al., 2018). The latter is particularly important in this case, as the current partnership is based on paying a premium per kilogram of pine sap harvested. Establishing a transparent and clear partnership contract is therefore one of the key steps of managing the pine resin company as the “Key Player” in the pine resin VC, and to maximize their support in leveraging FFG as community forestry.

### 5.1.2 Environmental and Socio-Economic Dimensions

This study revealed that the environmental aspect of the pine resin harvesting practices in Agam is unsustainable and does not fully follow the official SOPs from MoEF (2020). Although some practices follow the SOP from MoEF, there are areas where the company in this study does not fully follow the use of nitric acid for stimulant spraying. The weak enforcement to follow the official SOPs and limited technical guidance from the officials have led to inconsistent tapping techniques and chemical stimulant use. Many tappers in Agam still use a mixture of sulfuric and nitric acid, known as the Mazek or Rill method (Dkhar and Johar, 2024). While the use of this stimulant is known to increase sap production, it is also recognized as a method that causes more damage to the trees than other methods (Arifin et al., 2009; Cunningham, 2012). These non-compliant practices and the limited field supervision increase the risk of cumulative wounds and declining tree health over time. This finding aligns with Zakiyah et al. (2025), who also found that resin production practices in the other are of Indonesia is still far from advanced. Nevertheless, the environmental improvement recommendations from this study are supported by Rachmalia et al. (2022), which suggested the use of borers in order to reduce tree damage while maintaining productivity. While the adoption of technology could improve environmental performance, their adoption depends on financial feasibility, which is explored in the following economic dimension.

Economically, pine resin tapping activities provide potential for the livelihood of the community in Agam. The BaU scenario yields a positive NPV in 5 years (IDR 87.637.418) and a favorable BCR (1,32) with the first-year net benefit of IDR 89.280.000. While the Environmental Improvement scenario yields a slightly higher NPV in 5 years (90.540.366) and slightly more favorable BCR (1,34) because of reduced operational cost as the consequence of stopping using chemical stimulant, this scenario has slightly lower first-year net benefit of IDR 86.106.893. The lower net benefit stems from the cost of more investment in technical equipment in the first-year. While the additional capital cost is relatively low given the higher net profit in the following years, the calculation is based on the current number of tappers. Additional investment would be required if more tappers were hired, as each individual needs their own piece of equipment. This indicates that environmentally friendly techniques require more investment in the beginning but would

give higher benefits in the long run. The lower economic value when environmental practices are applied is a trade-off between profit and environmental sustainability. Without a shared commitment from the company to apply the Environmental Improvement scenario, achieving environmental sustainability would not be easy. This is where the Eco-Governance Improvement scenario plays a role in managing the private company that wants to partner with FFG to engage in pine resin activities.

The MCA results further illustrate the need to implement the Eco-Governance Improvement scenario (in addition to the Environmental Improvement scenario) to enhance the BaU scenario. The overall scores for the BaU (1,55) and Environmental Improvement (1,80) scenarios are relatively close. Although the environmental aspect carries a weight of 22,5%, its influence is not dominant compared to the other aspects. This suggests that even with environmental improvements, the performance of pine resin VC practices remains far from ideal in terms of overall sustainability. However, when regulatory improvements are applied through the Eco-Governance Improvement scenario, the overall score rises by approximately one point to 2,92, resulting in a more substantial enhancement of the VC's sustainability performance. These results highlight the need for the Eco-Governance Improvement scenario, where partnership agreement formally requires environmentally responsible practices, supported by more transparent and complete documents that allow stakeholders to be fairly involved and clarifies responsibilities among them.

However, the overall sustainability of pine resin VC would increase further with the implementation of socio-economic improvements through the Comprehensive Improvement scenario. The MCA results show that this scenario achieves the highest overall score of 3,91. With the addition of a business group unit and further training for human capital, the NPV over 5 years (105.024.315) would also increase. Although the Comprehensive Improvement scenario scores the highest among the other scenarios, this study does not suggest immediate implementation. Rather, the steady progression from the BaU scenario to the Comprehensive Improvement scenario provides stakeholders with options to improve the status quo step by step. The steady progression is considering the available capacity and feasibility of the involved parties, while considering trade-offs, comparability, compensability, and prioritization to achieve equitable sustainability (Lindfors, 2021). Additionally, it is possible to focus on just one aspect of the improvements, with some level of compensation for the others, if the community decides to do so.

### 5.1.3 Community Participation and Social Inclusion

Compared to what indirect stakeholders (local government, nonprofit organizations, and private company) perceive as helpful for the local economy through job opportunities in the pine resin VC, the community's perspective shows different reality. Involving local communities, at least in its current state, may not be suitable because they appear to be uninterested or lack the immediate capacity to participate. This indicates a

gap between the plans developed by external FFG stakeholders and the realities on the ground, caused by a failure to understand the local context. In this situation, the local community should be given the dignity and autonomy to decide for themselves whether they want to pursue the job opportunities offered (Macdonald, 2017). This gap also stems from a fundamental misunderstanding from external FFG on what they perceive as involving local communities in their project, which in this case is pine resin production VC.

While many external FFG involved in community forestry claim that their partnership programs will help develop the community, their definition of community participation may not truly reflect actual involvement. Community participation exists on a spectrum, ranging from weak to strong, depending on the level of engagement. Currently, communities are often merely informed of decisions, which is a weak form of engagement (Degnet et al., 2022). In contrast, strong participation requires active involvement in planning, implementation, and monitoring (Mbeche et al., 2021). Effective natural resource management, which in this case is pine resin, requires substantial user involvement, either through direct decision-making or legitimate representation, meaning that offering a job only is not sufficient (Timilsina & Timilsina, 2024). Therefore, to bridge this gap and to spark genuine interest from the local community, offering training and capacity building through knowledge transfer and information sharing would be essential for building trust among the local people to actively involved in the VC of pine resin production and reducing conflict (Apipoonyanon et al., 2020). This bridge could be achieved by external FFG stakeholders who want to implement programs for the local community, such as private companies and NGOs, through the Socio-Economic Improvement proposed in this study.

