Efficiency of timber harvesting from natural forest in Indonesia

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Abstract. The efficiency of timber harvesting and damage to residual stands is an aspect that needs serious attention because it has impacts on 1) increasing logs production, 2) saving natural forest resources, and 3) reducing the volume of the waste left in the forest has potential to create a risk of greenhouse gas emissions. This paper aims to provide information on the efficiency of timber harvesting and residual stand damage caused by harvesting activities in natural forests. The results showed that: 1) Efficiency of harvesting natural forest timber ranged from 75–86% with an average of 80.6% before applying the low impact (RIL) and varied from 82–95% with an average of 87.6% for the RIL techniques; 2) Damage to residual stands due to logging of non-RIL and RIL ranged from 27.76–40.71% with an average of 31.97% and 5–40% with an average of 22.20%, respectively; 3) The application of RIL techniques and the existence of sustainable forest management certification could improve the efficiency of timber utilization.

1. Introduction

Forest resources, especially natural forests, have ecological benefits, socio-cultural and economic functions, hence the forests need to be managed sustainably to ensure their function and maintain sustainability. Timber harvesting has a very important role in forest management activities, in terms of costs, productive time and forest sustainability. Harvesting activities may cause harvesting waste and damage to the remaining trees which difficult to avoid. The amount of timber harvesting costs reaches 30–50% of the total cost of forest management, the productive time of 40–60% of the total productive time of forest management and damage to stands of an average of 27.96% [1]. It was also stated that the most serious impact of timber harvesting that ignores the appropriate manner causes a decline in forest productivity.

In 1970-1990 through forest concession activities (as known as the permit to collect timber forest products in natural forests /IUPHHK-HA), forestry sector became the second largest state foreign exchange earner after oil and gas products, with annual production quota (APQ) logs from natural forests reach 20–40 million m³/year. The government, namely the Ministry of Forestry, determined APQ based on the exploitation factor number (EF) of 0.7. Technically EF numbers are an indicator of efficiency in timber harvesting, where the more efficient timber harvesting activities possess a greater value of EF numbers and the less wood waste, and vice versa. Timber harvesting defined as part of branch-free stems which should have been used but due to various reasons, they were left in the forest. The efficiency of wood is a comparison between wood that is actually utilized to that potential portion of branch-free stems that can be used.

Management of Indonesian natural forests has been getting better with the application of RIL (Reduced Impact logging) and low-carbon impacts (RIL-C). Improved management of natural forests is characterized by an increase in efficiency of forest harvesting and the number of business licenses to utilize timber forest products in natural forests (BLUTFP-NF) which are certified to manage sustainable production natural forest. The average efficiency of timber harvesting in 1993 was 75%, but then during 1995–2013, had a dramatic increase to 83% [2]. In fact, the efficiency of harvesting timber produced by BLUTFP-NF that obtains both the mandatory and voluntary sustainable forest management (SFM) certificates through the forest stewardship council scheme, reaches more
than 90% [3]. The number of (BLUTFP-NF) holders is 277 units with a concession area of 20.89 million ha and APQ round wood 9.10 million m³/year [4]. The numbers were less than that of 1992 when the start of forest concession rights activities reached a total of 567 units and a concession area of 60.48 million ha or compared to that of 2010, 304 units with concession area of 24.69 million ha, distributed in Kalimantan, Sumatera, Sulawesi, Maluku and Papua [5]. It was also stated that at present, the main producer of logs from natural forests in Indonesia relies only on these locations.

This study aims to obtain information on the efficiency of harvesting timber in Indonesia's natural forest. Increasing the efficiency of harvesting natural forest timber is very important for the continuity of natural production forest management.

2. Materials and methods

2.1 Time, location and materials for research

The research was carried out in Bogor in September in 2015. The materials and tools used were publications about the efficiency of forest harvesting, writing instruments, and computers.

2.2 Research procedure

2.3 The research was carried out by gathering secondary data with the details in the following:

- Collecting material in the form of results of research on the efficiency of forest harvesting;
- Reviewing the results of research in terms of aspects of timber utilization, wood waste and efficiency of timber harvesting.
- Discussing the results of the study of the efficiency of timber harvesting
- Drawing conclusions from the results of the efficiency of timber harvesting studies

2.4 Data analysis

The method of analysis used in this research is an explorative descriptive method. A descriptive exploratory method to get an idea of how the efficiency of harvesting is different for a certain period of time. The average analysis is used to see the direction of interrelation between time periods.

