Jurnal Belantara Vol. 8, No.2, August (336-347)
DOI: 10.29303/jbl.v8i2.1128
E-ISSN 2614-3453
P-ISSN 2614-7238

WORKING TIME, PRODUCTIVITY, AND COSTS OF MANUAL WOOD EXTRACTION IN PRIVATE FOREST COOPERATIVE IN PROBOLINGGO, EAST JAVA

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Received: 24/03/2025, Revised: 12/08/2025, Approved: 14/08/2025

ABSTRACT

Private forests in Indonesia mainly located in area where there are no transportation road network face problems in selecting wood extraction techniques. One of wood extraction techniques used was wood extraction technique using human power. The study aimed to analyze working time, productivity, and costs of wood extraction using human power in private forests. The study was conducted in the Alas Mandiri Private Forest Cooperative in Probolinggo, East Java. The study was carried out in two cutting blocks. The data collected included working time, productivity, and costs of wood extraction using human power. Working time data were obtained through video analysis, whereas diameter, and tree height data were collected through direct measurements in the field. Cost data was obtained through direct measurements and interviews. The results showed that wood extraction time per cycle varied from 4.49 to 16.30 minutes. The productivity of wood extraction using human power varied from 0.45 to 1.75 m^3/hour. The cost of wood extraction using human power in private forests varied from IDR. 162.03 to 266.68 /m^3/m. The skidding distance significantly affected the working time and productivity of wood extraction using human power. The study showed that the productivity of manual wood extraction decreases with increasing skidding distance. This implies that longer skidding distance, the higher the cost of wood extraction operation. The study recommends using an alternative wood extraction techniques for skidding distances exceeding 250 m.

Keywords: *human power; private forests; productivity; wood extraction; working time*

INTRODUCTION

The oldest wood extraction technique uses human power to transport wood from the forest to the landing. Recently, the method is still used in forest harvesting operations in several countries such as Indonesia (Dalya et al. 2020), Turkey (Gülci and Erdas 2018), and Thailand (Kaakkurivaara and Kaakkurivaara 2018). Forest harvesting in Türkiye is still carried out using manual systems for economic, social, and environmental reasons. Nearly 80% of forest harvesting is done mechanically in developed countries, while in Turkey only 5% uses mechanical power and the rest uses human power (Demir and Bilici 2010; Gülci and Erdas 2018).

The advantages of the manual forest harvesting system are that it is simple, environmentally friendly, creates work opportunities for the community, and is cheap. Meanwhile, the disadvantage of the system is the long working time, which directly affects the overall efficiency of the wood production process or reduces work productivity (Gülci and Erdas 2018). Manual wood skidding systems are generally used in difficult or steep terrain, where machines cannot operate (Kaakkurivaara and Kaakkurivaara 2018).

Private forests have an important role in forestry development and improving the welfare of rural communities in Indonesia (Wahyudi et al. 2018: Anatika et al. 2019). The development of private forests in Indonesia began in Java in 1930 by the Dutch colonial government (Suprapto 2010), and has been developing in almost all regions of Indonesia. The contribution of private forests to the income of private forest farmers varies from 70 to 91%, depending on the type of crops cultivated (Asmi et al. 2013; Nadeak et al. 2013; Tiurmasari et 2016).

Tree species planted in private forests in Indonesia consist of fast-growing and low-growing species. Fast-growing species are widely cultivated in private forests include gmelina (*Gmelina arborea*), sengon (*Paraserianthes falcataria*), jabon (*Anthocephalus cadamba*), and mangium (*Acacia mangium*) (Kandari et al. 2020; Wijayanto and Briliawan 2022; Wijayanto and Tsaniya 2022), while the low-growing species are teak (*Tectona grandis*), mahogany (*Swetenia mahagoni*), sungkai (*Peronema canescens*), and pulai (*Alstonia scholaris*) (Wijaya et al. 2015; Pratama et al. 2015). The private forests were a source of raw materials for the local sawmill, plywood, and bare core industries (Utama et al. 2019; Farhan et al. 2019).

Many private forests in Indonesia are developed in remote areas that have limited road network infrastructure and difficult terrain conditions (Hardjanto 2017; Dalya and Mujetahid 2019). The forest harvesting method used in private forests is the short wood (cut to length). The tree is cut using a chainsaw with lengths varying from 1-2 m. Wood extraction technique using human power by shouldering is used under certain conditions such as light wood, and short distances (Budiaman and Komalasari 2012). Poverty, lack of job opportunity in the village and low levels of education are the reasons why manual laborers work in private forest operations, including in wood transportation (Achmad et al. 2015; Hapsari et al. 2024).
A study on wood extraction using human power in Indonesia has been widely conducted in swamp forests outside Java and industrial plantation forests, whereas study in private forest is lacking. Manual wood extraction in peat swamp forests is carried out by a skidding team of 6-8 workers. The system's productivity was reported to be 1.44 m^3/hour for an average skidding distance of 135 m (Suhartana et al. 2009). Meanwhile, the productivity of wood extraction technique using human power in teak plantation forests on the island of Java was 0.78 m^3/hour (Tinambunan 2008). Therefore, the objectives of the study are: (1) to obtain knowledge about the work elements, and time consumption of wood extraction technique using human power in private forests; (2) to calculate the productivity and costs of wood extraction technique using human power in private forests; and to estimates the relationship between working time and productivity of wood extraction technique using human power and wood volume, as well as skidding distance.

