

# Optimization of wood waste from logging concession for local communities in tropical forest in Indonesia

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**Abstract.** Ruslim Y, Sari DR, Kristiningrum R, Purwanti E, Malik FB. 2026. Optimization of wood waste from logging concession for local communities in tropical forest in Indonesia. *Asian J For* 10 (1): r100106. <https://doi.org/10.13057/asianjfor/r100106>. Timber harvesting in selective logging in tropical forest often produces significant amount of wood wastes which arises due to technical errors in the field and inappropriate planning. Instead of being left in the forest, harvesting waste might be utilized by local community, but this optimization might need information on the classification and potential use of wood waste. This study aims to determine the amount of timber harvesting waste generated by logging concession and identify the potential utilization of wood waste for the surrounding community for subsistence and small scale commercial needs. The study was conducted at a logging concession in Berau District, East Kalimantan Province, Indonesia, with wood wastes were collected at six felling plots totalling six ha and two log landing areas (TPn). The most prevalent waste type in the felling plots was tree stump with a volume of 24.58 m<sup>3</sup>, followed by tree tip, base, buttress stump waste, broken stems, and wood knots with 22.44 m<sup>3</sup>, 21.63 m<sup>3</sup>, 4.18 m<sup>3</sup>, 3.5 m<sup>3</sup>, and 0.48 m<sup>3</sup>, respectively. The wood waste found at the landing site (TPn) was predominantly red meranti, with volume of 22.69 m<sup>3</sup>. The results of interviews to local communities indicated logging waste can be utilized for a range of applications, including the production of building materials, handicrafts, furniture, bioenergy, boats, household appliances, and traditional furniture. A study on the efficiency of wood waste from logging concessions and the legal framework surrounding its utilization is necessary to ensure that the use of wood waste by local communities remains both effective and compliant with legal regulations.

**Keywords:** Collaboration, empowerment, regulation, socio and economic, wood harvesting waste

## INTRODUCTION

Natural forests in Indonesia, specifically in East Kalimantan, Indonesia, have an important role in maintaining ecosystem balance and providing socio-economic benefits to surrounding community. In this regard, sustainable management of natural forests has become a major focus of national forestry policy, with special attention to social and economic aspects (Budiaman et al. 2020). Effective forest governance and management require active involvement of multiple stakeholders to address the complex challenges of forest management. Local governments play a crucial role by implementing policies that engage various stakeholders to promote sustainable forestry practices (Roengtam et al. 2023). The implementation of social forestry policies is essential for sustainable forest management and fostering community participation in forestry activities. These policies aim to balance the economic, ecological, and social needs of society, while also enhancing overall well-being (Iriyani et al. 2020).

In natural forest concession, logging accounts for the largest amount of harvesting waste (Ruslim et al. 2023). The amount of waste generated in natural forests remains significant, accounting for up to 45% of the total wood volume (Budiaman and Audia 2022). In wood extraction,

the use of low-impact logging technology, called Reduced Impact Logging (RIL), is essential to minimize environmental damage (Rotili et al. 2022). Forest biomass harvesting guidelines are designed to maintain ecological sustainability when collecting residues for bioenergy and bioproducts, supporting social acceptance of bioeconomic development (Titus et al. 2021). This method is consistent with global trends that require more productive, efficient, and eco-friendly forest management practices to promote long-term sustainability. Nevertheless, the implementation of RIL does not necessarily prevent logging waste (Lima et al. 2020), although it can reduce damage (Ruslim et al. 2016), and CO<sub>2</sub> emissions (Griscom et al. 2014, Numazawa et al. 2017, Roopsind et al. 2024). So far, RIL can achieve logging efficiency rate of 72.44% with 27.56% waste (Surasana and Limbong 2020). This waste has the potential to be utilized for further products (Roopsind et al. 2024).

Combining RIL with multistakeholder forest utilization can minimize environmental damage while providing socio-economic co-benefits to surrounding community. Previous research showed that wood harvesting utilization and waste factors in natural forests had significant implications for the quality of log production (Rianto et al. 2019). On the other hand, the multi-business forestry policy model has also been proven effective in enhancing the economy of communities around forests, as well as

reducing deforestation and forest degradation through more optimal utilization of wood waste (Soenarno et al. 2023; Wenda et al. 2023). In this context, optimizing the utilization of harvesting waste is a key strategy to improve operational efficiency and provide added value to forest community.

