The residual stand damages due to log skidding using crawler tractor at one logging company in Central Kalimantan

Dulsalam*, Sukadaryati and Soenarno

Forest Products Research and Development Center, Ministry of Environment and Forestry, Bogor, 16610, Indonesia

E-mail: dul.salam@gmail.com

Abstract. An investigation on residual stand damages due to log skidding using a skidding tractor was carried out at one logging company in Central Kalimantan in 2012. The objective is to find out information about residual stand damages on trees, poles, and sapling caused by Conventional Log Skidding (CLS system) and Low Impact Log Skidding (LILS system). Data on stand potency consists of tree, pole and sapling levels as well as the number of trees felled were collected. The investigation revealed that damage to the level of standing trees, poles, and sapling skidding caused by CLS system at PT Gunung Meranti was 11.40% (Coefficient of variation/CV) 7.95%; 9.53% (CV 14.74%) and 14.84% (CV 16.92%), respectively. The average damage of standing trees, poles and sapling caused by LILS system in PT Gunung Meranti respectively was 9.85% (CV 14.00%); 7.54% (CV 9.81%) and 12,55% (CV 16.60%). LILS system could reduce the damages to the standing trees.

1. Introduction

Log skidding is one of the elements of timber harvesting activities intended to move logs from the felling sites to the log landing place on the edge of the forest roads. The tool used to skim wood in Indonesia's natural forests is usually a crawler tractor. The use of the tractor has many other advantages: (1) it can move freely between the core trees in the selective cutting system, (2) it can be used safely up to 40% slope, and (3) it can be used at a sufficiently long skid distance [1]. Steel chain tractors have a low-pressure point [2]. The Caterpillar D7G tractor has been widely used to extract wood from the felling area to the landing [3]. The use of this type of tractor requires a large investment [4]. Timber skidding activities can cause damage to residual stands, especially at the tree, pole, and sapling levels.

To reduce the damage of the residual stand, skidding activities need to be carried out in a controlled manner. This is intended to make optimal use of forest resources and minimal not only a waste of resources but also environmental disturbances. The optimal use of forest resources will increase forest productivity and harvest efficiency and will reduce the amount of harvesting waste that occurs. Increasing forest productivity and the efficiency of timber harvesting are highly demanded in the context of supplying wood industry raw materials that are adequate in quantity and quality on the one hand and minimizing environmental disruptions that occur on the other.

Logging of natural forests in Indonesia involves employs chainsaws for felling and crawler bulldozers for skidding [5]. Residual stand damage as a result of logging or forest harvesting is not only caused by felling but also by skidding. Further explained that before logging begins, the company has to design a logging plan that includes tree maps as well as topographic maps and skidding...
roadmaps. In practice, many companies conduct inaccurate inventories owing to reasons such as having prepared inappropriate skidding road plans. One of the ways to improve harvesting efficiency is to use efficient and effective skidding techniques and cause minimal damage to standing stands. The magnitude of damage to residual stands in intensive silviculture areas was 24.58% and 15.43%, which consisted of 5.86% due to felling and 9.59% due to skidding [6, 7]. The closer the stand distance from the skid trail, the higher the residual stand damage occurs [8].

Damage to the residual stand mentioned above is damage to the stand at all levels of the residual stand with a certain diameter limit. Damage to the residual stand at the level of regeneration of the stand is still very limited. This paper tries to present the residual stand damage that happens at a forest company in Central Kalimantan. The aim is to provide information on damage to residual stands at various levels of residual stands. The information is expected to be useful for implementing timber skidding activities in the field and for policymakers in log skidding.

2. Materials and Methods

2.1. Materials

The study was conducted in the concession areas at PT Gunung Meranti in Central Kalimantan. The geographical location of PT Gunung Meranti's IUPHHK-HA area is 113°46' - 114°04' and 0°16' - 0°43'LS. The research plot included Lawang Tamang Village, Sungai Hanyu District, Kapuas Regency, Central Kalimantan Province. Topographic field topography (45%) is rather steep (15-25%). The research location has an altitude of 200-800 m above sea level. Research locations included climate A (Smith & Fergusson) with the highest rainfall per month of 356 mm/month and the lowest of 86 mm/month. This research was conducted in 2012.

