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BALANCE SHEET ANALYSIS OF PINE RESIN RESOURCES IN SOUTH SULAWESI

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ABSTRACT

Pine resin is a valuable non-timber forest product that serves as an important source of income for communities residing near forested areas. Despite ongoing extraction and utilization, limited information exists regarding the quantitative balance of this natural resource from initial reserves to final stocks. This study aims to clearly evaluate the physical and monetary balance of pine resin resources in a selected village in Gowa District South Sulawesi. Data were collected through interviews, field observations, and literature review. A purposive sampling method was employed to select 20 active pine resin tappers as respondents. The physical balance was determined by calculating the initial stock, annual additions, and the final stock, while the monetary balance was derived by converting final physical stock into monetary value. The results show that the final physical stock of pine resin reaches 23.584 kg per year with a corresponding monetary value of IDR 1,420,348,288. The findings clearly indicate that pine resin resources experience continuous annual depreciation when regeneration through pine tree planting is absent. These results emphasize the urgent need for sustainable pine resin management strategies to maintain resource availability and long-term community livelihoods.

Keywords: *Monetary Balance; Natural Resource; Physical Balance; Pine Resin; Sustainability*

INTRODUCTION

Forests are very beneficial for life, especially timber forest products and non-timber forest products (Derebe *et al.,* 2023; Talukdar *et al.,* 2021). In Indonesia, Non-Timber Forest Products (NTFPs) have a lot of potential for development (Wulandari *et al.,* 2023). Considered as the main product, NTFPs have a higher economic value than wood (Harbi *et al.,* 2023; Hazari *et al.,* 2023; Derebe & Alemu, 2023; Shackleton & Vos, 2022). Sustainability is maintained through sustainable harvesting methods, such as the use of pine sap as an NTFP commodity. Pine sap as an NTFP commodity is critical for forestry and provides benefits to industry (Mujetahid *et al.,* 2021).

Non-Timber Forest Products (NTFPs) include natural products from forests, including derivative products and cultivation products, except wood (Smith-hall & Chamberlain, 2023). These NTFPs are used for economic activities and to improve community welfare. NTFPs are the main or additional source of income for many households (Lepcha *et al.,* 2022; Njurumana & Octavia, 2020). One example of NTFPs processed by the community in Pa'ladingan Village, Bontolempangan District, Gowa Regency, is tapping pine resin with the koakan method.

Pine plants, especially Pinus merkusii or Tusam, have many benefits for the people of Indonesia (Imanuddin *et al.,* 2020). Pinus merkusii is very important because it is the only pine species native to Indonesia (Sulton *et al.,* 2024). Pine trees are used for timber production, sap production, and land conservation (Simalango *et al.,* 2024). Pine is a natural resource that has many benefits for humans due to its various uses (Dziedzinski *et al.,* 2021). In addition, pine trees are a source of NTFPs through sap (resin) production (Ramadhan *et al.,* 2022; Pawlowicz *et al.,* 2024).

Pine resin is one of the potential NTFP commodities. Indonesia's pine resin production is ranked third, after China and Brazil (Siregar *et al.,* 2022). Pine sap can produce gondorukem and turpentine, which are obtained through wounding or tapping (Berghuis & Sari, 2024). Gondorukem can be used for various purposes, such as making varnish, soap, batik, ink, paint, and others (Sulistyo *et al.,* 2024). On the other hand, turpentine can be used as a solvent for paints and varnishes, perfumery, and an ingredient for making synthetic camphor (Faly *et al.,* 2024).

Despite its high economic potential, information on the quantitative balance of pine resin resources, particularly regarding initial and final reserves, remains limited, creating constraints in sustainable utilization planning (Makkarennu *et al.,* 2025). Previous studies have largely focused on production and income aspects, while comprehensive assessments of physical and monetary resource balances at the local level are still scarce (Zhu et al., 2021; Makkarennu *et al.,* 2022). To ensure sustainable forest product utilization, a balance sheet approach is required to systematically record initial reserves, changes, and final reserves of natural resources. Natural resource and environmental balance sheets are generally classified into physical and monetary balance sheets.