In many cases, wood harvesting waste in the production natural forests is underutilized despite its potential. For example, a study assessed volume of wood waste in felling plots without exploring in depth its potential utilization and socio-economic benefits (Surasana and Limbong 2020). Wood harvesting waste has not been optimally utilized (Udali et al. 2025) because some species are not commercially valuable (Budiaman et al. 2020; Budiaman and Audia 2022). In the context of East Kalimantan, such waste might be useful to be utilized for the development of the National Capital City (IKN), which has pledged to adopt the concept of a forest city with wooden houses representing the key components.

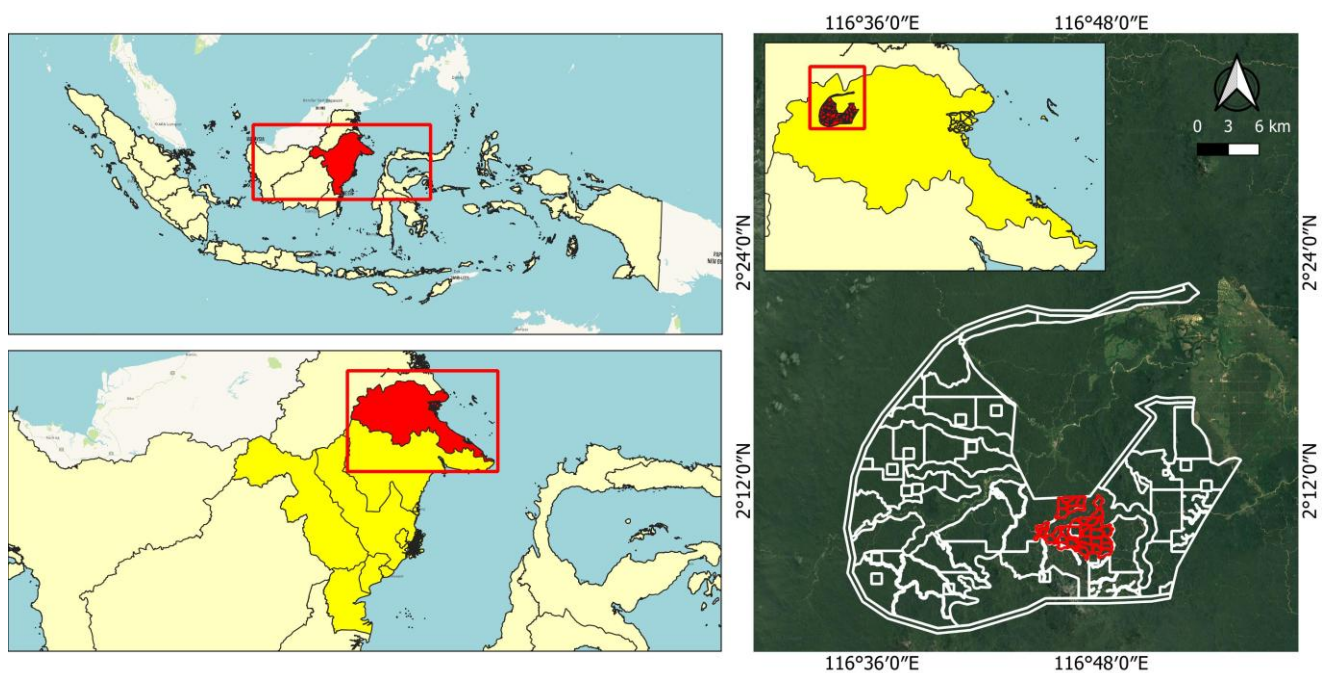
Until now, specific research on the utilization potential and socio-economic analysis of wood waste in logged-over forests is limited. Therefore, this research aims to assess the potential of wood waste produced by logging concession for utilization of local community. This study used a logging concession in East Kalimantan as case study which represents company committed to sustainable forest management. In doing so, this study will measure volume of waste, evaluate potential utilization, and analyze the socio-economic implications. A comprehensive method will be used in analyzing potential utilization of harvesting waste. The aspects to be investigated include the quantification and characterization of harvesting waste in the concession area, identification of potential waste utilization for industrial and local community purposes, as

well as recommendations for the optimization of sustainable harvesting waste utilization. The research also considers the current forestry regulatory and policy context, including efforts to improve forest governance and community participation in resource management. The results are expected to be academically relevant and provide practical input for stakeholders in the forestry sector, including the government, companies, and local community.