METHODS

Study Site

The study was conducted in private forests owned by forest farmers who are members of the Alas Mandiri Cooperative (KAM) in partnership with PT. Kutai Timber Indonesia in Probolinggo, East Java Province. The study site was in Kertosuko Village, Krucil District, Probolinggo Regency, East Java, Indonesia. The forests were located in an area that did not have road infrastructure. The access road between the study site and the public road was a footpath of 1 m in wide. The private forests observed implemented agroforestry planting patterns between forestry plants such as balsa (*Ochroma grandiflorum* Rowlee) and sengon (*Paraserianthes falcataria*), with other plants such as coffee (*Coffea* sp), ginger (*Zingiber officinale*), cassava (*Manihot esculenta*) and porang (*Amorphophallus muelleri*).

The private forests are cut using the "necessary cut" system (cutting the tree according to the monetary needs of the forest owner). The forest harvesting method applied at the study site was the short wood method. The felled tree was bucked to a length of 130 cm. Observations of wood extraction using human power were carried out in two cutting blocks. The topography in both cutting blocks is relatively the same, flat to rather steep (slope <20%). The first cutting block (CB1) was 50 m from the landing, the second was 250 m (CB2). The sample cutting blocks were selected purposively. One of the challenges faced in study on private forest harvesting is the difficulty in finding cutting blocks. Due to the “necessary-cut” system, so the cutting isn’t always possible. At the time of the study, there were several cutting blocks, but only two cutting blocks used human power to transport the logs. The other cutting blocks. The other cutting blocks, due to their distance from the landing site, the logs will be transported by motorcycle.

The same cutting team operated both cutting blocks. The cutting teams consisted of one chainsawman, one chainsawman’s helper, and four forest workers. The age of forest workers ranged from 37 to 48 years. The observed forest workers were selected based on their length of work experience in the private forest harvesting operations. Forest workers with extensive work experience were chosen as sample workers (n= 2). The landing was located on the side of the public road, which can be passed by trucks with a 4 to 5 m^3 capacity. The study was conducted for 2 months, from January to March 2023.

Working Time Study

The wood extraction technique applied at the study site used human power by carrying the wood on the shoulders (Figure 1). The working time for wood extraction was measured by analyzing video images recorded during wood skidding operations in the field. The camera used was a digital camera that had a digital stopwatch application. Based on observations of wood extraction works using human power at the study site, five work elements were obtained, namely walking towards the wood to be transported (WTW), lifting the wood onto shoulders (LFS), loaded travel towards the landing (LTL), placing and arranging the wood at the landing (PAW), and empty travel from the landing to the cutting site (ETC) (Table 1). One cycle of wood extraction starts from walking towards the wood to be transported to empty travel from the landing to the cutting site. Working time for each work element was measured and recorded.

(a) (b)

Figure 1. Wood extraction technique using human power by shouldering at the study site: (a) one log and (b) two logs.

Table 1. Beginning and ending of work elements of wood extraction use human power at the study site

Work element	Start	Finish
Traveling toward logs to be loaded	The operator starts traveling toward the logs	The operator stopped at the logs
Lifting the logs on the shoulder	End of previous work element	The operator finished putting the logs on the shoulder
Loaded travel	End of previous work element	The operator stopped at the landing
Unloading and arranging of the logs in the landing	End of previous work element	The operator deposited the log at the landing
Empty travel	End of previous work element	The operator arrived back at the cutting site

Working Time Structure

The study used the working time classification from Bjoherden and Thompson (1995). The working time used was working time at the workplace (WP). WP consisted of time for work (WT) and not for work (NT). NT included time for chatting, smoking, eating and drinking, resting, and waiting. WT is divided into two time groups: productive time (PW) and supporting time (SW). Meanwhile, productive time consisted of main time and complementary time. The main work time of the manual wood extraction system was loaded travel, while complimentary time included the work elements of lifting wood onto shoulders and arranging wood at the landing. Supporting time (SW) was the time used to carry out preparations, which included the work elements of walking to wood to be transported and empty travel (Figure 2).