The value of changes in initial reserves, planting, depletion, and final reserves in units of weight and volume are included in the physical balance sheet to show changes in the amount of natural resources, while the monetary balance sheet is used to calculate the amount received from natural resources in Rupiah (Makkarennu *et al.,* 2025). Therefore, this study aims to generate detailed information on pine resin utilization through physical and monetary balance analysis in Pa'ladingan Village, Bontolempangan Sub-district, Gowa Regency. The findings are expected to fill existing research gaps and support more efficient and sustainable management of pine resin resources at the community level.

METHOD

2.1. Study Site

The research was carried out in a highland area of Gowa Regency, South Sulawesi Province, Indonesia, focusing on a village administratively situated within Bontolempangan District. The study area, locally referred to as Pa'ladingan Village, covers approximately 19.6 km² and is located around 9 km from the district administrative center. In spatial terms, the area is positioned between 5°19′30″–5°22′30″ South latitude and 119°48′00″–119°51′00″ East longitude. The landscape is predominantly undulating to hilly, with forest ecosystems largely composed of pine stands. Local livelihoods are closely linked to forest-based activities, particularly the extraction of non-timber forest products such as pine resin. The administrative boundaries of the study area are illustrated in Figure 1.

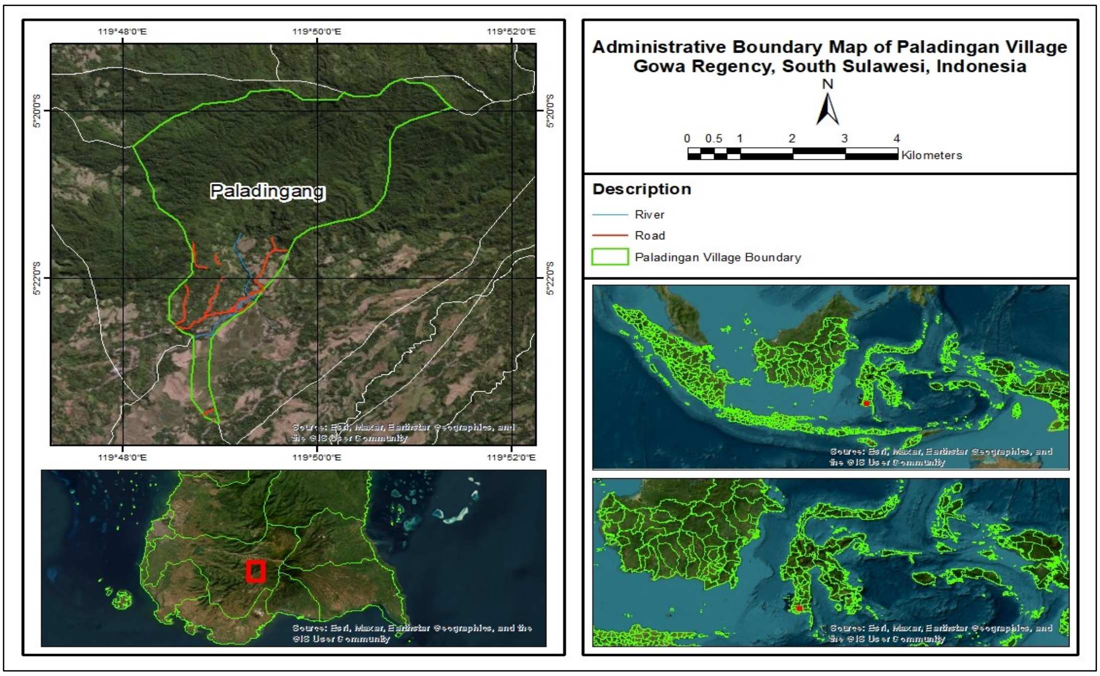

Figure 1. Study Site

2.2. Data Collection

A purposive sampling technique was employed to select research participants, targeting 20 respondents who were directly and consistently engaged in pine resin tapping activities during the study period. Data collection integrated both primary and secondary sources to ensure comprehensive analysis. Primary data were obtained through systematic field observations and face-to-face interviews using structured questionnaires. These data covered key variables, including the number of pine trees managed by each respondent, the harvesting condition of trees (tapped or untapped), average daily resin production, resin market prices per kilogram, labour allocation, and the equipment used in the tapping process. Secondary data were compiled from official government records and relevant institutional documents, encompassing demographic and socioeconomic characteristics of the local community, biophysical and geographic conditions of the study area, as well as previous studies and policy documents related to pine resin utilization and forest resource management. The integration of primary and secondary data sources enabled a robust assessment of both the physical and economic aspects of pine resin resource utilization.

2.3. Data Analysis

a. Physical Balance

The utilization of pine resin resources by local communities was assessed using a physical balance framework to capture changes in resource stocks over the study period. The physical balance, expressed in kilograms (kg), reflects the net variation between initial reserves, additions from growth or planting, and depletion resulting from extraction activities. The final physical reserve was estimated as:

$$\mathbf{CA_k = (CA_w + P) - D}$$

In this formulation, CA_k (kg) represents the final physical stock at the end of the study year, CA_w (kg) denotes the initial stock at the beginning of the period, Additions (P, kg) refer to increases in resource stock resulting from newly growing or planted pine trees, and (D, kg) refers to depletion associated with resource extraction during the year. This balance provides an overview of net physical stock changes and serves as an indicator of the sustainability of pine resin utilization at the community level.

b. Monetary Balance

To capture the economic dimension of resource utilization, the physical balance was translated into monetary terms using prevailing market prices, expressed in Indonesian Rupiah. The monetary balance incorporates the value of initial stocks and additions, adjusted for price changes over time (revaluation), and reduced by the economic value of depletion. The final monetary reserve was calculated as:

$$CA_k = (CA_w + P + R) - D$$

Here, the final monetary stock CA_k (IDR) reflects the net economic value of pine resin resources at the end of the study period. The term CA_w (IDR) represents the monetary value of initial stocks, (P) corresponds to the value of additions, and R (IDR) captures revaluation effects arising from changes in market prices between the beginning and the end of the year. The depletion component (D, IDR) represents the economic value of extracted resources.

The depletion value (D) is further calculated using:

$$D = Q \times U$$

In this expression, Q (kg) denotes the quantity of pine resin extracted during the study year, while U (IDR/kg) represents the unit rent, defined as the net economic return per kilogram of resource extracted. Unit rent was derived from the difference between the market price of pine resin and total extraction costs, thereby reflecting the economic value foregone due to resource depletion. This approach is consistent with natural resource accounting practices and provides insight into the long-term sustainability of current harvesting patterns.

RESULTS AND DISCUSSION

3.1. Physical Balance

The physical balance sheet outlines the initial and final stock levels of a natural resource, capturing measurable changes in physical units. In this study, the physical balance refers specifically to the community-based utilization of pine resin, with all measurements expressed in kilograms (kg). This balance encompasses additions (e.g., tree growth or new plantings) and subtractions (e.g., depletion due to harvesting), thereby reflecting variations in resource stock over a defined period. Changes in resource stocks result primarily from extraction for production purposes. However, fluctuations may also arise from other factors such as exploration activities or natural losses. The assessment of physical balance in this context includes four key components: initial reserves, additions, depletion, and final reserves.