## MATERIALS AND METHODS

### Study area and period

The study was carried out in the area of Forest Utilization Business Permit in natural forest (PBPH-HA) of PT Sumalindo Lestari Jaya IV (SLJ IV). The administrative location of PT SLJ IV is Segah Sub-district, Berau District, East Kalimantan Province, Indonesia. Its concession area is located between  $02^{\circ}04'00''$  and  $02^{\circ}21'00''$  N, and  $116^{\circ}30'00''$  and  $117^{\circ}00'00''$  E (Figure 1). The data was collected between July and October 2024 at the RKTYPH 2024 XII-04, XII-14, and XII-18 cutting blocks. The site lies between  $02^{\circ}04'00''$ - $02^{\circ}21'00''$  N and  $116^{\circ}30'00''$ - $117^{\circ}00'00''$  E (Figure 1). The concession area is 63,550 hectares with the vegetation is dominated with secondary natural forest. The topography is medium to steeply sloping, with the soil types primarily podzolic and latosol. The minimum monthly precipitation was 197.4 mm in January and the maximum was 329.8 mm in December. The forest stand composition was characterized by an uneven-aged forest, predominantly comprising species from the family Dipterocarpaceae (Ruslim et al. 2025).



**Figure 1.** Map of the study site located in a logging concession in Segah Sub-district, Berau District, East Kalimantan Province, Indonesia (Ruslim et al. 2025)

## Data collection procedures

### Determining of sample plots

The location of wood waste measurements was carried out in the RKT 2024 cutting blocks. The sampling plots were determined by employing a systematic sampling method that commenced purposively. Specifically, the plots were selected purposively within three designated logging compartments, with two plots selected per compartment, separated by approximately 100 m between plots within the compartment. The present study examined alterations in stand structure before and after harvesting. The research plots were formed into a square shape measuring 100m ×100m, and a total of six plots were created for the study.

### Wood waste data

Harvesting data were collected by measuring the diameter and height of waste in the felling plots and log landing areas (TPn). In the felling plots, subsequent to the commercial harvesting of trees with a diameter of 40 cm and above, an inventory was conducted of the residual logging waste from the stumps, bases and ends of trunks with a minimum diameter of 20 cm and a minimum length of 1 m. The dimensions of the branch-free trunk waste measured included the base diameter, tip diameter, and trunk length. Meanwhile, the measurement of wood waste was carried out at the log landing area (TPn) in two locations, namely TPn 14 and TPn 04. At the log landing area (TPn), the dimensions of the base and tip diameter, as well as the length of stem waste were also measured.

### Socio-economic data

The collection of socio-economic data was obtained through structured questionnaires, complemented with Focus Group Discussions (FGDs). The questionnaire covered a range of topics, including respondent characteristics, the types of wood harvesting waste utilised, utilisation purposes, perceived benefits, and constraints to utilisation. Prior to the primary survey, the questionnaire was subjected to a pre-test phase involving five respondents from a neighbouring community that exhibited comparable socio-economic characteristics. The objective of the pre-test was to evaluate the clarity, relevance, and interpretation of the questions by respondents. The feedback provided in the pre-test phase was utilised to refine ambiguous wording, adjust response categories, and ensure the cultural appropriateness of the questions. During the main phase of data collection, only the revised questionnaire was utilised (Buscle et al. 2022).

Social data related to the identification of potential wood waste utilization was collected in Long Laai Village, which was selected by purposive sampling since the village was closest to the PT SLJ IV company. Interviews guided using a questionnaire were conducted to 30 respondents including key figure of the village head.

### Utilization of wood waste by surrounding community

Information regarding the utilization of wood waste by the surrounding community was collected using interview method supported by questionnaires and documentation. Primary

data was processed from questionnaires submitted to key and case respondents. Key respondents were selected based on their knowledge and involvement in forestry policy and social institutions, and included village heads, traditional leaders, religious leaders and other individuals with relevant expertise. Case respondents, meanwhile, were individuals who had direct experience and involvement in forestry practices at the field level, and included people from Long Laai Village. Using these two types of respondents aimed to obtain in-depth, contextualized empirical data, as well as enabling data triangulation to increase the validity of the research results.