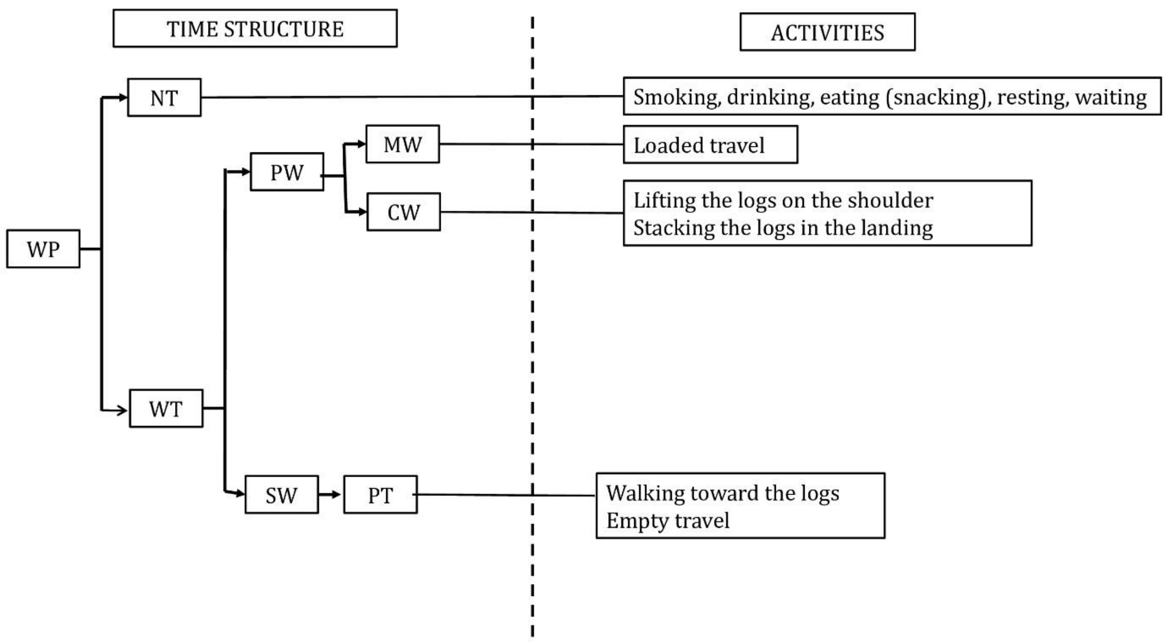

Figure 2. Classification of work time for wood extraction using human power at the research site (Bjoherden and Thompson, 1995).

Work Sampling

A preliminary study on the work time of wood extraction using human power was carried out to determine the adequacy of the data. The number of cycles observed was 73 for CB1 and 57 for CB2. Data adequacy testing referred to as Sutalaksana et al. (2006). The amount of observation data is declared sufficient if N'≤N (N'=minimum number of cycles required; N=number of cycles observed in preliminary study. The results showed that at a 95% confidence level, the N' values for the CB1 and CB2 were 40 and 39 cycles, respectively. Thus, the number of observations of 73 cycles for CB1 and 57 cycles for CB2 was theoretically sufficient for analyzing working time for wood extraction using human power. The minimum number of cycles required was calculated using the following equation:

$$N' = \left[\frac{\frac{K}{S}\sqrt{N \sum Xi^2 - (\sum Xi)^2}}{\sum Xi} \right]^2 .$$

Where:
N’= minimum number of cycles
N= number of cycles observed in preliminary study
K= confidence level, if confidence level is 95%, then K=1.96
S= sampling errors, if confidence level is 95%, then S = 5%
Xi= working time per cycle

Productivity

The productivity of wood extraction using human power was calculated based on the work-study. The diameter and length of the wood transported were measured at the landing, which was then used to calculate the volume of wood transported. The productivity of wood extraction using human power was obtained by dividing the production of wood extraction (m^3) by working time (hours). The volume of wood transported was calculated using the Brereton formula (BSN 2020):

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

Where:
V = volume of transported logs (m^3)
π = constant (3,14)
Dp = bottom diameter (cm)
Du = top diameter (cm)
P = length of transported logs (m)

Cost Analysis

The wage system of wood extraction at the study site was a daily system with effective working hours of 6 hours per day. The daily wage system is a wage system that determines the amount of wages based on the average labor productivity per day. The number of hours worked per day between activities and between locations varies, as does the amount of daily wages (Susilowati 2005). The cost per unit of wood extraction using human power was the ratio of the wages received by forest workers divided by the volume of wood transported, expressed in IDR/m^3.

RESULTS AND DISCUSSION

Working Time Distribution

The average skidding distance at CB1 was 69.09 m (standard deviation: 14.23, range: 50-102 m), while for CB2 was 293.86 m (standard deviation: 19.87, range: 252-320 m). The average working time for wood extraction using human power per cycle was 4.49 minutes (standard deviation: 1.03, range: 2.83-7.44 minutes) at CB1, while at CB2 was 16.30 minutes (standard deviation: 3.93; range 7.67-19.63 minutes). The study showed that the working time of wood extraction using human power per cycle at CB1 significantly differs from CB2 (Figure 3).