The materials in this study are wood that is ready for skidding, diesel, wood paint, plastic mining, and steel cables. The tools used in this study was field equipment which included skidding tractor, cameras, and stationery.

2.2. Methods

Primary data and secondary data were collected in this study. Primary data were collected through observing the potential of residual stands before skidding and observing the damage to residual stands after skidding. Observation of the potential of stands at tree level (plant that have a trunk diameter of 20 cm and up) was carried out a census in the observation plot. Observation of the potential of pole level stands (plants that have stem diameter between 10 cm to less than 20 cm) was carried out by taking samples measuring 10 m x 10 m in the sample plot. Observation of the potential of stock level saplings (plant that have stem diameter less than 10 cm and a height of 1.5 m) was carried out by taking samples of 5 x 5 m in the sample plot. Each plot is recorded by species according to the stand-level.

The procedures of the investigation were as follows:

a. Determine the location of the study purposively based on the ease of researching to achieve the stated goals and still consider population representation.

b. Make 3 observation plots for the skidding technique control and 3 plots for the conventional skidding technique at the selected location (Figure 1).

c. Observed the potential of residual stands at the level of trees, poles, and sapling before skidding which was stated by the number of stems per level of residual stands per plot. To estimate the degree of damage to trees, the Forestry Department's criteria [9] were used. Trees are considered damaged if they are one or more of the following conditions: (1) Tree canopy is damaged above 30% or a tree branch or large branch is broken and (2) Stem injury above ¼ around the trunk with a length of more than 1.5 m. The criteria for stand damage based on the percentage of standing stand damage are as follows [10]:

- Standing stand is called mild damage if damage < 25%
- Standing stand is called moderately damaged if damage between 25-50%
- Standing stand is called heavily damaged if damage > 50%
Remarks: A = The observation plots of the residual stands of tree level measuring 40 m x 40 m; B = The observation plots of the residual stands of pole level measuring 10 m x 10 m; C = The observation plots of the residual stands of sapling level measuring 5 m x 5 m

**Figure 1.** Sketch of the research plot placement

Observed residual stand damages due to CLS and LILS at the chosen location. CLS was done according to the skidding habits in the field. LILS was carried out as follows [11]: (1) skid trails were well planned; (2) good cooperation between the felling team and the skidding team; (3) improved tractor operator skills; (4) tractor operator made a planned skid trail; (5) the tractor only moved on the specified trail; (6) operators used the prepared winching path; (7) log skidding was sought not to cross rivers/grooves; (8) when skidding, the front of the skidding wood was lifted. Observations of damage to residual stands at tree level, poles and sapling were stated in the number of stems per residual stand-level per plot

2.3. **Data analysis**
Damage to the residual stand is calculated according to the formula:
- **tree level** :
  \[
  \text{JRP} \times \frac{KTP}{JTP} = \text{KTP} \tag{1}
  \]
  where, \(KTP\) = damage to standing trees left due to skidding (%), \(JRP\) = the number of residual stands at tree level damaged by skidding (trees), \(JTP\) = the number of trees remaining before the skidding (trees)
- **pole level**:
  \[
  \text{JRT} \times \frac{KTT}{JTT} = \text{KTT} \tag{2}
  \]
where, \( KTT \) = standing pole level damage due to skidding (%), \( JRT \) = number of residual stands at pole level damaged by skidding (poles), \( JTT \) = number of standing pole level stands before skidding (poles).

- Sapling level:

\[
\frac{JRPc}{KTPc} = \frac{JTPc}{JRPc}
\]

(3)

where, \( KTPc \) = stand damage left to sapling due to skidding (%), \( JRPc \) = the number of residual stand damage at sapling level by skidding (sapling), \( JTPc \) = the number of stands left before the skidding (sapling).

