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Quantification of Logging Residue from Harvesting of Rasamala Wood (*Altingia excelsa*)

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ABSTRACT: Logging residue is defined as the above-ground biomass left behind after log harvesting with a chainsaw, including branches, tops, and small trees that fall to the ground during the felling process. We investigated the logging residue from rasamala wood (*Altingia excelsa*) harvested in the Takokak Forest of Sukabumi Regency, Indonesia. The objectives of the study were to determine the percentage of logging residue volume, the locations where logging residue occurred, the percentage of barber chairs, and the relationship between tree diameter and height to the volume of logging residue. The results showed that the percentage of logging residue was 26.36%, with the residue primarily occurring at the felling site. Barber chair damage occurred in 58.8% of the total trees harvested. The larger the tree's diameter, the greater the volume of logging residue.

KEYWORDS: *Altingia excelsa*, barber chair, forest, logging residue.

INTRODUCTION

The forest on Java Island in Indonesia have been managed and controlled by Perhutani, a state-owned company overseeing approximately 2.4 million hectares of forest across Java and Madura Islands. The production forests, particularly teak and pine plantations, dominate the forested areas. In addition to teak and pine, other tree species are also planted and harvested by Perhutani. Each year, Perhutani harvests over 650,000 m³ of wood, primarily from teak, pine, mahogany, rosewood, jabon, albasia (sengon), gmelina, and rasamala [1]. Rasamala wood (*Altingia excelsa*) is one of the tree species that is the focus of this research.

Sukabumi is one of the regions in West Java Province under the management of Perhutani. The area of the Sukabumi Forest Management Unit is approximately 61,735 hectares. Every year, logging is carried out to produce logs for local consumption. According to the public summary of the Sukabumi Forest Management Unit, the log production in 2023 was 2,282 m³ of teak and 28,016 m³ of other tree species [2].

Logging residue is defined as the above-ground biomass left behind after log harvesting with a chainsaw, including branches, tops, and small trees that fall to the ground during the felling process. Tree harvesting begins with felling the tree, followed by bucking, then skidding the logs to the landing site. From there, the logs are loaded onto trucks and hauled or transported to the log yard. Each tree that is felled generates residue or residues that are not utilized and are left behind in the forest. The residue may consist of short pieces due to wood defects or breakage in the main trunk, stump, as well as parts of branches and twigs.

Some previous research showed, the percentage of logging residue in selective logging operations in natural forests in Central Kalimantan was 33.8%, and in West Sumatra it was 30.4% [3]. A study on logging residue in industrial plantation forests in South Sumatera found it to be 28.3% [4], while the logging residue in teak forest harvesting in Banyuwangi, East Java was 20.39% [5].

The objectives of this study were to analyze the percentage of logging residues generated from the harvesting of rasamala wood (*Altingia excelsa*) in the Takokak Forest of Sukabumi Regency, West Java, Indonesia. We also investigated the logging residue occurring in the log sections, main trunk stump, and branches. We calculated the percentage of barber chair and analyzing the relationship between tree diameter and height with the volume of logging residue.

STUDY LOCATION AND METHODS

Study location

The research was conducted in the work area of Perhutani on the harvesting activities of rasamala wood. The research location is in Takokak Forest of Sukabumi Regency, West Java, Indonesia. The research was carried out on logged over area plots, the selection of sample plots was carried out by purposive sampling. The number of sample trees was set at 15 percent from the number of trees

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felled per hectare. We found that 15 % were 51 trees as samples. We felled down 51 trees as replications ranging from 45−61 cm of the Diameter of the Breast Height (DBH). Measurements were carried out on as many as 6 to 7 trees for each measurement day.

Logging residue location

The measurements were taken at each location that corresponds to a stage in the forest harvesting process. These locations include (1) the felling site, (2) the landing site, and (3) the log yard.

Measurement of Logging Residue at the Felling Site

Logging residue measurements were taken after the felling of each sample tree. Logging residue refers to parts of the log that are not utilized and are left in the forest. The tree residues measured the stump, trimming the defective or broken section of the main trunk, upper section of the first branch (upper trunk), and branches.

a. **Stump**: This residue is located at the base of the tree, beneath the felling and back cut notches. The dimensions measured include diameter and height. The stump measurement is taken at the stump height (typically 10 cm) and the average stump diameter.