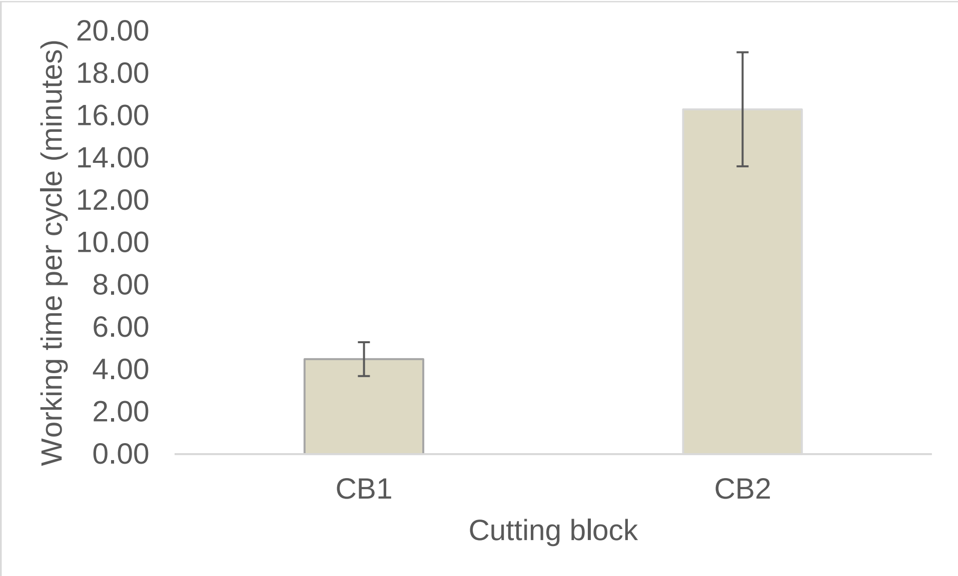

Figure 3. Average working time for wood skidding using human power per cycle at each cutting block.

Table 2. provides working time regression model of wood extraction using human power. The study showed that skidding distance was significant variable in the working time regression model of wood extraction using human power ($p<4.69E-40$)). However, logs volume was not a significant variable for estimating working time of wood extraction using human power ($p>0.42$). The appropriate equation of regression model was as follows (Adjusted R^2=0.84):

$$\text{Working time} = 0.74 + 0.06 \text{ skidding distance} - 10.98 \text{ logs volume}$$

Table 2. Analysis of variance for working time regression model of wood extraction using human power

Source	df	SS	MS	F	Significance F
Regression	2	3083.17	1541.58	258.45	2.26E-39
Residual	96	572.61	5.96		
Total	98	2655.78			

The work element of wood extraction using human power that consumes the most time is walking with a load to the landing, followed by walking without a load from the landing to the cutting block and personal delays. This applies both at CB1 and CB2. Loaded walking takes 38.31% of the time for CB1, while for CB2 was 49.53%. The work element that requires the least time is laying wood and arranging wood at the landing site, which is 1.82% for a CB1 and 0.77% for CB2 (Figure 4).

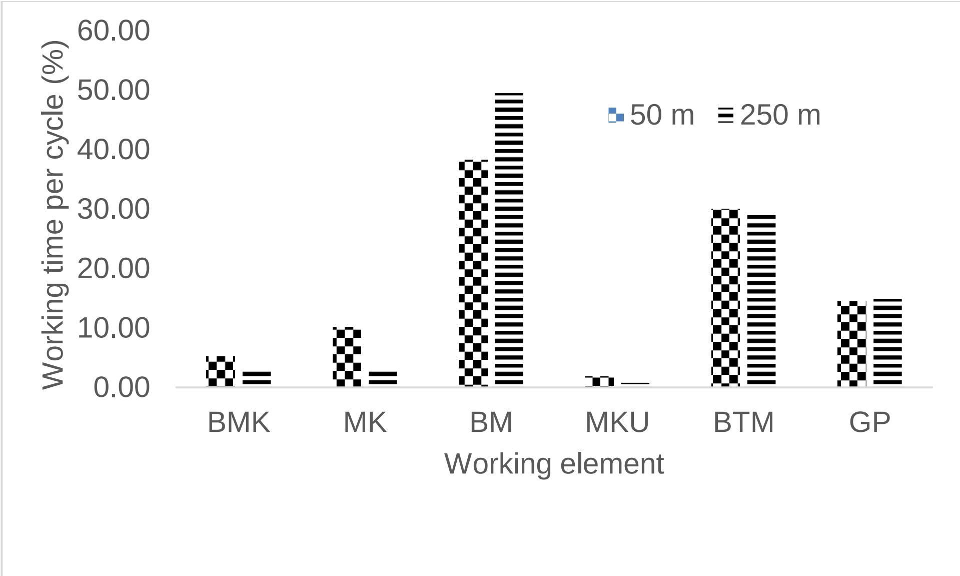

Figure 4. Distribution of work time for skidding using human power per cycle based on work elements.