3. Results and discussion

3.1 Timber harvesting natural forest and reduced impact logging on natural forest

Timber harvesting is a series of forestry activities that convert trees and other biomass into forms that can be moved to other locations so that it is beneficial to the economic and cultural life of the community [5]. Initially, timber harvesting was carried out conventionally using a system called Indonesian selective logging (TPI) and since 1989, the system has been changed to Sylvicultural System of Indonesian Planting and Selective Cutting (SSIPSC). There was poor planning in the conventional timber harvesting, limited training for operators of the chainsaw and skidding tractors. Furthermore, there was no control both at the time of implementation and at the post-harvest operations. At that time, the orientation of harvesting natural forests was prioritized as the country's foreign exchange earner, thus ignoring the principle of sustainable forest management. As a result, it causes: (a) excessive open land; (b) unnecessary felling of trees; (c) soil damage and excessive erosion; and (f) logging waste happened not only at the felling site but also at Temporary Timber Collection Sites (landing places) because of the testing process and measurement of the logs (grading & scaling).
The timber harvesting process generally consists of several main activities, as follow [6]:

- Operating the stump (stump operation), the felling of trees and the establishment of the beginning of the log;
- Skidding, which is to move the logs as a whole or in the form of logs from the felling place to a landing place, with a distance of only a few hundred meters;
- Loading, which is raising wood onto the transport equipment on the landing places;
- Main transportation (major transportation), which is transportation the logs from the landing places to the final destination (Log yard or log pond);
- Unloading namely log unloading at the destination.

Recognizing the remaining limited production forests and the risk of damage to forests by conventional timber harvesting, the technique of harvesting timber in natural forests that are more environmentally friendly, namely Reduced Impact Logging (RIL) techniques began in 2001. The RIL technique initially emphasizes on improvement of harvesting planning, implementing the controlled timber harvesting and measures to prevent damage from post-harvesting operations [8]. In its implementation, in order to achieve the goal of sustainable forest management in the TPTI system, there are three criteria for the RIL concept that must be obeyed, which consist of [7]:

- Timber harvesting is not allowed to exceed forest site production capacity so that it does not threaten the sustainability of timber production in the next cutting cycle;
- Forest damage does not exceed the capacity of ecosystem recovery so that forest damage that occurs immediately recovers and forest growth (increment) is maximal;
- Timber harvesting may not cause a scarcity of commercial type.

The activity of making the notch and notch back in felling trees to determine the fall direction must be undergone correctly. Determining the correct direction of felling the tree are as follows [8]:

- Wherever possible to avoid places with many obstacles, such as rocks, fallen trees, stumps, ditches;
- If the tree is located on a slope or cliff, then the direction of felling is directed to the top of the slope or at least parallel to the contour;
- Working towards a place where the stand is relatively less;
- The direction of felling is pursued in accordance with the direction of skidding or which makes it easier and
- In areas with flat conditions the direction of felling the tree is adjusted to the canopy and position of the tree.

3.2 Development on the efficiency of the timber harvesting in forest production

3.2.1 Periode before RIL system. It is estimated that the amount of wood harvesting waste ranges from 25-35% or reaches ± 20 million m³ [9] [10] [11]. The amount of wood waste did not include waste in the form of damaged trees, branches, twigs, stumps and waste as a result of the production process. Meanwhile, the results of a study of the Forest Products Research Institute in 1976–1978 stated that the amount of waste that occurred in 24 forest companies ranged between 25–48% or reached 5–12.6 million m³. This means that the timber harvesting activity is still wasteful and the harvesting efficiency is low, which ranges from 52–75%. Some research results suggest that the efficiency of harvesting wood for the use of stems to branch free stems is presented in Table 1 [2].
Table 1 Efficiency of harvesting timber from a dry land natural forests

| Year | Harvesting effect (%) | Wood waste (%) |
|------|------------------------|----------------|
| 1985 | 80                     | 20             |
| 1988 | 83                     | 17             |
| 1993 | 75                     | 25             |
| 1995 | 86                     | 14             |
| 1996 | 80                     | 20             |
| 1997 | 80                     | 20             |

Average 80.6 19.4

Source: [3]. Data is purposely processed

The efficiency of harvesting timber which is calculated to a diameter of 30 cm is still very low, ranging from 42–56%. This means that wood waste left in the forest reaches a range of 44–58%. Meanwhile, the results of research on the damage to residual stands in 1974-1993 ranged from 23.00 to 40.71% with an average of 32.20% or included in the category of damage to medium-level stands (Table 2) [12] [7].