The formula to calculate the volume of the stump is: $0.25 * \pi d^2 . T$

d : diameter (cm)

T : stump height (cm)

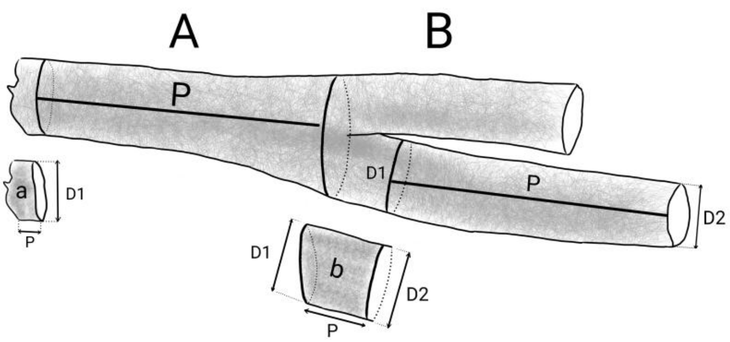

Figure 1 Measurement of the stump volume.

b. **Short trimming of the main trunk**. These short pieces consist of log that is defective or broken.

a dan b : short peace of defective or broken log

A : main trunk

B : upper trunk

D1 : diameter of base

D2 : diameter of top

P : length of log

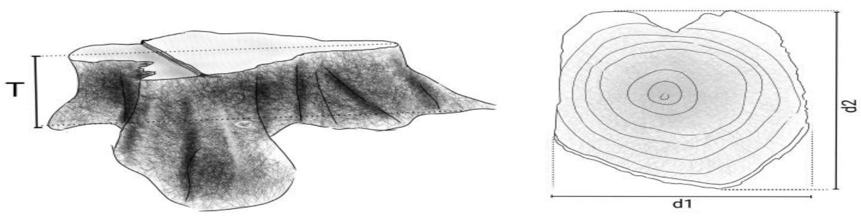

Figure 2 Short pieces of defective or broken log of main trunk

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c. **Upper trunk**: This residue refers to the section from the first branch to the crown connection of the main trunk. The dimensions measured include the base diameter, the top diameter, and the length of the trunk.

d. **Branches**: This component includes parts of the upper trunk that grow as branches on each side of the tree. Branches are distinguished from twigs, with branches typically having a diameter ≥30 cm. Measurements are taken for diameters greater than 4 cm.

Measurement of log residue at landing site

After the trees are felled and bucked, the logs are transported to the landing site. If breakage occurs at the ends of the logs, the damaged sections are cut off, resulting in additional log residue.

Measurement of log residue at log yard

The logs are transported from the landing site to the log yard. Upon arrival, there may be defects such as end breakage. These broken ends are then cut off, creating additional log residue.

Measurement of Stump Splitting (Barber Chair)

After a tree is felled, the stump remains, which may exhibit barber chair damage because of the felling process. The number of barber chairs is identified on the felled trees. Each day, 6-7 trees are felled, and the occurrences of barber chair damage are recorded.

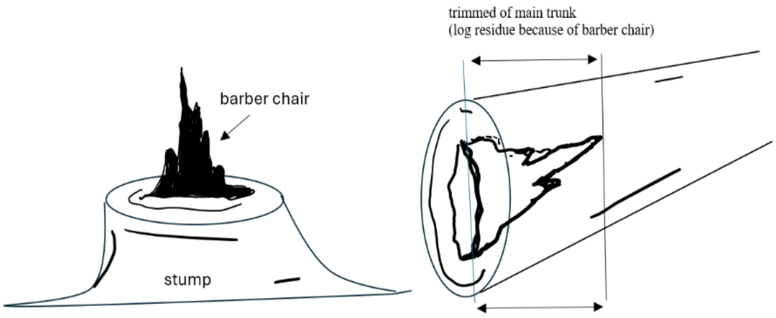

Figure 3 Barber Chair and trimmed of the main trunk.

Calculation and analysis of log residue volume

The calculation of each log residue is done using the following formula:

a. The standing tree volume is calculated based on the following formula:

$$VB = \frac{1}{4}\pi + (\frac{dbh}{100})^2 \times tbc \times f$$

VB = volume of standing tree (m^3)
π (*phi*) = konstanta (3,14)
dbh = *diameter at breast height* (dbh) of the tree (cm)
tbc = tree height up to first branch (m)
f b = form factor (0,7)

b. The volume of each piece of log residue was calculated as follows:

$$VL = \frac{1}{4}\pi \left[\frac{\frac{1}{2}(Dp + Du)}{100}\right]^2 P$$

VL = volume of the log (m^3)
π (*phi*) = konstanta (3.14)
Dp = average diameter of the base (cm)