Note:

MBK = walking towards the wood to be transported;
MK= lifting wood to shoulders;
BM= loaded travel;
MKU = placing and arranging wood at the landing;
BTM = empty travel;
GP= personal delay.

The results showed that around 85% of the time when wood skidding in private forests using a manual system is working time, while the remainder (15%) is non-working time. This applies both for CB1 and CB2. The distribution of time for work is respectively main time, preparation time, and additional time (Figure 5).

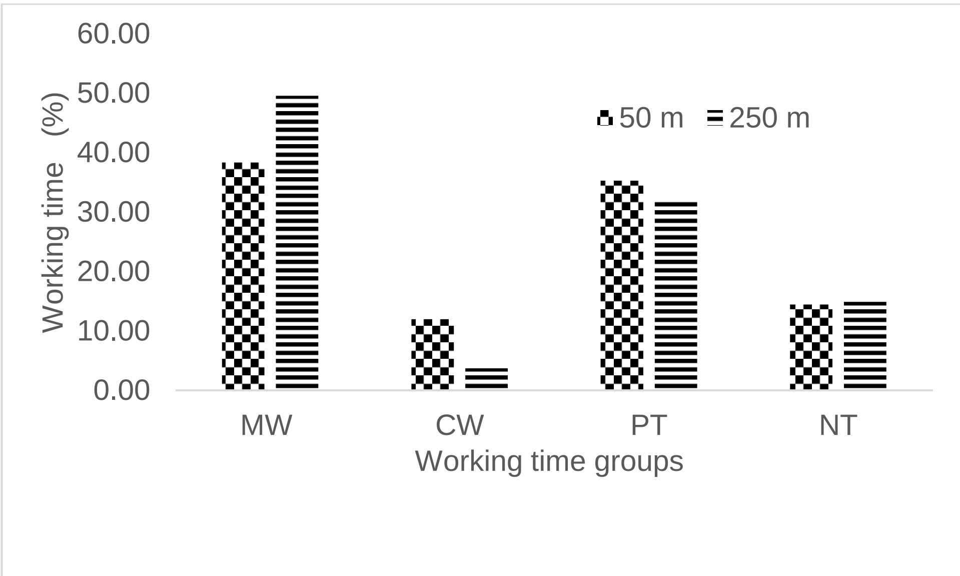

Figure 5. Distribution of work time for wood skidding using human power per cycle in private forests based on work time groups.

Note:

MW= main working time;
CW= complementary working time;
PT= productive time;
NT= non-working time

The results showed that most (84-94%) of the time when extracting wood using human power in private forests is loaded travel to the landing, empty travel, and personal delays. While the remainder (6-16%) was spent on wood extraction time, which involved walking towards the wood, lifting the wood onto the shoulders, and arranging logs at the landing. Personal delay was the highest ineffective work time in wood extraction using human power in private forests in Indonesia. Meanwhile, research on manual wood extraction in several other countries such as Turkiye shows different results, where the highest ineffective time is operational delay (Caliskan 2012). The work organization of wood extraction using human power in Türkiye is better than that in private forests in Indonesia. A well-organized work organization can reduce the time spent on personal delays.

Productivity

The average diameter of wood transported in CB1 was 17 cm with a range of 7-33 cm, while in CB2 was 20 cm with a range of 9-36 cm. The length of wood transported in both cutting plots was the same, namely 1.30 m. The results showed that the average productivity of wood extraction using human power per cycle at CB1 is greater than at CB2. The average productivity of wood extraction using human power at CB1 1 was 1.75 m^3/hour, while at CB2 was 0.45 m^3/hour (Table 3). The results showed that the productivity of wood extraction using human power per cycle for CB1 significantly differs from CB2 (Figure 6).