As the local people who are members of FFG currently do not show clear interest in participating in the pine resin production VC, the transformation of this VC toward sustainability should still consider alternative ways to involve the local community in the strong community participation manner. A clear partnership agreement, with a more transparent allocation of premiums for FFG from pine resin production (as proposed by the Eco-Governance Improvement scenario), would empower the FFG with a defined financial modality. This funding could then be channelled to enhance community participation through other Group Business Units (as proposed by the Comprehensive Improvement scenario), which would be developed based on the interests and most promising capacities of the local community. This stage is where external FFG stakeholders could play a significant role in providing programs that improve the capacity, knowledge, and skills of the local community based on their actual aspirations. As a result, both the transformation of pine resin production VC and the community forestry goal of improving the livelihoods of local communities could still be achieved while respecting their autonomy and dignity.

## 5.2 A participatory Framework for Sustainable Value Chain Transformation

In this study, MCA was employed as a participatory decision-making tool to address the wicked problem of VC transformation for sustainable pine resin production within the context of community forestry, where multidimensional aspects contribute to the complexity (Muñoz et al., 2016). This was done by integrating institutional, environmental, social, and economic aspects. These sustainability aspects were further weighted as criteria for assessing the scenarios, incorporating stakeholder perceptions of the relative importance of each aspect in the pine resin VC. This approach enables stakeholder involvement in the decision-making process while revealing potential trade-offs among their different objectives in a transparent manner (Macharis et al., 2012). Moreover, the preceding analyses conducted before applying MCA serve as a ‘diagnosis’ of the status quo. This allows for the development of tailored improvement scenarios to identify the optimal scenario, which may vary for each community forestry case.

The innovation and adaptation of the MCA framework in this study are essential to respond to the need for contextualized decision-making tools that accommodate the unique characteristics found in developing countries (Ananda and Herath, 2009). This is especially important in cases as critical as those involving NTFPs, where tailoring criteria and indicators used are part of the effort to ensure that the framework captured the specific sustainability dimensions of pine resin production VC. Unlike the existing community forestry-related frameworks in Indonesia, the framework developed in this study serves both as a diagnostic tool and as a prescriptive guide. Existing frameworks, for instance ‘The FSC National Forest Stewardship Standard of Indonesia’ by FSC, mainly focus on monitoring and evaluation, which emphasize the diagnostic step alone (FSC, 2020). In contrast, the final results of the framework of this study function as a ‘prescription’ derived from the diagnoses made in earlier analyses. Furthermore, the framework of this study highlights the importance of incorporating community voices to remain aligned with the core purpose of community forestry.

Although MCA has been widely applied to address multidimensional and deeply rooted problems in various sectors, its use in developing VC transformation strategies for NTFPs within the context of community forestry is almost nonexistent virtually to say the least. This is especially true when compared to its more common application in timber-related issues. Moreover, a study by Kpadé et al. (2024) identified a significant gap in the application of MCA to forest management in developing countries, despite its proven effectiveness in other contexts. This gap is likely due to limited resources and technological infrastructure. As a result, it is important to adapt MCA frameworks to the specific context of each case, particularly given the complex aspects of sustainability in forestry (Ananda and Herath, 2009).

### 5.3 Broader Implications

Beyond the Agam case, the framework developed in this study could be applied to other community forestry cases in Indonesia, with appropriate adaptations to account for differences across regions, schemes, and time periods (Rakatama and Pandit, 2020; Fisher et al., 2018). As such, the framework serves as a flexible tool to accommodate local variability. By recognizing community perspectives in decision-making, the framework aligns with Indonesia's primary community forestry goals to empower local communities while conserving the forest and maintaining its environmental function (Pambudi, 2020; MoEF, 2021).

Moreover, as briefly discussed in the previous section, the applicability of this framework extends beyond Indonesia to other tropical developing countries, where the context resembles Indonesian community forestry. It would be particularly relevant in cases where forests are managed or owned by communities that are heavily reliant on forest resources (Kpadé et al., 2024; Maraseni et al., 2019). Although contextual differences would require some adjustments, smallholder NTFP-based communities across developing countries often face similar complex and interconnected sustainability challenges as examined in this study (Ananda and Herath, 2009; Thorpe, 2018). As the participatory MCA-based framework developed here can be applied beyond Indonesia, it not only supports local decision-making but also contributes to the achievement of the initial global social forestry goals, which since the 1970s have aimed to integrate local communities, governments, and the private sector (van Noordwijk, 2020).

### 5.4 Uncertainty

The results of this study come with some uncertainties, which result in the findings not fully capturing reality. Firstly, in the FGDs, some participants may not have been able to fully express themselves, as they knew each other personally. Moreover, since there was a mix of participants from different age groups and genders, there might have been psychological barriers, such as a lack of confidence or shyness, which could have made them hesitant to express themselves. Therefore, there is a possibility that they were careful about what to say to avoid potential consequences after the discussion (Adekola & Olumati, 2023).

Secondly, the uncertainty comes from selection bias in the sampling of stakeholders, as most of the analyses were done in a qualitative manner. The purposive sampling for interviews done in this study relies on the researcher's subjective judgment of who can provide the best information, which could affect the internal validity of the information provided by the interviewee (Vasileiou et al., 2018). As for the FGDs, non-probability sampling was used by the researcher in selecting participants, meaning that not all members of the local community had an equal chance of participating in this study (Adekola & Olumati, 2023). The other noteworthy uncertainty comes from language barrier, as the local people sometimes mix the conversation with Indonesian, Malay, and the local

dialect. However, it was addressed by rechecking with the interviewee whenever there was doubt about fully understanding what they meant.

## 5.5 Limitations

### *Sustainable development concept*

The three aspects of environmental, social, and economic, supported by the institutional aspect of sustainable development concept used in this study, possess risks of simplification as it was adapted based on the needs of the location and timeframe of this study, both within each aspect and in how they interact. For instance, the environmental aspect of this study mostly focused on biodiversity within the limited understanding of pine forests and the generalization of avoiding negative environmental impacts. In future studies adapting the framework of this study, it would be worth considering the inclusion of ecosystem functions, water resources, and soil health for environmental sustainability assessment (FSC, 2020). Moreover, the macro-level indicators used in this study may be too broad for decision-making at the VC level. Therefore, the specific biophysical structure of society should be considered in future studies, if possible (von Geibler et al., 2010).