The questions asked to case respondents included (i) personal data, such as name, sex, religion, age, civil status, education, marital status, and the number of family members, as well as main community and forestry activities in the last three months; (ii) community origin, namely length of stay in the village, the origin of the population, reasons for settling, economic activities developed, processes for obtaining forest area land, management methods; (iii) forest access by community, comprises knowledge of village boundaries, location of house/residence, distance from the forest area, main road access, knowledge of forest area around residence, origin of knowledge about forest area, village boundary, type of village boundary, condition of forest around residence and causes of damage; (iv) community dependence and distribution of forest resource benefits, consists of land utilization, land use, protection model, and forest function benefits.

## Data analysis

### Waste volume calculation

The calculation of volume of stump and stem waste uses the following Brereton metric formula (BSN 2020):

$$V = \frac{1}{4} \pi \times \bar{D}^2 \times L$$

Where,  $V$  is volume or content of logs ( $m^3$ ),  $L$  is the length of log (m) and  $\bar{D}$  is the diameter of log (cm). The diameter of waste is measured by the following formula (Mujetahid et al. 2022):

$$\bar{D} = \frac{\bar{D}_p + \bar{D}_u}{2} = \frac{\frac{1}{2}(d_1 + d_2) + \frac{1}{2}(d_3 + d_4)}{2}$$

Where,  $\bar{D}$  is the average diameter of logs (cm),  $\bar{D}_p$  is the average diameter of the base bontos (cross-section of a log) in multiples of one full cm, obtained from the shortest ( $d_1$ ) and longest diameter ( $d_2$ ) through the center of the bontos (cm), and  $\bar{D}_u$  is the average diameter of the end bontos in full multiples of one cm, obtained from the shortest ( $d_3$ ) and longest ( $d_4$ ) diameters through the center of the bontos (cm).

Calculation of the total volume of wood waste using the following formula (Mujetahid et al. 2022):

$$VL_{tp} = VL_{tg} + VL_{bu}$$

Where,  $V_{L_{tp}}$  is the total volume of waste per tree ( $m^3$ ),  $V_{L_{tg}}$  is the volume of stump waste ( $m^3$ ), and  $V_{L_{bu}}$  is the volume of main stem waste ( $m^3$ ).

#### Identification of potential utilization of wood waste by community

This research uses the qualitative descriptive analysis method to analyze, describe, and summarize various conditions, and situations of data collected in the form of interviews or observations. The data collected is recapitulated and tabulated and a graph is made of the answers given by the respondents.

## RESULTS AND DISCUSSION

### Type of wood waste

The wood waste considered in this study were those generated from timber species with commercial value, including red meranti (e.g., *Shorea leprosula* and *Shorea parvifolia*) and yellow meranti (e.g., *Shorea gibbosa*). There were several forms of wood waste as presented in Figure 2.

### Quantification harvesting waste

The calculation of harvesting waste in natural forest logging concession was carried out by measuring waste in the felling plots across six sampling plots with size of  $100 \times 100$  m each (1 ha area), totalling 6 ha, and at the log landing area (TPn). In the felling plots, there were 69 wood waste samples covering stump, base, stem, and tip. There were two log landing areas sampled with a total of 35 wood waste samples.

The most prevalent waste in the felling plots is stump waste (A) with volume of  $24.58 m^3$ , followed by wood tip (B) and base (C) with  $22.44 m^3$  and  $21.63 m^3$ , respectively (Table 1). Meanwhile, buttress stump waste was found in three samples with volume of  $4.18 m^3$ . For stem waste due to wood knots (D) and broken stem (E), only one sample was found for each waste form with volume of  $0.48 m^3$  and  $3.5 m^3$ , respectively.

Forest harvesting wastes found at log landing areas (TPn) in sortie form were dominated by red meranti species, with an average diameter and length of 51 cm and 3.40 m, respectively. From the results of measurement in the field, the volume of waste reported at landing areas (TPn) was  $22.69 m^3$ . Waste can be caused by cutting the remaining ends of wood carried out at landing (TPn), as well as the presence of bent wood, hole trees, and knots or defects.