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Du = average diameter of the top (cm)
P = length of log (m)

c. The volume of logging residue generated by each felled tree and the average residue volume per tree.

c.1. Volume of log residue in each of felled tree (m^3)=

Volume of stump (m^3) + volume of residue from main trunk (m^3) +volume of upper trunk (m^3) + volume of branches (m^3)

$$\text{c.2. Average of residue each tree } (m^3/\text{tree}) = \frac{\text{Total } residue\ (m^3)}{\text{Number of tree felled}}$$

d. The percentage of barber chair:

Percentage of barber chair = (total tree felled / the number of barber chair) x 100 %

e. Analysis of the relationship between the volume of log residue and diameter of the tree and tree height. The linier regression was used to examine the correlation and relationship between the volume of log residue and the diameter and height of the felled tree.

RESULT AND DISCUSSION

Harvesting was carried out on 51 trees. The average volume of each tree felled is 1.3 m^3. The average diameter of the trees was 49 cm, with an average total height of 29 m. In **Table 1**, the logging residue volume for each tree was around 0.35 m^3. The percentage of logging residue was 26.36%. Logging residue only occurs at the stump site. At the stump site, felling and bucking were carried out. It was the felling and bucking process that causes logging residue. After the tree was felled and divided into logs, the logs were transported from the stump site to the landing site, with an average distance of 250 m. From the collection site, the logs are transported to the log yard with an average distance of 6 km. At the landing site and log yard, it did not log damage occur. It did not need to trim the ends of the logs, so logging residue did not occur. However, in some species of wood, end cracks often occur, which causes the log to be cut at the ends, creating residue in the log yard.

Table 1 Total volume of harvested trees and percentage of the logging residue.

Location	Total volume of harvested tree from 51 trees (m^3)	Total volume of logging residue (m^3)	Volume of logging residue each tree (m^3)	Percentage of logging residue (%)
	a	b	b/51 trees	(b/a) * 100%
Stump site	67.05	17.68	0.35	26.36
Landing site	0.00	0.00		0.00
Log yard	0.00	0.00		0.00

The section of the tree that has been felled exhibits residue occurrence. Residue was present in the stump, main trunk up to the first branch, upper trunk, and branches. The highest percentage of residue occurs in the upper trunk, at 34.28%, while the smallest percentage was found in the main trunk, at 14.29% (**Table 2**) This was because the main trunk is the part of the tree that is most extensively utilized, resulting in minimal residue. In the main trunk, holes occur at the base due to the barber chair phenomenon and this section was trimmed and became logging residue.

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Table 2 Logging residue in each part of tree

Section of tree	Volume of residue from 51 tree harvested (m^3)	Volume of residue from each tree (m^3)	Percentage of volume residue in each part of tree (%)
Stump	5.38	0.11	31.43
Main trunk	2.62	0.05	14.29
Upper trunk	6.09	0.12	34.28
Branches	3.60	0.07	20.00
Total	17.68	0.35	100.00

The barber chair occurs due to the lack of skill of the chainsaw operator during the felling notch process. If the felling notch is made too deep, it tends to result in a barber chair. A barber chair occurs in the stump, where the surface is uneven, and visible wood tears are found above the stump, this is the barber chair. Because of the barber chair, a hole develops at the base part of the main trunk, which will eventually be cut. The cutting of this log's end results in the end section becoming residue. The volume of log residue from barber chair showed in **Table 3.**

Table 3 Volume of residue from barber chair at the stump

Barber chair or without barberchair	Number of & Percentage (%)	Volume of the stump (m^3)	Residue volume of main trunk trimmed because of barber chair (m^3)
Stump with barber chair	30 (58.8%)	3.79	1.94
Stump without barber chair	21 (41.2%)	1.59	0.00
Total	51 (100.00)	5.38	1.94