For the social aspect of this study, particularly regarding the local community's perceptions, data collection and analysis were conducted by treating the 'community' as a single entity, due to the time constraints of the study. For future adaptations of the framework from this study, it would be worth considering unpacking the social aspect through social stratification, such as gender, caste, and education, which are the most influential factors in the local community's participation in community forestry management (Timilsina & Timilsina, 2024). As for the economic aspects, some cost and benefit components may differ slightly from actual values. The simplification of calculation also did not consider the long-term effect of 35 years' timeframe across different scenarios, which is the duration of the granted Community Forestry for FFG LS. Moreover, the benefit-sharing and distribution were not thoroughly considered, even though they are crucial to ensuring the effectiveness of the improvement (Rakatama & Pandit, 2020). Therefore, future studies should take these aspects into account.

### *MCA: Simplified method*

There is significant flexibility in tailoring the MCA method, including the use of continuous methods with programming languages, full aggregation methods, and partial aggregation methods (Dean, 2022). However, the approach implemented in this study was a simplified one, as the more complex methods mentioned before this would require additional data that involve the Analytical Hierarchy Process (AHP) and GIS, which are often not available or accessible in developing countries (Kpadé et al., 2024). The simplified method of MCA, as implemented in this study, is more suitable in situations where the stakeholders involved are not familiar with complex equation systems, and where flexibility and adaptability from the simplified method would result in easier

replication for other cases of VC transformation under the community forestry context, to follow the framework from this study (Dean, 2022). Therefore, in situations where data is available and technological infrastructure is not a problem, it is worth considering applying the more complex method of MCA.

#### *MCA: Scenario making*

For a more collaborative scenario development process, involving stakeholders in detailing the scenarios could lead to a more inclusive approach that considers perspectives that may otherwise be missed, possibilities that are often not explored, and issues that tend to be overlooked. This is especially important in cases where relying on a single analyst or the data obtained may not capture the full reality (Ananda & Herath, 2009; Dean, 2022). Due to limited time for fieldwork, it was not possible to involve stakeholders in the scenario creation process, as this step was intended to be completed last, after the analyses from the preceding methods. Nevertheless, since the MCA methods used in this study applied an iterative process that incorporated the perceptions of local people and stakeholders, it helped minimize the risk of overlooking key issues and ensured that stakeholder perspectives were reflected.

For future study, it is worth considering involving local communities in the context of community forestry to develop scenarios that have a lower potential for conflict. When involving stakeholders and local communities is possible, applying the backcasting method to create scenarios could be a good option, as it offers a normative desired future state and works backward with some comprehensive elements such as identifying actions, milestones, and strategies needed to be achieved within a certain time frame while involving stakeholders in the process (de Bruin et al., 2017).

#### *MCA: Subjective assignment of weight*

While MCA is intended to reduce subjectivity in decision-making, the assignment of weights to criteria inevitably reflects stakeholder preferences, which can vary across individuals and may change over time. Even when weights are assigned at the organizational level, it does not guarantee that all members will agree, as perception of each criterion's importance can differ from person to person (Muñoz et al., 2016). Moreover, the weights chosen by stakeholders could largely be arbitrary, which may lead to inconsistent decisions. Therefore, even conducting a sensitivity analysis to examine robustness may not resolve the issue of subjectivity as the vary results under different weight sets do not eliminate the need to eventually adopt one scenario. In such cases, employing ordinal or rank-based weighting methods for assigning weights can offer a more transparent and manageable alternative (Dean, 2022).

#### *Contextual differences of community forestry*

Study location may not accurately represent the whole community forestry in Indonesia and other developing countries (Rakatama & Pandit; Fisher et al., 2018).

Therefore, when applying the framework of this study to another location for NTFP VC under the community forestry context, it is important to consider the geographic and local conditions where these frameworks will be used (Magry et al., 2022)

## Chapter 6. Conclusion & Recommendations

### 6.1 Conclusion

The findings from this study indicate that the institutional, environmental, economic, and social aspects of the upstream pine resin VC in Padang Tarok Village, Agam, are generally immature and still require significant improvement to achieve sustainability and align with the goals of community forestry. Achieving optimal VC transformation for sustainable pine resin production will require improvements across all four sustainability aspects, along with active community participation throughout the implementation process.

**SRQ 1: How has the community in Agam obtained the Social Forestry permit, and how does this process compare to the formal procedures?**

There are three main steps in the application of social forestry carried out by FFG LS: the application for community forestry, the verification of administrative and technical requirements, and the issuance of the social forestry permit by MoEF. All these steps are quite similar to those outlined in the national-level regulations by the MoEF concerning 'Social Forestry' and align with the Community Forestry permit received by the FFG. It is noteworthy that most of these steps were assisted by a private company, which later became a partner in conducting pine resin production activities with FFG. However, supporting documents such as the Business Plan or Social Forestry Management Plan have not been officially approved, although pine resin production activity within the community forestry area has already begun. The pine resin production activity is carried out by the private company as FFG's partner, which was not selected through a formal selection process by FFG's members.

**SRQ 2: How is the existing upstream VC of pine resin in Agam, Indonesia, starting from sourcing in the forest to transporting to the manufacturing factory?**

The upstream VC process of crude pine resin production in Agam involves four main units, which are harvesting, collection and aggregation, local logistics and storage, and transport to the manufacturing site. The whole process of the upstream VC is considered traditional as the equipment used is manual or semi-manual, without the use of automation or advanced technologies. The pine resin production VC in Agam includes various groups of stakeholders, ranging from the national level down to the village level.

**SRQ 3: What are the benefits of social forestry?**

The monetary benefits from the existing pine resin production VC come from the harvested crude pine resin only. In the initial 5 years, the project shows an NPV of IDR 87.64

million and a BCR of 1.32, indicating that the benefits outweigh the costs during this period. The benefit is distributed through premium payments from the private company to the FFG, local people entitled to the land in the forest, and the village government. However, there are other potential sources of monetary and non-monetary benefits for the FFG that can be used either for the pine resin production VC or for other potential group business units under the FFG. The village government could offer village funds, technical training, and capacity building. There are also potential benefits from NGOs in the form of grant money and capacity building. All these potential benefits could be earned by going through some steps of application.