Table 1. The volume of timber harvesting waste in logging plots

Plot	Average volume of stump waste ( $m^3$ )	Average volume of buttress stump waste ( $m^3$ )	Average volume of base waste ( $m^3$ )	Average volume of wood knots of stem waste ( $m^3$ )	Average volume of broken stems waste ( $m^3$ )	Average volume of tip waste ( $m^3$ )
Plot 1	0.30	-	0.12	-	-	0.21
Plot 2	0.56	1.27	0.95	0.48	3.5	0.45
Plot 3	0.49	-	0.34	-	-	0.58
Plot 4	0.32	1.65	0.21	-	-	0.47
Plot 5	0.29	-	0.32	-	-	0.17
Plot 6	0.33	-	0.43	-	-	0.15
Total	24.58	4.18	21.63	0.48	3.5	22.44



Figure 2. Form of logging waste in felling plots: A. Buttress stump waste, B. Tip waste, and C. Base waste and landing areas, D. Wood knots, and E. Broken stem

**Potential utilization of wood waste by the surrounding community**

*General description of Long Lai Village*

Long Laai Village is located on the banks of the Mahakam River, which is a tributary of the Segah River in the Segah Sub-district. According to Decree No. 942 of 2013, the village is situated in area across several statuses, i.e. Forestry, Non-Forestry, and Protected Forest with an altitude between 400 to 500 above sea level and an air temperature ranging from 25-30°Celsius. Administratively, Long Laai Village consists of four hamlets (RT), namely RT 1, 2, 3, and 4. The village borders Bulungan District, Long Ayap, Punan Mahkam, and Punan Segah to the north, east, south, and west, respectively. The distance from the capital of Berau District (Tanjung Redeb) is approximately 143 km, and can be reached by car (road) and boat (river) for 4-5 hours and 8-10 hours, respectively with cost approximately IDR 2,500,000 using a 4WD car. The majority of villagers are indigenous community of Dayak Gaai tribe although there are families from the Dayak Punan, Kenyah, Javanese, Bulungan, Timorese, Bugis and Banjar that mingle to maintain harmony and cohesiveness. The majority of religions practiced by Long Laai residents are Catholicism, Christianity, and Islam.

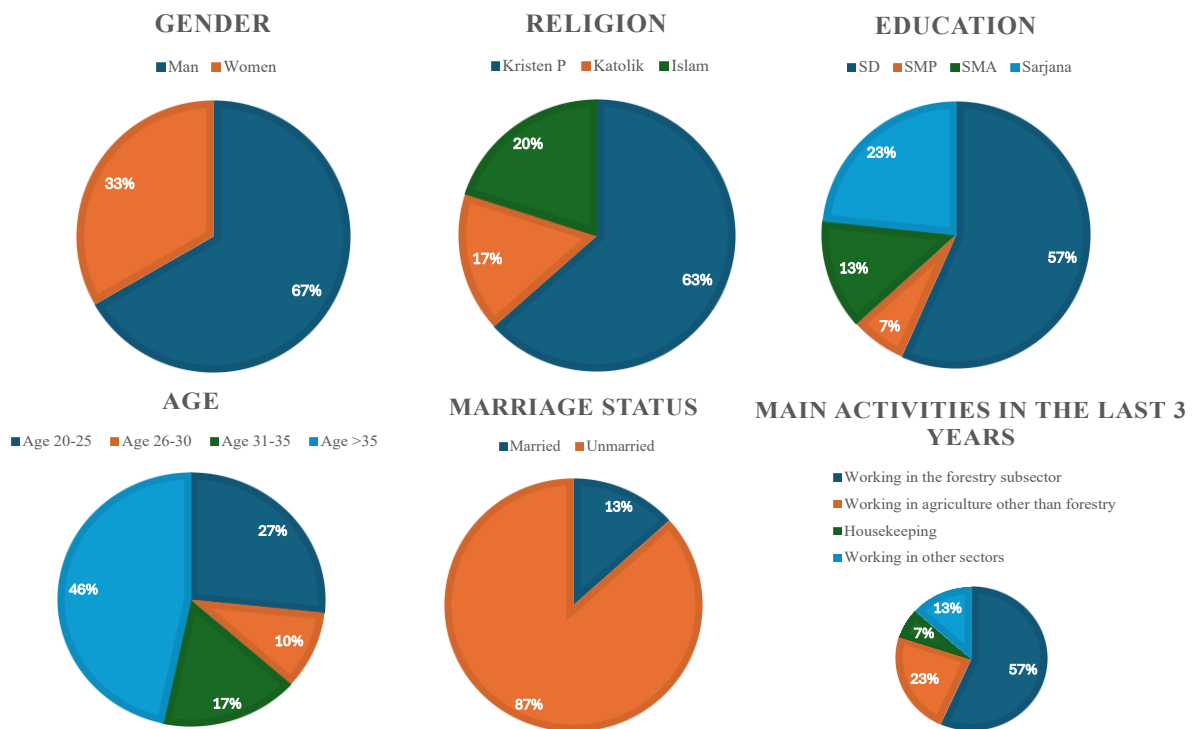
The area of PT SLJ IV is located within the administrative of Long Laai Village, thus collaboration and understanding between the company and villagers are vital for the management of natural resource in the area. The community of Long Laai Village utilize forest for hunting and gathering, which might reach the Upper Segah River and the tributaries to the border of Bulungan District. The community practice slash-and-burn agriculture to produce food resources, primarily rice. There are also lands designated as a mixed garden, consisting of fruit and wood