Table 2 Average damage to standing trees in conventional harvesting techniques

| Researcher | Location     | Average damage of residual stand (%) |
|------------|--------------|--------------------------------------|
| Tinal & Pallenewn (1974)* | East Kalimantan | 36.40 |
| Muhandis (1976)* | Puru Island | 23.00 |
| Firdinandus (1978)* | West Kalimantan | 40.71 |
| Elias (2016) | Borneo | 27.96 |
| Average | | 32.2 |

Remark: a = [7].

3.2.2. The Period after RIL system. From 2001 until now natural forest management by business license for utilization of timber forest products of natural forest has changed even better with the implementation of the principles of Sustainable Production Forest Management (SPFM) and reduced impact logging (RIL) harvesting techniques. Selection of the system and harvesting techniques must meet the requirements to: 1) minimize stand and soil damages, 2) reduce timber harvesting waste, and 3) provide good quality timber production [13].

Management of natural forest production is getting better as indicated with more efficient timber harvesting and lower damage to residual stands. Increasing efficiency of timber harvesting means increasing the volume of round wood production and ensuring more sustainability. This is simply due to the increase of production volume obtained without increasing logging area and the number of the cut trees. The Ministry of Environment and Forestry perceived direct economic benefits in the form of increase non-tax state revenues.

Advantages of the RIL timber harvesting are as follows [14]: 1) damage to fewer stands (41%); 2) the area covered by the skidding track is relatively the same (50%); (3) areas damaged by fewer road constructions (40%); (4) lower canopy opening (33%); (5) the volume of logs lost as waste was less (33%). Nevertheless, the fact in the field some IUPHHK-HK still apply RIL technology partially. This has led to the efficiency of optimal timber harvesting and many kinds of woods logging waste in the forest. The results of the 2013-2017 study had conducted in several IUPHHK-HA showed that the efficiency of timber harvesting averaged 86.3% (Table 2) and left wood waste on average by 13.7% or still far from the target set by RIL which is a maximum of 5% [15]. Therefore, the active role of the Agency for Development, Research and Innovation are still needed to continue to innovate zero-waste and environmentally friendly timber harvesting methods. The efficiency of timber harvesting at several BLUTFP-NF in 2015–2017.
Table 3. Efficiency of timber harvesting at several BLUTFP-NF in 2015–2017

| IUPHHK-HA/Location | Average of (%) | Efficiency of timber harvesting | Damage to residual stand |
|---------------------|----------------|--------------------------------|-------------------------|
| PT. Inhutani I Sambarata (East Kalimantan, mandatory, 2015) | 86 | 32.42 |
| PT. Segara Indochem (East Kalimantan, mandatory, 2015) | 77 | No data |
| PT. Karya Lestari (East Kalimantan, mandatory, 2015) | 85 | No data |
| PT. Wijaya Sentosa (Papua, voluntary, 2016) | 88 | 25.18 |
| PT. Jati Dharma Indah Plywood Industries (Papua, mandatory, 2016) | 86 | 20.95 |
| PT. Prosperity of Berkah Timber (East Kalimantan, voluntary, 2014) | 92 | No data |
| PT. Kayu Tribuana Rama (Central Kalimantan, voluntary, 2016) | 84 | 24.93 |
| PT. Ratah Timber (East Kalimantan, voluntary, 2014) | 88 | 10.43 |
| PT. Roda Mas Timber (East Kalimantan, voluntary, 2014) | 91 | 5.94 |
| PT. Belayan River Timber (East Kalimantan, voluntary, 2015) | 86 | 35.55 |
| Average | 86.3 | 22.2 |

Sources: [15] (Data purposely processed)

Based on the research results in Table 1 and Table 3, it can be illustrated that the application of RIL technology can reduce wood harvesting waste, as in Figure 1.