Table 3. Basic information on the productivity of wood extraction uses human power in private forests at the study site

Forest worker	Number of trips	Number of logs	Volume (m^3)	Working time (hours)	Productivity (m^3/hour)
Cutting block 1 (CB1)					
1	30	78	1,89	1,05	1,80
2	43	91	2,88	1,68	1,71
Summ	73	169	4,77	2,73	3,51
Average					1,76
Cutting block 2 (CB2)					
1	29	53	1,80	4,12	0,44
2	28	59	1,66	3,62	0,46
Summ	57	112	3,46	7,74	0,90
Average					0,45

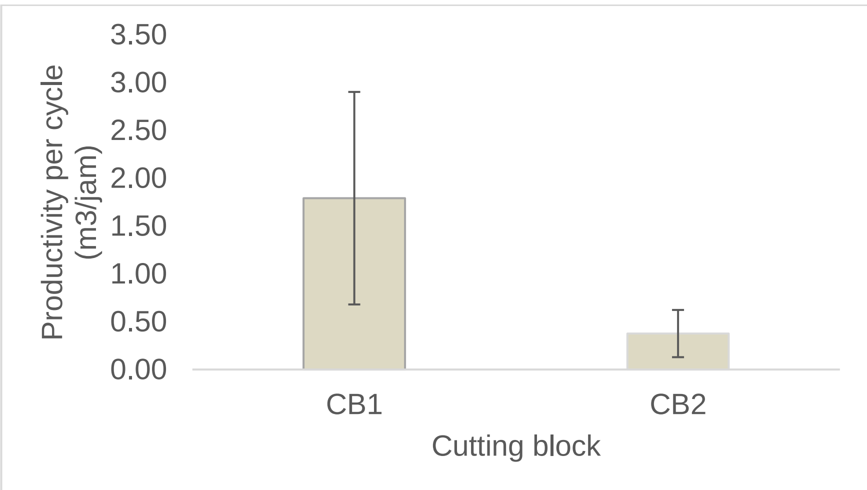

Figure 6. Average productivity of wood extraction uses human power per cycle at each cutting block.

The study showed that skidding distance was a significant variable in the productivity regression model of wood extraction using human power (p=3.81E-24) (Table 4). The equation of productivity regression model was as follows (Adjusted R^2=0.65):

$$\text{Productivity} = 1.11 - 0.0036 \text{ skidding distance}$$

Table 4. Analysis of variance for the working time regression model of wood extraction using human power

Source	df	SS	MS	F	Significance F
Regression	1	10.17	10.17	184.16	3.81E-24
Residual	97	5.36	0.06		
Total	98	15.53			

The study showed that the productivity of wood extraction using human power in private forests is 1.75 m^3/hour for average skidding distance of 69.09 m and 0.45 m^3/hour for average skidding distance of 293.86 m. The study obtained greater results compared to previous study. Kaakkurivaara and Kaakkurivaara (2018) reported that the productivity of wood extraction using human power in Thailand was 0.30 m^3/hour with a skidding distance of 25 m. Study in Thailand was conducted on terrain with a field slope of 26-41%, while the terrain conditions at the study were below 20%. The results showed that skidding distance is an important factor in transporting wood from the stump to the landing. Skidding distance determines the amount of productivity and cost per unit. For the same wood volume, wood extraction productivity decreased with increasing skidding distance, while skidding costs increased with increasing skidding distance. In general, this study obtained results that were similar to the previous research. Previous studies found that skidding distance is a key factor influencing wood skidding operations with any skidding equipments used (Kaakkurivaara and Kaakkurivaara 2018; Strandgard et al 2017; Nikooy et al 2013). ProductivityIn of wood skidding using forwarders and grapple skidders increases with shorter distances (Strandgard et al. 2017; Proto at al. 2018). A similar results will occurs when wood skidding uses other skidding tools such as animals or cables (Kaakkurivaara and Kaakkurivaara 2018); Caliskan 2012).

Skidding Cost

Based on interviews with forest workers, the average wage received was IDR 140,000/day. With 6 working hours per day, the skidding cost is IDR. 23,33/hour. Thus, the average wood skidding cost per unit is IDR. 13,330/m^3 for an average skidding distance of 69.09 m and IDR 51.851/m^3 for an average skidding distance of 293.86 m. The study showed that the cost per unit of wood skidding using human power increases with increasing skidding distance. The cost of wood skidding with an average skidding distance of 293.86 m was four times the cost of skidding wood with an average skidding distance of 69.09 m. However, wood extraction using human power is the most cost-effective skidding technique when compared to other skidding techniques, such as animal power (Kaakkurivaara and Kaakkurivaara 2018) and manual winching (Caliskan 2012). Besides, wood extraction techniques using human power in private forests in Indonesia are a profitable alternative and suitable for the conditions of communities around the private forests. The wood extraction technique using human power is not only simple and cheap but also minimizes damage to standing trees and soil, creates employment opportunities for local communities around private forests, and does not require investment. However, wood extraction techniques using human power have several weaknesses. Forest work is demanding and hazardous. As reported by Johan (2021), the massive weight of wood and the intensive transport distances can raise the risk and hard labor for forest workers. Furthermore, Kusuma et al. (2023) reported that manual materials handling activities such as lifting, lowering, and carrying materials can cause ergonomic hazards and injuries to forest workers.