#### SRQ 4: How do the stakeholders perceive the existing pine resin VC? (Social aspect)

The perception of stakeholders, excluding the local community, generally sees the pine resin production VC within community forestry in a positive light. As for the local community, four main themes emerged from their perception. Firstly, their current livelihood priorities and aspirations focus on farming-related needs and other diverse livelihood types but show no clear interest in pine resin production for themselves. Moreover, the local community also expressed that the barriers to joining the VC include both structural and capacity-related challenges. Then, they have additional concerns regarding environmental and forest governance risks. Lastly, their perceived benefits from the VC lean more towards expectations beyond the pine resin production itself.

#### SRQ 5: What is the optimal alternative scenario for the VC transformation for sustainable pine resin production?

Based on the MCA results, the Comprehensive Improvement scenario has the highest score among the four alternative scenarios. This scenario includes improvements across four aspects of sustainability. However, this study does not suggest that it should be immediately prioritized for implementation. Rather, the steady progression from the BaU scenario to the Comprehensive Improvement scenario provides stakeholders with options to improve the status quo step by step, taking into account the available capacity and feasibility of the involved parties, while considering trade-offs, comparability, compensability, and prioritization to achieve equitable sustainability. Additionally, it is possible to focus on just one aspect of the improvements, with some level of compensation for the others, if the community decides to do so.

## 6.2 Recommendations

### 6.2.1 For the decision-makers, such as the leaders of FFG, government, NGOs, and private companies:

- a. Using the research framework presented in this study as guidance for making decisions related to the transformation of sustainable pine resin production VC, especially within the context of community forestry.
- b. Building trust and mutual understanding with the local community by creating a safe partnership through FFG, offering capacity sharing, responding to their training

requests, making connections through fair partnership agreements, and working together by learning from each other. In this process, external stakeholders learn to adapt to the socio-cultural context of the local community, while the local community learns how to maximize its potential for a better livelihood.

- c. To implement the alternative scenario proposed by this study gradually, starting with the Environmental Improvement scenario and eventually reaching the Comprehensive Improvement scenario, while recognizing that adopting all improvement scenarios as exactly may not be required, as innovation and adaptation to different implementation timelines and the evolving capacity of the local communities may be necessary.

#### 6.2.2 For further research, addressing the gaps and limitations from this study:

- a. Develop a more comprehensive concept of sustainable development to be embedded into the research framework, covering both more comprehensive adaptation for each aspect of sustainability and their interlinkages.
- b. For more precise scenario development, involving stakeholders would be ideal. The backcasting method is worth considering, as it offers a more comprehensive perspective.
- c. As MCA is a highly flexible method, it is worth considering the application of more advanced methods, such as the full aggregation method, and making adjustments in steps, such as using ordinal or rank-based weighting.
- d. When time allows, consider probability sampling for selecting participants for FGDs and interviews. Adding statistical analysis would strengthen the evidence's significance.

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## Appendix

### Supporting data of analyses and results

**Table A.** Lists of interviewed stakeholders with the purpose details

Type of stakeholders	Stakeholders	Number of Participants	Date of interview	Remarks
Administrative Government Bodies	Village Government ( <i>Nagari</i> )	5	13 April 2025	Interviewed the Nagari Secretary and neighborhood chiefs, primarily to understand the village and FFG's conditions and the history of pine forests and tapping in the area. Insights to the existing supply chain were also discussed.
		1	17 April 2025	Interviewed the Nagari Secretary to confirm the potential benefits the Nagari could offer to the FFG and to support stakeholder analysis.
Government forestry authorities	Forest Management Unit ( <i>Kesatuan Pengelola Hutan</i> )	1	12 April 2025	Conducted interviews to understand the historical context of pine forests and tapping, as well as to support stakeholder analysis.
	Forestry Extension Worker ( <i>Penyuluh Kehutanan</i> )	1	15 April 2025	The interview was conducted at once with both stakeholders to support stakeholder analysis and to gain a better understanding of the field conditions of pine forests, including insights into the existing supply chain.
	Forest Ranger ( <i>Polisi Hutan</i> )	1		
Nonprofit Organization	Implementing NGO	3	15 May 2025	Interview was conducted with the proposal writer, program manager, and program officer for stakeholder analysis.
	Inter-governmental Organization	1	15 April 2025	Interviewed the program officer for stakeholder analysis.

	/Funding Agency			
Tappers	Local Tapper	1	17 April 2025	Conducted interviews for stakeholder analysis and gaining insight into the supply chain.
	Outside Tapper	1	14 April 2025	
Business Ventures	Pine Resin Company	2	13 April 2025	Interviewed the operational director and a field worker directly in the field to understand the upstream supply chain.
		2	15 April 2025	
		2	1 May 2025	Interviewed the founder and operational director for stakeholder analysis and gathered information on the downstream supply chain.
Forest Farmer Organization	Community Forest Farmer Group ( <i>Kelompok Tani Hutan</i> )	1	14 April 2025	Interviewed the head of the FFG to understand the group's structure and current condition.
		2	17 April 2025	Interviewed the head and treasurer of the FFG for stakeholder analysis.
	Nagari Forest Management Institution ( <i>Lembaga Pengelola Hutan Nagari</i> )	3	14 April 2025	Interviewed the head, forest ranger, and the head of one activity unit to understand their perspective as a more mature community forestry group, and how their experience could inspire and benefit the new FFG.
		3	16 April 2025	

**Table B.** Existing VC Capital Cost

Details	Amount (IDR)	Quantity per Tapper	Number of Tapper	Quantity for All	Final Amount (IDR)
<b>Equipment</b>					
Reusable chemical bucket	50.000	N/A	N/A	2	100.000
Motorcycle purchase for resin transport	5.000.000	N/A	N/A	2	10.000.000
Personal protective equipment for tappers	200.000	1	3	N/A	600.000
Chemical spray bottle	30.000	1	3	N/A	90.000
<b>Infrastructure</b>					
Forest tapper shelter construction	5.000.000	N/A	N/A	1	5.000.000

Pathway construction for resin transport	5.000.000	N/A	N/A	1	5.000.000
<b>Total (IDR)</b>					<b>20.790.000</b>