![Figure 1. Dynamical changes of potential logging wastes](image)

When the average of national log annual production quota is 9.1 million m³/year [4] it is estimated that the potency of logging wastes reaches ± 1.128 million m³/year. The potency of logging waste has not been utilized yet by BLUTFP-NF because of economic considerations. The research results in
2015 on BLUTFP-NF indicated that the logging efficiency depends on felled tree diameter [15]. The relationship between wood utilization efficiency shown by the value of the exploitation factor and tree diameter is presented in Figure 2.

![Figure 2. Relationship between felled tree diameter and exploitation factor](image)

Technically, it's easy to understand because cutting large-diameter trees is more difficult than smaller diameter one. Large trees in natural forests have generally buttresses, causing an imperfection for making notches. As a result, there is often an error in the direction of felling the tree causing wood to break. The broken wood not only occurs at the base of the stem but also at the end of the tree trunk even sometimes in the middle of the tree. Many factors that influence the efficiency of timber harvesting are technical, economical and ecological as well as policy aspects [2]. Of these four factors, technical logging and management policies have a greater influence on the efficiency of timber harvesting. The facts in the field indicate that differences in management conditions of BLUTFP-NF more influential than other technical factors. The size of the role of each factor varies between BLUTFP-NF and each other. This is in line with another research[19] that the efficiency of timber harvesting is mainly influenced by the systems and techniques of timber harvesting activities. Timber harvesting techniques cannot be separated from the component of timber harvesting activities, such as determining the direction of felling trees, tree cutting, skidding, loading and unloading as well as transportation. One of the most principle influences on the efficiency of wood harvesters is the habit of cutting methods carried out by chainsaw operators and skidding tractor operators who work on the basis of practicality to obtain a volume of prime quality timber. [16]

3.2.3. Impact of timber harvesting efficiency. The increasing efficiency of timber harvesting not only benefits the holders of business license for timber forest products utilization of natural forests but also the Ministry of Environment and Forestry. The impact for the holders of business license for timber forest products utilization of natural forests is that the holders will an increase in production volume which has implications for revenue from the sale of logs. Besides that, the government namely the Ministry of Forestry will increase non-tax state revenue and reduce the rate of forest exploitation. As an illustration, with the assumption that annual production quota of 9.1 million m³ / year, the selling price of logs is 2.2 million/m³, non-tax state revenue is in accordance with the regulations (Rp 271.750/m³), basic price of logs of Rp 760.000/m³ and the potency for timber to be harvested ranges from 20-30 m³/ha, the impact of increasing the efficiency of timber harvesting is presented in Table 4.

| Tree diameter (cm) | Exploitation factor value |
|-------------------|--------------------------|
| 50                | 0.91                     |
| 100               | 0.90                     |
| 150               | 0.89                     |
| 200               | 0.88                     |

\[ Y = \frac{5000}{x} + 0.05 \]
\[ R^2 = 0.7224 \]
Table 4 Impacts of the increasing timber harvesting efficiency

| Description                             | Timber harvesting efficiency (%) |
|-----------------------------------------|----------------------------------|
|                                         | Base line determination of JPT   | Before RIL | After RIL |
| Annual production quota (million m³/year) | 9,10                             | 10.354     | 10.58     |
| Additional wood volume (million m³/year)  | -                               | 0.964      | 1.480     |
| Additional value of timber sell (x IDR trillion/year) | -                               | 2,120      | 3,256     |
| Additional acquisition of PNBP (x IDR billion) | -                               | 261,967    | 402,190   |
| Extensive felling savings (ha/year)       | 32,133 - 47.700                  | 49,000 - 74,000 |

Table 4 above shows that the increased efficiency of timber harvesting increased national log production volumes ranging from 0.964 to 1.48 million m³/year with a value of Rp 2,120–Rp 3,256 trillion/year. If it is associated with a deficit of raw material requirements for the national wood processing industry, an average of 23.3 million m³/year, the increasing efficiency of timber harvesting can contribute 4–6%. In addition, the increasing efficiency of timber harvesting can increase the potential of non-tax state revenue by Rp. 288,055–Rp. 402,190 billion/year or 7–9.8% of the average non-tax state revenue target during 2011–2015 amounting to Rp. 4.1 trillion/year [4]. From Table 3 it can be seen that increasing efficiency also has an impact on the reduced area of timber harvesting which ranges from 30,000–74,000 ha/year.