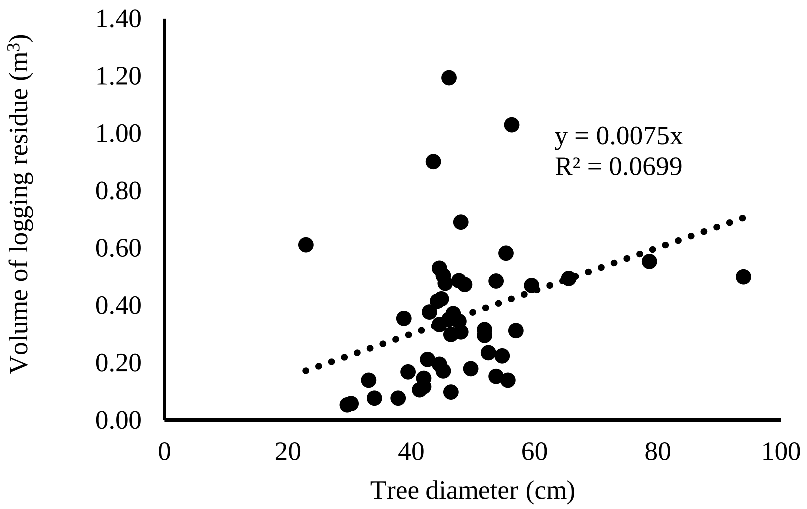

Figure 4 Relationship between tree diameter and volume of logging residue

The linier regression show the relationship between tree diameter and a number of logging residue. The diameter increase the more higher logging residue with coefisient determination R^2 = 71% (**Figure 4**).

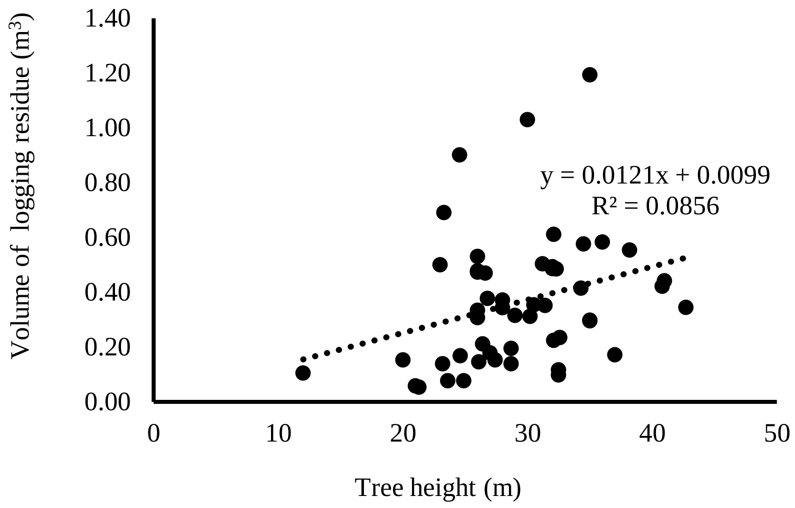

Figure 5 Relationship between tree height and volume of logging residue

The linier regression show the relationship between tree height and a number of logging residue. The tree height increases the more higher logging residue volume with coefisient determination R^2 = 8.5% (**Figure 5**). Tree diamater can explain that more than 71% volume of the logging residue caused by this factor. On the other than only 8.5% explained by the tree height.

Logging activities, such as felling and bucking the log, generally leave behind residues that can still be utilized for various energy purposes. Several studies on the utilization of logging residues for energy have been conducted in various countries [6,7,8,9,10,11,12].

Logging residue can result not only from tree felling and bucking processes, but it can also arise from residual stand damage. Trees surrounding the felled trees suffer severe damage and become residue in the forest. This residual stand damage occurs with every tree felling, manifesting as broken stems, crown injuries, and other forms of tree damage [13,14]. These logging residues leave biomass within the forest [15,16,17].

The Reduce Impact Logging (RIL) technique is expected to reduce residual stand damage while simultaneously decreasing logging residues within the forest. RIL has been shown to impact residual stand damage [18], biomass recovery [19,20], and carbon emissions [21,22]. Several studies on Reduce Impact Logging have been conducted in Indonesia [23,24].

CONCLUSION

Logging residue occurs solely at the felling site. Logging residue refers to wood parts that are not utilized and are left behind in the forest, including stumps, cuts in the main trunk, upper trunk, and branches. The total volume of logging residue is 26.36%, with the upper trunk representing the largest portion of residue in a tree. The occurrence of barber chairs at 58.8% indicates that chainsaw operators lack adequate training in proper notch cutting techniques. Tree diameter is directly related to the volume of logging residue, the larger the tree diameter, the greater the volume of waste.

REFERENCES

1. Perhutani. Company Profile. 2022. https://www.perhutani.co.id/ ; accessed on September 7th, 2024.
2. Perhutani Forest Management Unit Sukabumi. Public Summary 2023; https://www.perhutani.co.id/kph-sukabumi/; accessed on September 1st, 2024.
3. Matangaran JR, Rishadi H. Quantification of logging residue and biomass generated by an industrial plantation forest in Indonesia. International Journal of Ecology and Development. 2014; 27:77-88.
4. Matangaran JR, Anggoro R. Logging residue of teak harvesting in East Java, Indonesia (in Indonesian). Jurnal Perennial. 2012; 8(2):88-92.