The **initial reserve** represents the amount of pine resin resource available at the beginning of the study period, determined by the number of productive pine trees owned by farmers. The **addition** of trees during the year supports the sustainability of resin tapping by ensuring a continuous supply of raw material. Planting or regenerating pine trees is essential for maintaining long-term availability of the resource and for securing consistent livelihood opportunities for local resin tappers. **Depletion** refers to the reduction in resource stock due to extraction activities, which reflects the quantity of pine resin harvested during the study year. This decrease occurs naturally and is a consequence of the resource's utilization. The level of depletion is a direct indicator of how much of the available resource has been consumed. The data on initial reserves, additions, and depletion based on the productivity of pine resin harvested in 2023 are presented in Figure 2 and Figure 3.

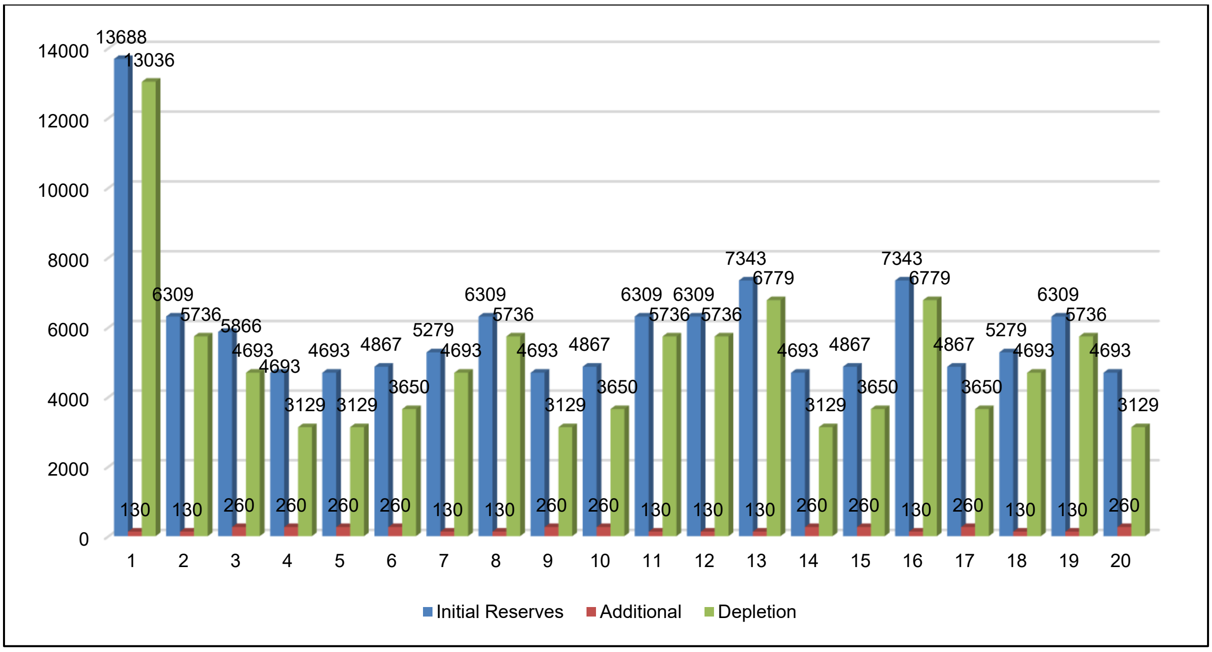

Figure 2. Productivity of Pine Sap

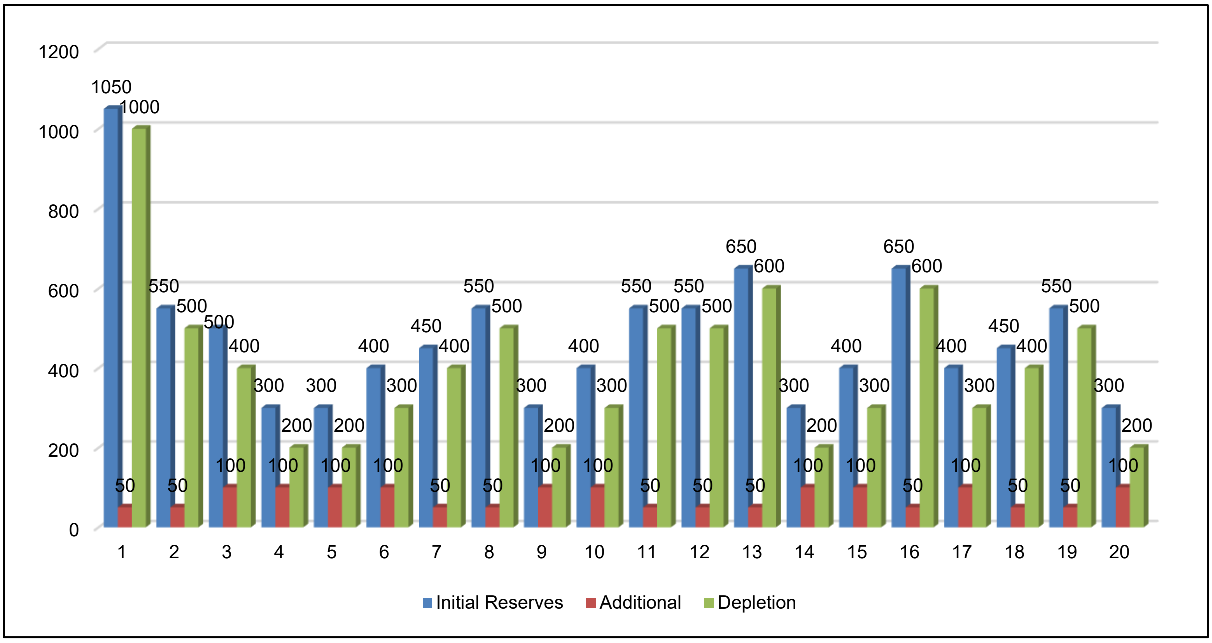

Figure 3. Number of Trees

The figure illustrates the initial stock of pine trees utilized for resin tapping by the local community in 2023. A total of 9,600 pine trees were actively tapped, generating approximately 119,277 kg of pine resin per year. This production figure represents the aggregated output reported by respondents who were actively engaged in resin extraction activities. Based on field data, the average diameter of tapped pine trees was approximately 50 cm, indicating that resin yield tends to increase with tree diameter. In contrast, 1,500 pine trees remained untapped, with a potential resin yield estimated at 3,900 kg per year. These trees were generally excluded from tapping activities because their stem dimensions did not meet the minimum standards required for resin extraction.

The figure also depicts the level of resource depletion resulting from resin harvesting practices. The total amount of resin extracted during the study period reached 99,598 kg, derived from 8,100 tapped trees. Variations in resin yield among farmers were observed, reflecting differences in harvesting outcomes. Such variability can be attributed to several factors, particularly the tapping techniques applied. Characteristics such as the configuration of tapping wounds, tapping patterns, wound width and depth, frequency of wound renewal, and the use of chemical or mechanical stimulants play a critical role in influencing resin productivity.

The final reserves of pine resin were utilized by the community in the research location.