4. Conclusion and suggestions

Natural forest management in Indonesia has improved, characterized by several improvements of efficiency in timber harvesting of 10.6–16.3%, additional wood volume of 0.954–1.480 million m³/year, increase in non-tax state revenue of 7–9%, reduction in felling area of 32,133–74,000 ha/year and increased fulfillment of wood deficits of 4–6% per year. Increased efficiency of timber harvesting has an impact on a) increasing round wood production, b) reducing wood waste in the forest, c) savings in natural forest resources and d) increasing non-tax state revenue. Better studies and innovations in the method of harvesting natural forest timber are still needed for the innovation of zero waste and environmentally friendly.

References

[1] Elias, Applegate, G., Kartawinata, K., Machfudh, & Klassen, A. (2001). Guidelines for Indonesia's reduced impact logging (Bogor, Center for International Forestry Research)
[2] Idris, MM, Dulsalam, Soenarno & Sukanda. 2013. Revision of exploitation factors for logging optimization. Proceedings of the Exposition of the 2012 Research Results on Forest Engineering and Forest Products Processing (Bogor, The Center for Research and Development on Forest Engineering and Forst Products Processing)
[3] Soenarno, Dulsalam, & Endom, W. 2013. Factors of exploitation in limited production forests in IUPHHK-HA PT Berkah Kemakmuran Timber. Journal of Forest Product Research (Vol. 31).
[4] Ministry of Environment and Forestry. 2016. Ministry of Environment and Forestry Statistics 2015. Jakarta: Data and Information Center.
[5] Suparto, R.S. 1982. Modern Forest Exploitation Book (Bogor, Faculty of Forestry IPB).
[6] Wiradinata, S . 1989. Logging planning for decreasing the logging wastes and the residual stand damages. Proceedings of the Seminar on Forest Exploitation (Bogor, Forest Products Research Institute)
[7] Elias. 2008. *Forest Area Opening*. IPB Press. Bogor.

[8] Elias. (2016). *Application of reduced impact logging in order to reform forest exploitation and corruption in Indonesia's tropical natural forest management* (Bogor, Faculty of Forestry, IPB).

[9] Klassen, A. (2011). *Consideration in planning low impact logging*. (Hasbillah, Ed.) Jakarta: Tropical Forest Foundation.

[10] Silitonga, Jam & Hiras S. (1980). *Supervision is needed to reduce waste and ensure forest sustainability*. Proceedings of the Seminar on Forest Exploitation in Cisarua on July 8, 1980. (Bogor, Forest Products Research Institute)

[11] Sumitro, A. (1980). *Skidding methods to reduce waste and damage to stands live in forests outside Java*. Proceedings of the Seminar on Forest Exploitation in Cisarua on July 8, 1980 (Bogor, Forest Products Research Institute)

[12] Wiradinata, S & Widarmana, S (1980). *Logging planning for reduced waste and damage to residual stands*. Proceedings of the forest exploitation seminar (Bogor, Forest Products Research Institute)

[13] Wahyudi. (2013). *Silviculture system in Indonesia theory and implementation*. Palangka Raya: Palangka Raya University.

[14] Ruslandi. (2013). *Application of low-carbon impact logging (RIL-C)*. Jakarta: The Nature Conservancy.

[15] Soenarno, Endom, W., Basari, Z., Suhartana, S., Dulsalam, & Yuniawati. (2016). Factors of forest exploitation in the East Kalimantan Sub Region. *Journal of Forest Product Research*, 34(4), 335–348.

[16] Mansyur, A., Tirkaamiana, M., & Sutejo, H. (2013). Harvesting waste and IUPHHK-HA exploitation factors PT Rizki Kacida Reana, Paser Regency, East Kalimantan Province. *AGRIFOR, XII*, 116–131.

[17] Putz, FE, Dykstra, DP, & Heinrich, R. (2000). *Why Poor Logging Practices Persist in the Tropics* (Vol. 14).