3. Results and Discussion

3.1. Residual damages to tree level

The results of observations of tree potential and tree level stand damage are presented in Appendix 1. From Appendix 1 it can be calculated that residual stand damages on tree are as presented in Table 1.

|              | CLS system | LILS system |
|--------------|------------|-------------|
| Plot         | Damages (%)| Plot        | Damages (%)|
| 1            | 9.42       | 1           | 9.17        |
| 2            | 12.22      | 2           | 10.71       |
| 3            | 13.46      | 3           | 10.10       |
| Total        | 35.10      | Total       | 29.98       |
| Mean         | 11.70      | Mean        | 9.99        |
| SD           | 1.19       | SD          | 0.45        |
| CV           | 10.21      | CV          | 4.48        |

SD = Standard of deviation; CV = Coefficient of variation

Damage to residual stands at tree level due to timber skidding also varies from one felling technique to another skidding technique (Table 1). The average stand damage caused by the CSL system tends to be higher when compared to the average stand damage caused by the LILS system i.e. sequentially 11.70% compared to 9.99% in PT Gunung Meranti. Meanwhile, the CV value of residual stand damage caused by the LILS system is lower than the CSL system, ie 4.48%, and 10.21%, respectively. This reflected that there were still many wood skidding work teams at PT Gunung Meranti that use the CSL system. In general, it can be said that the skidding of wood using LILS system causes the amount of damage relatively few stands compared to the CSL system. The reduced impact logging system in the tropical natural forest caused lower damage on a residual stand when compared with the conventional timber harvesting [12]. The residual stand damage caused by harvesting activity in hilly tropical forests ranged from 19.27 to 34.90% with an average of 24.37% [13]. Furthermore, the residual stand damage varied from 17 to 40% [14].

3.2. Residual damages to poles level

The recapitulation of a pole stands residual damage measurement based on attachment 2 is presented in Table 2 below.
Table 2. Residual damages to pole level

|         | CLS system | LILS system |
|---------|------------|-------------|
| Plot    | Damages (%)| Plot        | Damages (%)|
| 1       | 12.68      | 1           | 10.00       |
| 2       | 11.95      | 2           | 11.25       |
| 3       | 12.8       | 3           | 9.48        |
| Total   | 36.81      | Total       | 30.73       |
| Mean    | 12.27      | Mean        | 10.24       |
| SD      | 0.22       | SD          | 0.52        |
| CV      | 1.76       | CV          | 5.13        |

SD = Standard of deviation; CV = Coefficient of variation

The average of pole level damage caused by the CSL system tends to be higher when compared to the average of pole level damage caused by the LILS system i.e. sequentially 12.27% compared to 10.24%. As well as damage to residual stands at the tree level, LILS system also causes damage to residual stands that occur at a lower level.

Damage to residual stands due to the selective logging system at tropical forests in Central Kalimantan was higher than in West Sumatera, which was 27.8% and 22.4%, respectively [5]. Further mentioned the percentage of damage to residual stands increased with increasing intensity of logging in both locations.

3.3. Residual damages to sapling level

The recapitulation of a pole stands residual damage measurement based on attachment is presented in Table 3 below. Based on Table 3, stand damage at the level of sapling caused by the activities of skidding wood using the LILS system was lower than the CSL system. The average sapling level damage caused by the CSL system and LILS system were 14.99% and 13.01%, respectively.