tree species as well as plantation crops such as cocoa. Cultivation areas are located on the left and right sides of the Segah River and the tributaries, as well as rubber, agarwood, and other hardwood plantations. The soil type in Long Laai village is generally reddish-yellow in color.

Most of the residents work as artisanal gold miners, slash-and-burn farmers, and hunters and gatherers of non-wood forest products such as agarwood, fish, and others. There are two educational facilities in the village, i.e. state elementary school (SD) and junior high school (SMP). These schools are intended for children who will continue from the elementary level, specifically those from the villages along the upstream of Segah River.

*Profiles of the respondents*

Based on gender, 67% of the respondents were male and 33% were female. Most community in Long Laai Village are Protestant Christians (Kristen P) with a percentage of 63%, followed by Muslims (Islam) and Catholics (Katolik) at 20% and 17%, respectively. A total of 57% had education at elementary school, followed by bachelor's degree (Sarjana), senior high school (SMA), and junior high school at 23%, 13%, and 7%, respectively. The average age distribution of respondents was as follows: over 35 years old (46%), 20-25 years old (27%), 31-35 years old (17%), and 26-30 years old (10%). Meanwhile, only 87% of respondents were married. Regarding the main activity in the last 3 years, 57%, 23%, 13%, and 7% worked in forestry, agriculture, other sectors and took care of the household, respectively. The visualization of the percentage of respondents' personal data can be seen in the Figure 3.



**Figure 3.** Profiles of the respondents in Long Laai Village, Segah Sub-district, Berau District, East Kalimantan, Indonesia

### *Potential utilization of wood waste by community*

The Long Laai Village community uses forest products in the form of wood for various needs such as building materials for residential houses, traditional houses, worship, offices, schools, swallows' nests and bridges, and materials for furniture, small motorized boat and furniture. For such uses, community prefers wood from the forest around the village rather than buying which are sourced from private land and not company areas. The types of wood often used are meranti, ulin, keruing, and arau wood with price ranging from IDR 1 million - 5 million per cubic meter depending on the type. Most of wood is sold to the local community for home needs or small-scale furniture. The sales outside the village are rarely carried out due to limited transportation access.

Wood processing activities undertaken by the villagers include making wooden houses, with costs depending on the size and the materials. In Long Laai village, there are two wood processing business owners, they are constrained by licensing, lack of skilled human resources, and transportation infrastructure which relying on the hauling road managed by the PT SLJ IV. The Long Laai Village community also uses firewood as fuel but some use portable LPG for daily needs. Community mainly uses firewood stored under the house when LPG is scarce or expensive and during ceremonies or traditional events.

According to interviews with respondents, there is expansion plan to develop the business by conducting pre-orders and improving the skills of local community in making furniture or wood-processing to maximize the utilization of wood. Potential markets outside Long Laai Village do exist but have not been maximized. Currently, wood is only sold to fulfil local needs and the supplies are only within the village. The expansion plan continues to face challenges, particularly concerning human resource capacities. Obtaining licenses to enter new markets remains difficult due to the complexities regarding official permits for logging, which hinder the sale of timber outside the village. Furthermore, poor road infrastructure causes transportation issues. Long Laai Village community can take strategic steps to overcome the problem of logging permits such as (i) Establishing partnerships with companies or government agencies engaged in forestry to speed up the licensing process. These partnerships provide access to technologies that facilitate sustainable logging. (ii) Community can obtain legal assistance from NGOs or legal consultants to ensure the licensing process accords with regulations. (iii) Community or local entrepreneurs can apply for formal logging licenses with authorities, such as the Forestry Service or related agencies. This provides legality for logging activities and facilitates access to broader markets. (iv) The community might forming Joint Business Groups where they can more easily apply for permits collectively. This can strengthen the position in dealing with the bureaucracy and speed up the licensing process.