An effort that can be used to reduce skidding costs is increasing skidding productivity. Increasing productivity can be done by collecting wood before the skidding operation at the felling site (pre-bunching), and using skidding equipment with a large load capacity. Nikooy et al. (2013) reported that the productivity of skidding operations increases when pre-bunching is applied in the cutting blocks. However, for wood skidding techniques using human power, increasing the carrying capacity can't be done due to human physical limitations. Increasing productivity and reducing the costs of skidding with human power can be achieved by using manual skidding tools such as a sulky (Spinelli & Magagnotti 2012). Other advantages of the use of manual skidding tools in forestry activities include reducing the potential hazards and work accidents.

The study has two potential limitations. First, the study was conducted in two cutting blocks of private forests planted with agroforestry patterns. Second, the study was conducted in the city of Probolinggo, East Java. Meanwhile, private forests can be found in almost all provinces. These two limitations lead to inaccurate generalization of the study results to a larger population. Therefore, future studies with a large sample size and across regions are crucial.

CONCLUSION

The study revealed the working time, productivity, and costs of wood extraction using human power, which is commonly used in private forest harvesting in Indonesia. Working time and productivity of wood extraction using human power are affected by skidding distance, while the volume of timber transported is non-significant. The study showed that wood extraction using human power is a cost-efficient option of private forest harvesting in term of short skidding distances. The results obtained from the study can help parties who pay attention to private forest management to understand the characteristics and performance of wood extraction using human power in private forests. The high amount of time spent on personal delays is important information for forest harvesting planners and contractors to evaluate the efficiency of wood extraction using human power in private forests. It is hoped that the results of this study can be used to improve harvesting systems, rationalize work, regulate wages, and estimate the costs of harvesting private forests in Probolinggo, East Java.

REFERENCES

Achmad, B., Purwanto, R. H., Sabarudin, S., & Sumardi. (2015). Tingkat pendapatan dan curahan tenaga kerja pada hutan rakyat di Kabupaten Ciamis. *Jurnal Ilmu Kehutanan*, 9(2), 105–116.

Anatika, E., Kaskoyo, H., Febryano, I.G., & Banuwa, I.S. (2019). Private Forest Management in Tulang Bawang Barat. *Jurnal Sylva Lestari,* 7(1), 42–51.

Asmi, M.T., Qurniati, R., & Haryono, D. (2013). Agroforestry composition and its contribution household income in Pesawaran Indah village district Pesawaran Lampung. *Jurnal Sylva Lestari*, 1(1), 55–64.

Budiaman, A., & Komalasari, P. (2012). Waste of felling and on-site production of teak square wood of the community forests. *Journal of Tropical Forest Management*, 18 (3), 164-168. doi: 10.7226/jtfm.18.3.164

Bjorheden, R. & Thompson, M.A. (1995). *An international nomenclature for forest work study*. In: Field, David B., ed. Proceedings of IUFRO 1995 S3.04 Subject Area: 20th World Congress; Tampere, Finland. Orono, Maine: University of Maine: 190-215.

[BSN] Badan Standardisasi Nasional. 2020. *SNI 8911 2020 Pengukuran dan Penetapan Isi Kayu Bundar*. Jakarta: BSN.

Caliskan, E. (2012). Productivity and cost analysis of manual felling and skidding in oriental spruce (*Picea orientalis L.*) forests. *Annals of Forest Research*. 55(2), 297-308.

Dalya, N., & Mujetahid, A. (2019). Infrastructure role of harvesting system in the community forest. *IOP Conference Series: Earth and Environmental Science*, 270, 012010. doi:10.1088/1755-1315/270/1/012010.

Dalya, N., Mujetahid, A., & Gautama, I. (2020). Study of wood harvesting system in community forest. *IOP Conference Series: Earth and Environmental Science*, 575, 012136. doi:10.1088/1755-1315/575/1/012136.

Demir, M., & Bilici. E. (2010). *Assessment of timber harvesting mechanization level in Turkey*. In: FORMEC 2010 Forest Engineering: Meeting the Needs of the Society and the Environment July 11 – 14, Padova, Italy.

Farhan, F., Sari, N. M., & Thamrin, G. A. R. (2019). Inventory of the raw materials for bare core sengon wood at Surya Satrya Timur Company, Banjarmasin. *Journal of Sylva Scienteae,* 2(3).

Gülci, N., & Erdas, O. (2018). Comparison of timber loading productivity between manual system and electric powered winch system. *European Journal Forest Engineering*, 4(1), 1-6.

Hardjanto. (2017). *Private forest management*. Bogor: IPB Press,

Hapsari, T. A., Dharmawan, A., & Sita, R. (2024). Hutan rakyat dalam sistem penghidupan rumah tangga petani dan peranannya dalam industri penggergajian kayu di pedesaan: Studi kasus Desa Prigi, Kabupaten Banjarnegara. *Jurnal Sains Komunikasidan Pengembangan Masyarakat*, 8(1), 14–28.