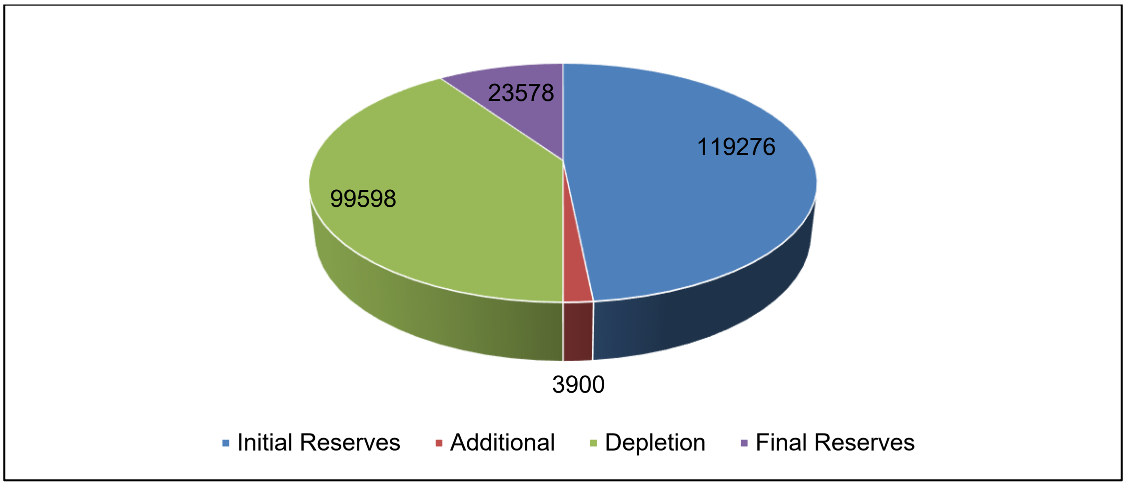

Figure 4. Physical Balance Final Reserves

The ending stock recorded for a given year subsequently becomes the opening stock for the following accounting period. The physical balance framework provides a systematic representation of changes in forest resource availability by accounting for opening reserves, increments due to growth, reductions resulting from extraction, and the remaining stock at the end of the period. In 2023, the opening stock of pine resin amounted to 119,276 kg. During the same year, additional potential reserves contributed approximately 3,900 kg, while extraction activities resulted in a reduction of 99,598 kg. Consequently, the remaining stock at the end of the accounting period was estimated at 23,578 kg. These figures indicate a consistent downward trend in pine resin availability under current harvesting practices. In the absence of replanting or regeneration initiatives, the remaining stock is expected to continue declining in subsequent years, increasing the risk of resource scarcity at the study site and undermining the long-term sustainability of pine resin utilization.

3.2. Monetary Balance

The monetary balance provides an economic representation of the remaining value of pine resin resources at the end of the accounting period. This assessment translates physical stocks into monetary terms by incorporating the value of opening reserves, incremental additions, and reductions resulting from tapping activities. When market prices vary between the beginning and the end of the year, a revaluation component is incorporated to ensure that changes in price levels are adequately reflected in the monetary estimates. In practice, this adjustment is determined through consultation with local communities and relevant stakeholders to align valuation assumptions with prevailing market conditions.

The closing monetary balance is derived by aggregating the value of opening reserves, additions, and any revaluation effects, and subsequently subtracting the estimated depletion value. Opening reserves represent the quantity of pine resin resources initially controlled by farmers, while additions reflect efforts to sustain long-term availability through the maintenance or expansion of pine stands. The magnitude of both opening reserves and additions for the year 2023 is illustrated in Figure 5.