Regarding the challenges in human resources, several steps can be considered, such as (i) Promoting senior or more experienced artisanal wood-makers to share knowledge and train other villagers through mentoring

programs. (ii) Establishing cooperatives or joint business groups to facilitate continuous education and management skills training for villagers. This can also improve access to necessary modern equipment. (iii) Collaborating with vocational schools, colleges, or training centers to provide formal and informal education to the villagers. In this context, the latest methods in wood processing and business management can be learned. (iv) Conducting specialized training related to wood processing, efficient and environmentally friendly logging, as well as other skills such as construction. This training can be facilitated by the government or private organizations working on rural development. Transportation issues regarding the distribution of wood can be addressed through several measures, such as (i) The local government and companies such as PT SLJ IV can collaborate on village road development programs, (ii) The use of water transportation, which can be a cheaper and more effective alternative for moving large quantities of materials to locations difficult to reach by land transportation.

Wood harvesting waste generated by PT SLJ IV shows variations in the type and volume used by the surrounding community in Long Laai Village. The types of wood waste used include stumps, ends, bases, and log waste, with the majority of the samples consisting of red and yellow meranti. Waste is generated from the cutting of residual wood ends, as well as from bent, deformed, or irregularly growing wood. The product can be used by community for various purposes such as building, furniture and handicraft products, household tools as well as making small motorized boat. For example, the construction of a wooden house with a type of 7×12 m costs IDR 35 million for the raw material. Making a small motorized boat can take about 1 week with good material such as arau or meranti wood. The price is around IDR 6-7 million per unit with a minimum boat size of 7 meters long and 1 meter wide excluding the engine. In this context, the price of engines of 18 PK and 14 PK for a small motorized boat are around IDR 18 and 16 million per unit, respectively.

The utilization of wood waste produced by PT SLJ IV can have economic value from several aspects, such as (i) providing training to local community. Wood waste can be turned into products such as handicrafts, buildings, and raw materials for the furniture industry. (ii) Wood waste can be used as fuel in the form of firewood or be processed into biomass briquettes with higher selling value. (iii) Community can be trained by PT SLJ IV or third parties such as NGOs, to enhance the ability to turn wood waste into economically valuable products. Waste management is improved by these approaches, which also create new economic opportunities by finding new uses for waste materials (Leone et al. 2025). With effective collaboration, it is anticipated that there will be greater certainty in the market for multi-business products from communities near forests. This partnership will not only enhance the well-being of local communities but also contribute to the sustainable management of forest resources (Wenda et al. 2023).

From discussions with several community leaders, waste from wood trunks in the log landing area (TPn) with

a minimum diameter and length of 30 cm and 2 m is required to meet wood needs of each household. Wood is processed into boards and beams, which can be used as building materials for houses, furniture, and door panels. Therefore, the government and the company must consider policies to process waste in the surrounding villages. Government intervention is critical to mitigate the environmental impact on communities living near forests. By providing guidance, regulations, and support, the government can direct communities towards sustainable practices (Utami et al. 2021). The Multi-Business Forestry Policy seeks to diversify the products and services derived from forests, promoting sustainability while also generating economic benefits. This policy framework can guide the creation of regulations that support various forest-related activities (Suryanto et al. 2023).

In conclusion, the findings of this study illustrate that timber harvesting operations in production forests generate wood waste with considerable potential for utilisation by the community. Evidence from PT SLJ IV indicates that the effective management of wood waste has the potential to contribute to the improvement of local livelihoods, provided that it is supported by institutional collaborations. Nevertheless, sustainable outcomes are contingent not solely on community participation, but also on integrated governance involving government authorities and forest concession holders. It is imperative to acknowledge the pivotal role of technical assistance, market facilitation, and policy support in enhancing community capacity and ensuring economic viability. Collaborative forest governance is therefore essential to optimise resource efficiency and enhance sustainable forest management in production forest landscapes.

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