**Table C.** Existing VC Operational Cost

Details	Value (IDR)	Remarks	Frequency Type	Quantity per Tapper	Quantity	Amount per month (IDR)	Per Year (IDR)
<b>Labor</b>							
Payment per kg to resin tappers	4500	In average	Monthly	1000	3	13.500.000	162.000.000
Annual performance bonus for tappers	1000000	Only considering outside tappers	Annual		3		3.000.000
Annual holiday allowance for tappers	400000	Only considering outside tappers	Annual		3		1.200.000
Forest guardian fee per kg	500		Monthly	3000	1	1.500.000	18.000.000
Coordinator salary per kg	1000		Monthly	3000	1	3.000.000	36.000.000
<b>Transport</b>							
Resin downhill transport fee	350		Monthly	3000		1.050.000	12.600.000
Driver fee for resin transport to warehouse per kg	200		Monthly	3000		600.000	7.200.000
Resin transport fee to manufacturing site per kg	900	In average	Monthly	3000		2.700.000	32.400.000
<b>Social Support</b>							
Tapper home travel support	1000000	Number of outside tappers went home this year	Annual		2		2.000.000
Tapper health support	150000		Annual		3	450.000	5.400.000
<b>Packaging</b>							

Single-use resin sack	3000	1 sack per 60 kg	Monthly		50	150.000	1.800.000
Single-use resin plastic liner	4000		Monthly		50	200.000	2.400.000
<b>Chemical Spraying</b>							
Sulfuric acid	232500	for 3 tons	Monthly			232.500	2.790.000
Nitric acid	232500	for 3 tons	Monthly			232.500	2.790.000
<b>Consumable equipment</b>							
Reusable coconut resin container	250		Annual		3.000		750.000
<b>TOTAL (IDR)</b>							<b>290.330.000</b>

**Table D.** Existing VC Maintenance Cost

Details	Value (IDR)	Type	Amount per year (IDR)
<b>Infrastructure</b>			
Storage facility repair cost	21600000	Yearly	21.600.000
Paved path maintenance	200000	Monthly	2.400.000
Tree clearing for safety	500000	Monthly	6.000.000
<b>Equipment</b>			
Motorcycle maintenance	800000	Semi-annual	1.600.000
<b>TOTAL (IDR)</b>			<b>31.600.000</b>

**Table E.** Criteria, sub-criteria, and Indicator for MCA with the sources

Criteria	Sub-criteria	Indicator	Source
Environmental	Biodiversity is maintained or enhanced.	Pine resin is extracted through low impact tapping techniques that minimize tree wounding and damage, thereby maintaining, enhancing, or restoring the structural and ecological features of pine forests and safeguarding the diversity of all naturally occurring species and their genetic diversity.	Adapted from Art. 189(3) of MoEF Reg. No. 9/2021 (MoEF, 2021) and Indicator 6.6.3 from FSC document (FSC, 2020).
	Effective measures to avoid negative impacts of management	All community forest management activities are planned and implemented to prevent negative impacts and	Adapted from Criterion 6.3 on Principle 6: Environmental

	activities on environmental values	to protect environmental values.	Values and Impacts; and Indicator 6.3.1 from FSC document (FSC, 2020).
Social	Representation of stakeholders, particularly women, youth, and marginalized groups.	Culturally appropriate engagement processes ensure that all stakeholders, particularly women, youth, elderly, and marginalized groups, are identified as appropriate representatives, and are equitably represented and engaged in community forestry management decision-making processes.	Art. 189(4) of MoEF Reg. No. 9/2021 (MoEF, 2021) and Indicator 7.6.2 from FSC document (FSC, 2020).
	Job-specific training and oversight are provided to workers to support the safe and effective execution of the Management Plan and associated operations	Training programs are planned and implemented to ensure all workers possess the job-specific knowledge and skills required to safely execute Management Plan activities.	Adapted from Criterion 2.5 on Principle 2: Workers' Rights and Employment Conditions and Indicator 2.5.2 from FSC document (FSC, 2020)
	Community Free, Prior, and Informed Consent (FPIC) in resin value chain decisions	Community FPIC processes are planned and implemented for all resin value chain decisions, ensuring communities receive comprehensive information about their resource rights and obligations.	Adapted from Criterion 3.2 on Principle 3: Indigenous Peoples' Rights and Indicator 3.2.4 (FSC, 2020)
	Effectiveness of community engagement and participation in resin value chain management	Culturally appropriate engagement processes are established and implemented to inform communities about specific Management Plan activities and benefit distribution arrangements, with active invitations for local community involvement.	Adapted from Criterion 4.2 on Principle 4: Community Relations and Indicator 4.2.1 from FSC document (FSC, 2020).

Economic	The capacity to use resources efficiently and access financial institutions and markets.	Financial planning demonstrates efficient resource allocation and sufficient Management Plan funding by leveraging external organizational aids.	Art. 189(5) of MoEF Reg. No. 9/2021 (MoEF, 2021) and Indicator from FSC document (FSC, 2020).
	Economic viability and profitability of the pine resin value chain for the community	Diversification of local economic sources by enabling alternative economic activities other than pine resin extraction in community forestry areas, with active community participation.	Adapted from Criterion 5.1 on Principle 5: Benefits from the Forest and Indicator 5.1.1 from FSC document (FSC, 2020)
	Contribution of the activities under the social forestry permit to local employment and livelihood diversification	Prioritizing the employment of local people, where local and non-local options demonstrate equivalent cost, quality and capacity, preference is given to local people.	Adapted from Criterion 5.4 on Principle 5: Benefits from the Forest and Indicator 5.4.1 from FSC document (FSC, 2020).
Institutional	Availability of the necessary administrative documentation.	Minimum documents such as RKPS and AD/ART are available and transparency from all stakeholders involved is demonstrated through accessible documentation and open communication processes.	Art. 189(2) of MoEF Reg. No. 9/2021 (MoEF, 2021).
	Compliance with national and local laws and regulations governing social forestry and resin production.	All follow-up documents, regulations, and administrative are developed according to the national and local laws demonstrate full compliance with legal recommendations and requirements.	Adapted from Criterion 1.1 on Principle 1: Compliance with Laws (FSC, 2020)
	Clarity and community involvement in long-term	A clear plan for community involvement in long-term management is documented in the Management Plan and	Adapted from Criterion 7.1 on Principle 7: Management

	management planning under the social forestry permit.	related materials, consistent with the social forestry permit.	Planning and Indicator 7.1.1
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**Table F.** Comparison between SOP tapping procedures and field practices