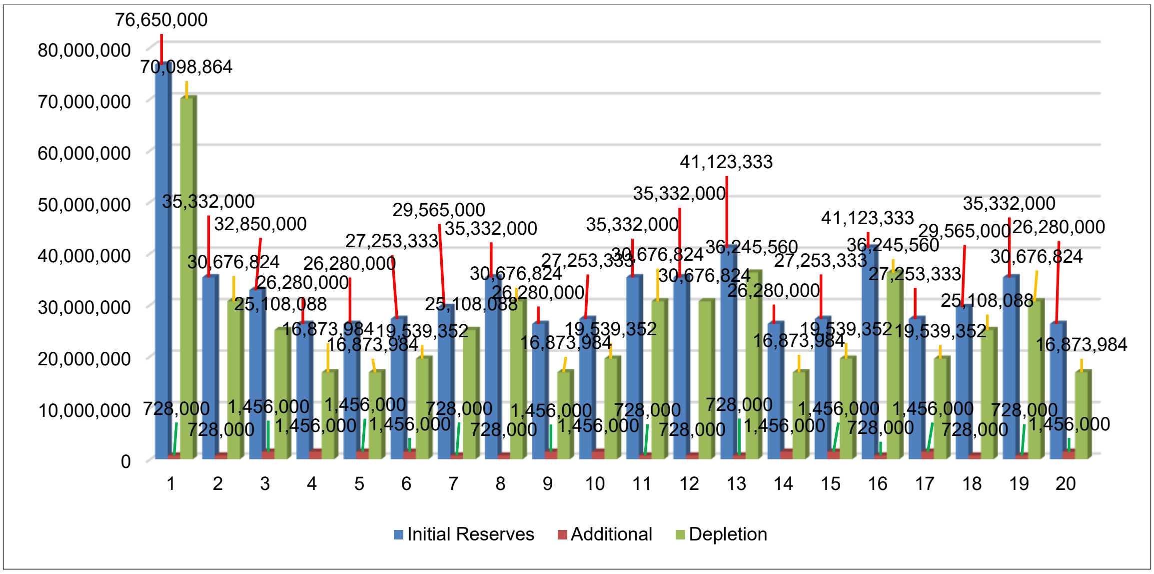

Figure 5. Monetary Balance Initial Reserves

Depletion value refers to the annual reduction in the value of a natural resource due to its utilization. It is calculated by multiplying the production volume of the forest resource utilized by the community with the corresponding unit rent. Unit rent represents the valuation rate used to estimate the economic loss resulting from resource extraction. As an alternative cost approach, the value of a reasonable return is benchmarked against the prevailing interest rate for bank loans. To assess the potential economic value that could be realized by the government as the resource owner, the return on investment generated through community use is considered indicative of a fair return. In this study, an interest rate of 12% was employed as a proxy for the expected return. The income generated by each farmer is required to calculate the unit rent, which is subsequently adjusted by subtracting the production costs incurred.

Table 1. Unit Rent Calculation

No. Respondent	Production Cost (IDR/kg)	Gross Profit (IDR/kg)	Decent Profit (IDR/kg)	Unit Rent (IDR/kg)
1	199	5401	24	5377
2	225	5375	27	5348
3	223	5377	27	5350
4	184	5416	22	5394
5	184	5416	22	5394
6	220	5380	26	5353
7	223	5377	27	5350
8	225	5375	27	5348
9	184	5416	22	5394
10	220	5380	26	5353
11	225	5375	27	5348
12	225	5375	27	5348
13	226	5374	27	5347
14	184	5416	22	5394
15	220	5380	26	5353
16	226	5374	27	5347
17	220	5380	26	5353
18	223	5377	27	5350
19	225	5375	27	5348
20	184	5416	22	5394

Source: Field survey, 2024

Table 1 presents the estimation of unit rent, which serves as a key parameter for determining the depletion value of pine resin resources. Unit rent represents the economic rent generated per kilogram of resin tapping and reflects the net value of resource use. Based on this estimate, the depletion value of pine resin was calculated by multiplying the quantity of resin tapping by the corresponding unit rent. In addition, the study assessed the total revaluation value of forest product utilization, which captures changes in the economic value of pine resin attributable to price fluctuations over the study period. The aggregated revaluation value of pine resin utilization at the study site is illustrated in Figure 6.

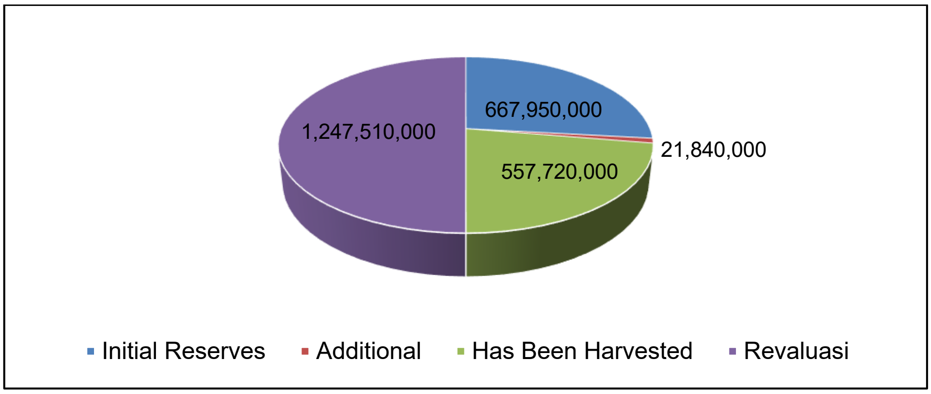

Figure 6. Revaluation (IDR)