Table 3. Residual damages to sapling level

|         | CLS system | LILS system |
|---------|------------|-------------|
| Plot    | Damages (%)| Plot        | Damages (%)|
| 1       | 12.59      | 1           | 13.24       |
| 2       | 18.38      | 2           | 14.04       |
| 3       | 14.01      | 3           | 11.86       |
| Total   | 44.99      | Total       | 39.05       |
| Mean    | 14.99      | Mean        | 13.01       |
| SD      | 1.74       | SD          | 0.63        |
| CV      | 11.62      | CV          | 4.86        |

SD = Standard of deviation; CV = Coefficient of variation

The results of this study showed that the average value of percentage of standing damage in the tree level was lower than at the pole level, both in the CSL system and in the LILS system, i.e. 11.70% versus 12.27% for the CSL system and 9.9% compared 10.24% for the LILS system. Likewise, the pole stand level, where the average value of the residual stand damage was lower than the sapling level either due to the CSL system or the LILS system, which was 12.27% compared to 14.99% for the CSL system and 10.24% compared to 13.01% in the LILS system. Meanwhile the results of that study by others researchers were follow 17%-40% [14]; 24.3% [13]; 33.15% for a conventional system and 19.53% for RIL system [12]. The residual damage value of damage to the residual stand from the results of this study was lower when compared to the results by other researchers. This can
be understood because of the difference in calculation of damage to residual stand, where the value on the reference results was the calculation of damage to residual stands due to logging activities while in the results of this study was caused by the activity of skidding wood. Degradation of residual stand in the form of sapling, poles, and trees that be caused by forest harvesting activity namely 14.07%; 14.73% and 11.04%, respectively [15]. That is included in the low degradation category because it implements part of reducing impact logging principles.

4. Conclusion
Damage to the level of standing trees, poles, and sapling in the CLS system at PT Gunung Meranti was 11.40%, 9.53%, and 14.84%. Meanwhile, the average damage of standing trees, poles, and sapling due to the LILS system was 9.85%, 7.54%, and 12.55%, respectively. LILS system could reduce the damages of residual standing trees. Reduced impact log skidding is recommended to be implemented in order to reduce the residual stand damaged.

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## Appendix 1. Stand potency and residual stand damage on tree level caused by log skidding

| Skidding technique/Plot | Stand potency before skidding (trees/ha) | Stand damages (trees/ha) | Damage percentage /% |
|------------------------|------------------------------------------|--------------------------|----------------------|
| CSL system             |                                          |                          |                      |
| 1                      | 276                                      | 26                       | 9.42                 |
| 2                      | 180                                      | 22                       | 12.22                |
| 3                      | 156                                      | 21                       | 13.46                |
| LILS system            |                                          |                          |                      |
| 1                      | 240                                      | 22                       | 9.17                 |
| 2                      | 168                                      | 18                       | 10.71                |
| 3                      | 198                                      | 20                       | 10.10                |

## Appendix 2. Stand potency and residual stand damage on poles level caused by log skidding

| Skidding technique/Plot | Stand potency before skidding (poles/ha) | Stand damages (poles/ha) | Damage percentage /% |
|------------------------|------------------------------------------|--------------------------|----------------------|
| CSL system             |                                          |                          |                      |
| 1                      | 426                                      | 54                       | 12.68                |
| 2                      | 318                                      | 22                       | 11.95                |
| 3                      | 258                                      | 18                       | 12.18                |
| LILS system            |                                          |                          |                      |
| 1                      | 114                                      | 12                       | 10.00                |
| 2                      | 134                                      | 15                       | 11.25                |
| 3                      | 132                                      | 12                       | 9.48                 |

## Appendix 3. Stand potency and residual stand damage on sapling level caused by log skidding

| Skidding technique/Plot | Stand potency before skidding (sapling/ha) | Stand damages (sapling/ha) | Damage percentage /% |
|------------------------|--------------------------------------------|-----------------------------|----------------------|
| CSL system             |                                            |                             |                      |
| 1                      | 6190                                       | 800                         | 12.50                |
| 2                      | 6950                                       | 1200                        | 18.38                |
| 3                      | 5500                                       | 800                         | 14.01                |
| LILS system            |                                            |                             |                      |
| 1                      | 3200                                       | 424                         | 13.24                |
| 2                      | 4500                                       | 632                         | 14.04                |
| 3                      | 5500                                       | 652                         | 11.86                |