Aspects	SOP (MoEF, 2020)	Field Practices
Number of wounds made in one tree	<ul style="list-style-type: none"> <li>• Circumference 62 – 85 cm = Maximum 1 active tapping wound</li> <li>• Circumference 86 – 105 cm = Maximum 2 active tapping wounds</li> <li>• Circumference 106 – 124 cm = Maximum 3 active tapping wounds</li> <li>• Circumference 125 – 148 cm = Maximum 4 active tapping wounds</li> <li>• Circumference 149 – 175 cm = Maximum 5 active tapping wounds</li> <li>• Circumference &gt; 175 cm = 6 or more active tapping wounds</li> </ul>	Mostly in compliance with SOP
Depth of the tapping wound	Maximum 2.5 cm (excluding the outer bark)	There is no exact measurement, but the maximum depth should not exceed the height of a palm
Wound renewal interval	Maximum 0,5 cm per 5 days	Every 10-15 days, but the depth of renewal is not specified

**Table G.** Comparison between SOP stimulant spraying procedures and field practices

Aspects	SOP (MoEF, 2020)	Field Practices
Types of stimulants used	Organic stimulant or sulfuric acid based on altitude	A diluted acid solution of nitric acid and sulfuric acid.
Chemical stimulant composition	Composition based on altitude: <ul style="list-style-type: none"> <li>• ≤ 700 mdpl: organic stimulant</li> <li>• 701 - 900 mdpl: maximum 10% of sulfuric acid</li> <li>• 901 – 1100 mdpl: maximum 15% of sulfuric acid</li> <li>• &gt; 1100 mdpl: maximum 20% of sulfuric acid</li> </ul>	<ul style="list-style-type: none"> <li>• Typically, 11% nitric acid, 11% sulfuric acid, and 78% water</li> <li>• During higher temperatures, 10% nitric acid, 10% sulfuric acid, and 80% water</li> </ul>
Dosage	1 cc applied at each tapping wound renewal	One spray from the bottle was applied per wound renewal

## Stakeholders Analysis

The arrangement of elements of interest and influence elements for Stakeholder Analysis are shown in Table H. Each cell would be filled with '+' signs to indicate the level of interest or influence for each category: three '+' signs represented the highest level, two '+' signs indicated a moderate level, one '+' sign signified a low level, and the absence of signs denoted insignificance. The table was completed based on the results of interviews with each stakeholder. The stakeholders were grouped based on their type, including administrative government bodies, government forestry authorities, nonprofit organizations, local residents, tapper, business venture, and forest farmer organization.

**Table H.** Stakeholders' level of interests and influence

Type of Stakeholder	Stakeholders	Interests				Influence		
		Sustainable development				Instruments of Power		
		Environmenta	Economic	Social	Institutional	Condign	Compensator	Conditioning
Administrative government bodies	Village Government			+			++	++
Government forestry authorities	Forest Management Unit	+				+++		
	Forestry Extension Worker	+				+		
	Forest Ranger	+				+		
Nonprofit Organizations	Implementing NGO	++	++	++			++	
	Intergovernmental Organization – Funding Agency	++	++	++			+++	
Residents	Village residents		+					
Field workers	Local tapper		++					
	Outside tapper and worker		+++					
Business Ventures	Pine resin company		+++				++	++
Forest Farmer Organization	Community FFG		++	++				

For future improvements, Table I shows the sources of monetary benefits that the relevant stakeholders could provide to FFG for the VC.

**Table I.** Potential sources of monetary benefits

Source	Benefits	Details
Village government	Village funds ( <i>Dana desa</i> )	<ul style="list-style-type: none"> <li>Allocation of village funds is planned through village planning meetings (Musrenbang). If LPHN or FFG needs financial support, they can submit a proposal to be reviewed under the Medium-Term Development Plan (RPJM), which is prepared yearly by the village government.</li> <li>The amount of money that can be allocated from Nagari annually for FFG is usually around IDR 15 million as a grant.</li> </ul>
Nonprofit Organizations	Grant money	NGOs, through funding from intergovernmental organizations, can provide various types of capacity building through specific programs with higher levels of funding. However, these programs usually involve a more rigid application process and stricter monitoring and evaluation for their continuation.

In addition to monetary benefits, Table J shows potential non-monetary benefits that the relevant stakeholders could provide to FFG for the VC.

**Table J.** Potential sources of non-monetary benefits

Source	Intervention/Programmatic Offering	Anticipated Outcome (Potential Benefit)
Village government	Technical training ( <i>Bimbingan teknis</i> )	In collaboration with FMU, the training includes lessons for the board of management of FFG managing the organization including on how to report finances, development of unit functions, and how to implement technology equipment.
	Capacity building	<ul style="list-style-type: none"> <li>For the members of FFG with activity details depending on the proposal submitted to village government by the management of FFG. The capacity building activities usually will be coordinated by an officer from the village government.</li> <li>For example, if a farmer field school is proposed, funding can reach up to IDR 60 million. This includes speaker fees, meals, stationery, participant allowances, and so on. This amount of money for field school can cover 20–30 sessions. Usually, the speakers are provided by the</li> </ul>

		<i>Nagari</i> (Local Village Government). In this case, the money allocation from the Village Government is not given to be managed by FFG but is managed directly by the Village Government.
Nonprofit Organizations	Capacity building	<ul style="list-style-type: none"> <li>• NGOs, through funding from intergovernmental organizations (IGOs), can provide various types of capacity building through specific programs with higher levels of funding. However, these programs usually involve a more rigid application process and stricter monitoring and evaluation (M&amp;E) for their continuation.</li> <li>• For example, the current program is funded by one of the UN bodies and implemented through a collaboration between a business venture and an NGO as the grantee, with FFG as the beneficiary. The program runs for only two years, and its continuation depends on the results of KPIs, which will be assessed through a monitoring and evaluation (M&amp;E) process. The program is aimed at VC transformation of pine resin, where aspects such as ESG, GEDSI, investability, and additionality are key indicators that motivated the intergovernmental organization to grant the program.</li> </ul>