5. Matangaran JR, Partiani T, Purnamasari DR. Exploitation factor and quantification of logging residue in order to increase the efficiency of harvesting natural forest (in Indonesian). Jurnal Bumi Lestari. 2013; 13(2):384-393.
6. Nurmi J. Recovery of logging residues for energy from spruce (Pices abies) dominated stands. Biomass and Bioenergy. 2007; 31(6): 375-380.
7. Liu W, Hou Y, Lu W, Yang M, Yan Y, Peng C, Yu Z. Global estimation of the eliminate change of logging residue utilization biofuels. Forest Ecology and Management. 2020; 462:18000.
8. Wikstrom F. The potential of energy utilization from logging residues with regard to availability of ashes. Biomass and Bioenergy. 2007; 31(1):40-45.
9. Pokharel R, Glara RK, Grebner DL, Grado SC. Nurmi J. Recovery of logging residues for energy from spruce (Pices abies) dominated stands. Biomass and Bioenergy. 2007; 31(6): 375-380.
10. Malinen J, Pesonen M, Maatta T, Kajanus M. Potential harvest for wood fuels (energy wood) from logging residues and first thinning in Southern Finland. Biomass and Bioenergy. 2001; 20(3):189-198.
11. Moskalik T, Gendek A. Production of Chips from Logging Residues and Their Qiality for Energy: A Review of European Literature. Forest. 2019; 10:262.
12. Stampfer K, Kanzian C. Current state and development possibilities of wood chip supply chains in Austria. Croation of Journal Forest Engineering. 2006; 27:135-145.
13. Matangaran JR, Putra EI, Diatin I, Mujahid M, Adlan Q. Residual stand damage from selective logging of tropical forests: A comparative case study in central Kalimantan and West Sumatra, Indonesia. Global Ecology and Conservation. 2019; e00688
14. Matangaran J, Rishadi H. Quantification of logging residue and biomass generated by an industrial plantation forest in Indonesia. International Journal of Ecology and Development. 2014; 27(1): 77e88.
15. Gabisa, E.W., Gheewala, S.H., 2018. Potential of bio-energy production in Ethiopia based on available biomass residues. Biomass Bioenergy. 2018; (111): 77e87.
16. RaniusT, Hämäläinen A, Egnell G, Olsson B, Eklof K, Stendahl J, Felton A. The effects of logging residue extraction for energy on ecosystem services and biodiversity: a synthesis. Journal of Environmental Management. 2018; 09; 409e425.
17. Vance ED, Prisley SP, Schilling EB, Tatum VL, Wigley TB, Lucier AA, Van Deusen PC. Environmental implications of harvesting lower value biomass in forests. Forest Ecology Management. 2018; (407): 47e56.
18. Pereira Jr R, Zweede J, Asner GP, Keller M. Forest canopy damage and recovery in reduce-impact and conventional selective logging in eastern Para Brazil. Forest Ecology and Management. 2002; 168:77-89.
19. Vidal E, West TAP, Putz FE. Recovery of biomass and merchantable timber volume twenty years after conventional and reduced-impact logging in Amazonian Brazil. Forest Ecology and Management. 2016; 376:1-8.
20. West TAP, Vidal E, Putz FE. Forest biomass recovery after conventional and reduced impact logging in Amazonian Brazil. Forest Ecology and Management. 2014; 314:59-63.
21. Ellis EA, Montero ES, Gomes IUH, Montera JAR, Ellis PW, Ward DR, Reyes PB, Putz FE. Reduced impact logging practices reduce forest disturbance and carbon emissions in community managed forest on Yucatan Peninsula, Mexico. Forest Ecology and Management. 2019; 437:396-410.
22. Griscom BW, Ellis PW, Burivalova Z, Halperin J, Marthinus D, Runting RK, Ruslandi, Shoch D, Putz FE. Reduce impact logging in Borneo to minimize carbon emissions and impact on sensitive habitats while maintaining timber yields. Forest Ecology and Management 2019; 438:176-185.
23. Sist P, Sheil D, Kartawinata K, Priyadi H. Reduce impact Logging in Indonesian Borneo: some result confirming the need for new silviculture prescriptions. Forest Ecology and Management. 2003; 415-427.
24. Bertault JG, Sist P. An experimental comparison of different harvesting intensities with reduced impact and conventional logging in East Kalimantan, Indonesia. Forest Ecology and Management. 1997; 94:209-218.

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