Figure 6 illustrates a total revaluation value of IDR 1,247,510,000, derived from the aggregated monetary value of initial reserves, resource additions, and harvested pine resin during the study period. This revaluation reflects adjustments in the economic value of pine resin resources associated with price dynamics over time. The monetary balance framework therefore provides a more accurate representation of the remaining value of pine resin resources. Based on this approach, the estimated monetary value of the final reserves is presented below.

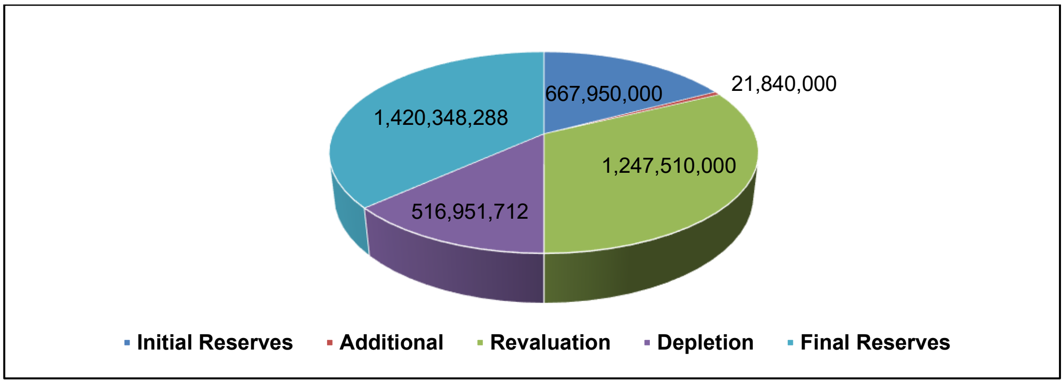

Figure 7. Monetary Balance Final Reserves (IDR)

The monetary balance reflects the actual economic value of the final reserves of pine resin. The initial reserve was valued at IDR 667,950,000, which increased by IDR 21,840,000 due to additional resource availability, bringing the subtotal to IDR 689,790,000. This value was further adjusted by a revaluation gain of IDR 1,247,510,000. After accounting for a depletion value of IDR 516,951,712, the final monetary reserve amounted to IDR 1,420,348,288. The depletion calculation was based on the concept of unit rent, excluding labour costs, as pine resin tappers in the study area conduct tapping activities independently without employing additional workers. Consequently, wage-related expenses were not included in the depletion valuation.

CONCLUSIONS AND RECOMMENDATIONS

The results of this study show that the final reserve of pine resin recorded in the physical balance sheet reaches 23,584 kg per year, with a corresponding monetary value of IDR 1,420,348,288, highlighting the economic importance of pine resin for local livelihoods. However, the comparison between initial and final reserves clearly indicates a declining trend in resource availability, reflecting continuous extraction without adequate replenishment. This finding directly addresses the main objective of the study by demonstrating how physical and monetary balance analysis can reveal early signals of resource depletion at the community level. The results imply that, without systematic replanting and regeneration efforts, pine resin reserves will continue to decrease annually, potentially threatening both resource sustainability and income stability. Therefore, strengthening sustainable forest management through collaboration between local communities and relevant institutions, supported by training and capacity-building programs, is essential to ensure responsible utilization, maintain forest ecosystem functions, and secure long-term benefits from non-timber forest products.

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