**Table K.** Environmental Aspect Improvement Narrative

Components to be Improved	Existing Method	Improved Method
Tree trunk tapping	<ul style="list-style-type: none"> <li>• Manual tapping is carried out using a tap knife, employing the Hugues or French Method. This technique involves slicing the secondary xylem of the trunk in 8 to 10 cm wide sections at intervals of every 10 to 15 days (Dkhar and Johar, 2024). However, this method is considered more harmful to the tree compared to other techniques, as it involves the removal of wood strips (López-Álvarez et al., 2023).</li> <li>• Improvements in this area are needed to address local community concerns about trees dying due to continuous tapping.</li> </ul>	The impact of tapping may differ among various pine trees based on factors such as location, species, extraction method, as well as intraspecific genetic variation, pest presence, and climatic conditions (López-Álvarez et al., 2023). However, a measured tapping thickness using a borer, and without chemical stimulant, can help balance the trade-off between growth and resin production. This method is also called as <i>biogemme</i> program. According to Du et al. (2021),

Stimulant	<ul style="list-style-type: none"> <li>• A stimulant spray composed of equal parts hydrochloric acid (HCl) and sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) is applied to the tree as part of the method known as Mazek or Rill (Dkhar and Johar, 2024). When compared to other stimulation methods, including the Chinese and American approaches, the Mazek method produced the lowest yields (Cunningham, 2012).</li> <li>• The use of this chemical mixture has caused the death of several animals in the surrounding area, which has the potential to continue occurring if this method is maintained.</li> </ul>	a moderate resin-tapping intensity with certain considerations could offer an effective solution.
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**Table L.** Institutional Improvement Narrative

<b>Components to be Improved</b>	<b>Existing Governance</b>	<b>Improved Governance</b>
The availability of supporting documents for the sustainability of the FFG.	<ul style="list-style-type: none"> <li>• The Social Forestry Management Plan document is not yet available, and there is no Articles of Association (AD/ART) document for the FFG.</li> </ul>	<ul style="list-style-type: none"> <li>• The management of the FFG completes the necessary RKPS and Articles of Association (AD/ART) documents by leveraging existing networks with stakeholders.</li> </ul>
The clarity of the active role of the FFG in the pine resin SC partnership document.	<ul style="list-style-type: none"> <li>• The company pays premiums to the FFG to operate and harvest pine resin, while managing it without dominating the involvement of the community in the process.</li> </ul>	<ul style="list-style-type: none"> <li>• Transparency through a standardized partnership agreement document involving the local community by prioritizing their employment throughout the entire VC, while also providing training and capacity-building opportunities to prepare them for these roles.</li> </ul>
The clarity of the other stakeholders	<ul style="list-style-type: none"> <li>• The agreement documents lack details regarding the distribution of premiums and the responsibilities associated with the income.</li> </ul>	<ul style="list-style-type: none"> <li>• Transparency through a standardized partnership document in managing the premiums paid by the company to relevant stakeholders, accompanied by clear responsibilities that</li> </ul>

involvement in social forestry activities in accordance with applicable regulations.	<ul style="list-style-type: none"> <li>• The involvement of stakeholders outside the FFG in pine resin tapping is not fully understood by the community.</li> </ul>	justify their entitlement to the premium, ensuring fair benefits for the community as recipients of the social forestry permit.
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**Table M.** Socio-Economic Improvement Narrative

<b>Components to be Improve</b>	<b>Existing Socio-Economic</b>	<b>Improved Socio-Economic</b>
Pine resin management in social forestry area	<ul style="list-style-type: none"> <li>• It is fully managed by a company from outside the area with a payment system based on premiums to the FFG per kilogram of harvest, which had also previously helped in the establishment of this FFG.</li> <li>• Some community members are skeptical about people from outside the area managing the pine resin tapping activities.</li> </ul>	<ul style="list-style-type: none"> <li>• The management of the FFG requests funding for the procurement of equipment related to pine resin harvesting by utilizing assistance from the local government and/or NGOs.</li> <li>• They propose technical guidance on pine resin harvesting management to the local government and/or NGOs, with the goal of taking full control of the management.</li> </ul>
FFG Operationality	<ul style="list-style-type: none"> <li>• The only activity of the FFG after receiving the social forestry permit is pine resin harvesting, and very few members are involved.</li> <li>• The local community hopes that if there is assistance through the FFG, it will not only focus on pine resin tapping activities but also include activities that align with their current professions and interests.</li> <li>• Pine resin in the long term will not be as profitable as now.</li> </ul>	<ul style="list-style-type: none"> <li>• Add honeybee KUPS (Farmer Group Business Unit) as an activity under the social forestry permit in addition to pine resin harvesting</li> <li>• Submit training programs from local government and NGOs related to conventional farming, sewing, and small business management.</li> </ul>
Tappers welfare	<ul style="list-style-type: none"> <li>• Most of the tappers come from outside the area. There are a few local tappers, but it is not their main occupation.</li> </ul>	<ul style="list-style-type: none"> <li>• Pine tapping training for local communities interested in becoming tappers.</li> </ul>

	<ul style="list-style-type: none"> <li>Some community members agree that pine tapping training is still beneficial to hold for those interested in becoming tappers.</li> </ul>	<ul style="list-style-type: none"> <li>Provide formal training to existing tappers on proper tapping procedures according to SOPs, as well as safety training. Register them for health insurance, at a minimum, the BPJS insurance.</li> </ul>
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**Table N.** CBA of Environmental-Improvement and Eco-Governance scenarios

Time (year)	2025	2030	2035	2040	2045	2050	2055	2060
<b>Cost Component</b>								
Capital Cost	29.543.107	0	0	0	0	0	0	0
Operational Cost	284.750.000	284.750.000	284.750.000	284.750.000	284.750.000	284.750.000	284.750.000	284.750.000
Maintenance Cost	31.600.000	31.600.000	31.600.000	31.600.000	31.600.000	31.600.000	31.600.000	31.600.000
<b>Benefit Component</b>								
Crude pine resin	432.000.000	432.000.000	432.000.000	432.000.000	432.000.000	432.000.000	432.000.000	432.000.000
PV Cost	345.893.107	196.428.461	121.966.620	75.731.675	47.023.412	29.197.839	18.129.561	11.257.031
PV Benefit	432.000.000	268.238.012	166.554.701	103.417.365	64.214.047	39.871.871	24.757.295	15.372.332
<b>Nett PV Benefit</b>	<b>86.106.893</b>	<b>71.809.551</b>	<b>44.588.081</b>	<b>27.685.691</b>	<b>17.190.636</b>	<b>10.674.032</b>	<b>6.627.734</b>	<b>4.115.301</b>
<b>NPV 5 years</b>	90.540.366							
<b>BCR 5 years</b>	1,34							
<b>NPV 35 years</b>	34.327.254							
<b>BCR 35 years</b>	1,35							

The key differences compared to the existing CBA are these scenarios omitting the chemical stimulant from operational cost and adding the purchase of borers to the capital cost.

**Table O.** CBA of Comprehensive scenario

Time (year)	2025	2030	2035	2040	2045	2050	2055	2060
<b>Cost Component</b>								
Capital Cost	0	0	0	0	0	0	0	0
Operational Cost	284.750.000	284.750.000	284.750.000	284.750.000	284.750.000	284.750.000	284.750.000	284.750.000
Maintenance Cost	31.600.000	31.600.000	31.600.000	31.600.000	31.600.000	31.600.000	31.600.000	31.600.000
<b>Benefit Component</b>								
Crude pine resin	432.000.000	432.000.000	432.000.000	432.000.000	432.000.000	432.000.000	432.000.000	432.000.000
Honeybee	120.000.000	120.000.000	120.000.000	120.000.000	120.000.000	120.000.000	120.000.000	120.000.000
PV Cost	393.473.362	196.428.461	121.966.620	75.731.675	47.023.412	29.197.839	18.129.561	11.257.031
PV Benefit	552.000.000	268.238.012	166.554.701	103.417.365	64.214.047	39.871.871	24.757.295	15.372.332
<b>Nett PV Benefit</b>	<b>158.526.638</b>	<b>71.809.551</b>	<b>44.588.081</b>	<b>27.685.691</b>	<b>17.190.636</b>	<b>10.674.032</b>	<b>6.627.734</b>	<b>4.115.301</b>
<b>NPV 5 years</b>	105.024.315							
<b>BCR 5 years</b>	1,38							
<b>NPV 35 years</b>	36.396.389							
<b>BCR 35 years</b>	1,37							

The key differences compared to the existing CBA are these scenarios omitting the chemical stimulant from operational cost, adding the purchase of borers to the capital cost, and has new income from honeybee farmer business group.

**Table P.** Performance Matrix of Scenarios for MCA

Criteria	Sub-criteria	Management Options (MO)			
		BaU	Environmental Improvement	Eco-Governance Improvement	Comprehensive Improvement
Environmental	Biodiversity is maintained or enhanced.	1	3	3	3
	Effective measures to avoid negative impacts of management activities on environmental values	1	3	3	3
Institutional	Availability of the necessary administrative documentation.	1	1	4	4
	Compliance with national and local laws and regulations governing social forestry and resin production.	3	3	5	5
	Clarity and community involvement in long-term management planning under the social forestry decree.	2	2	4	4
Social	Representation of stakeholders, particularly women, youth, and marginalized groups.	1	1	3	5
	Job-specific training and oversight are provided to workers to support the safe and effective execution of the Management Plan and associated operations	1	1	3	4
	Community Free, Prior, and Informed Consent (FPIC) in resin value chain decisions	1	1	3	4
	Effectiveness of community engagement and participation in resin value chain management	1	1	3	4

Economic	The capacity to use resources efficiently and access financial institutions and markets.	2	2	3	4
	Economic viability and profitability of the pine resin value chain for the community	3	1	1	4
	Contribution of the activities under the social forestry decree to local employment and livelihood diversification	1	1	1	4

**Table Q.** Alternative scenarios from combined improvement narratives

Scen ario	Summary of the Conditions Applied			Economic Viability
	Environmental	Institutional	Socio-economic	
BaU	Manual tapping is carried out using a tap knife. This technique involves slicing the secondary xylem of the trunk in 8 to 10 cm wide sections at intervals of every 10 to 15 days. A stimulant spray composed of equal parts hydrochloric acid (HCl) and sulfuric acid (H <sub>2</sub> SO <sub>4</sub> ) is applied to the tree.	The RKPS and AD/ART documents are not yet available. The company pays premiums to the FFG to operate and harvest pine resin, without dominating community involvement. However, the agreement documents lack details on premium distribution and income responsibilities. Stakeholder involvement outside the FFG in resin tapping	The operation is fully managed by an external company using a premium-based payment system per kilogram of harvest, which also supported the formation of the FFG. Since receiving the social forestry permit, the group's only activity is pine resin harvesting, with limited member involvement. Most tappers are from outside the area, while a few local tappers participate, though it is not their primary occupation.	<b>NPV 5 years:</b> IDR 87.637.41887. 637.418 <b>BCR 5 years:</b> 1,32

Environmental Improvement	Tapping the tree trunk to a measured depth using a borerT, followed by spraying the tapped wound with an environmentally friendly solvent.	is not fully understood by the community.		<b>NPV 5 years:</b> IDR 90.540.366 <b>BCR 5 years:</b> 1,34
Eco-Governance		The FFG management prepares the RKPS and AD/ART documents using stakeholder networks. Transparency is promoted through a standardized MoU that involves the local community by prioritizing their employment across the VC and offering training and capacity-building. The MoU also ensures transparency in managing company-paid premiums, with clear responsibilities to justify entitlement and guarantee fair benefits for the community as social forestry permit holders.		<b>NPV 5 years:</b> IDR 90.540.366 <b>BCR 5 years:</b> 1,34:
Comprehensive Improvement			The FFG management seeks funding for pine resin harvesting equipment through support from the local government and/or NGOs. They propose technical guidance on harvesting management to work toward full control. Honey bee KUPS is added as an activity under the social forestry permit. They also request training programs in conventional farming, sewing, and small business management. Pine tapping training is offered to interested locals, while existing tappers receive formal SOP-based tapping and safety training, along with BPJS health insurance registration.	<b>NPV 5 years:</b> IDR 105.024.315 <b>BCR 5 years:</b> 1,38

## **Artificial Intelligence Statement**

This study utilized artificial intelligence (AI) platforms in the process, with the platforms used and their purposes are outlined below:

1. ChatGPT: Used only to check the grammar and clarity of the text. The platform was not used to generate the text or any other type of content. Its responses were consulted only as a reference option when in doubt and were not adopted in full. Example: <https://chatgpt.com/share/68fe888d-1d7c-8013-955c-44a8b5dfbb3a>
2. Google Cloud Speech-to-Text: Used to transcribe recorded audio interviews and FGDs that the writer confidently believes do not contain sensitive or confidential information, and from interviewees who gave verbal consent for their interviews to be used as part of the research publication.