Johann, E. (2021). Transportation of wood out of the forest along short distances. *International Journal of Wood Culture*, 1(1-3), 80–111.

Kaakkurivaara, N., & Kaakkurivaara, T. (2018). Productivity and cost analysis of three timber extraction methods on steep terrain in Thailand. *Croatian Journal of Forests Engineering*, 39(2): 213–221

Kandari, A.M., Kasim, S., Mando, L.O.A.S., & Palebangan, S.T. (2020). Kondisi iklim dan potensi tegakan sengon (*Falcataria molluccan (Miq.*)) di hutan rakyat desa Jati Bali kabupaten Konawe Selatan. *Jurnal Belantara*, 3(2), 116–127.

Kusuma, E. W., Anisa, A. F., Intanni, R. M., Widodo, E., & Santosa, J. G. B. (2023). Manual material handling training for workers in the furniture industry. *Journal of Safety Education*, 1(2), 29–36.

Nikooy, M., Esmailnezhad, A., & Naghdi, R. (2013). Productivity and cost analysis of skidding with Timberjack 450C in forest plantations in Shafaroud watershed, Iran. *Journal of Forest Science,* 59 (7): 261–266.

Nadeak, N., Qurniati, R., & Hidayat, W. (2013). Financial analysis of agroforestry cropping patterns in Pesawaran Indah village, Padang Cermin sub-district, Pesawaran district, Lampung. *Jurnal Sylva Lestari,* 1(1): 65–74.

Proto, A. R., Macrì, G., Visser, R., Russo, D., & Zimbalatti, G. (2018). Comparison of timber extraction productivity between winch and grapple skidding: A Case study in Southern Italian Forests. *Forests*, 9, 61. doi:10.3390/f9020061.

Pratama, A.R., Yuwono, S.B., & Hilamanto, R. (2015): Private forest management by a group of community forest owners in Bandar Village, Sidomulyo District, South Lampung Regency. *Jurnal Sylva Lestari*, 3(2): 99–112.

Spinelli, R., & Magagnotti, N. (2012). Wood extraction with farm tractor and sulky: Estimating productivity, cost, and energy consumption. *Small-Scale Forestry*, 11, 73–85.

Suhartana, S., Sukanda, & Yuniawati. (2009). Productivity and cost of log skidding in peat swamp forest estate: A case study at a forest company in Riau. *Jurnal Penelitian Hasil Hutan,* 27(4), 369–380. doi: 10.20886/jphh.2009.27.4.369–380.

Sutalaksana, I.Z., Anggawisastra, R., & Tjakraatmadja, J.H. (2006). *Teknik Perancangan Sistem Kerja.* Bandung: Institut Ieknologi Bandung.

Susilowati, S.H. (2005). Gejala pergeseran kelembagaan upah pada pertanian padi sawah. *Forum Penelitian Agro Ekonomi*, 23(1), 48–60.

Suprapto, E. (2010). *Hutan Rakyat: Aspek Produksi, Ekologi dan Kelembagaan*. Seminar Nasional Kontribusi Pengurangan Emisi Karbon dari Kawasan Hutan yang Dikelola Masyarakat Secara Lestari dan Berkelanjutan. Jakarta, 29 Juli 2010.

Strandgard, M., Mitchell, R., & Acuna, M. (2017). Time consumption and productivity of a forwarder operating on a slope in a cut-to-length harvest system in a *Pinus radiata D. Don* pine plantation. *Journal of Forest Science*, 63 (7), 324–330. doi: 10.17221/10/2017-JFS

Tinambunan, D. (2008). Appropriate technology in forest harvesting in Indonesia: developments, advantages, weaknesses, and policies needed to optimize its utilization. *Journal of Forest Policy Analysis,* 5(2), 59–76. https://doi.org/10.20886/jakk.2008.5.2.%25p

Tiurmasari, S., Hilmanto, R., & Herwanti, S. (2016). Vegetation analysis and prosperous of society agroforestry organizer in the Sumber Agung village, Kemiling district, Bandar Lampung. *Jurnal Sylva Lestari,* 4(3), 71–82.

Utama, R .C., Febryano, I.G., Herwanti, S., & Hidayat, W. (2019). Marketing channels of sengon (*Falcataria moluccana*) on the local community sawn timber industry in Sukamarga Village, Abung Tinggi Sub-district, North Lampung Regency. *Jurnal Sylva Lestari*, 7(2), 195-203. http://dx.doi.org/10.23960/jsl27195-203

Wahyudi, Damiri, M., Christopheros, & Pahawang. (2018). Wood quality of *Peronema canescencs* and *Paraserianthes falcatar*ia in the community forest of Tabalong, South Kalimantan). *Jurnal Hutan Tropika*, 13(1), 10–18.

Wijaya, A., Hardjanto, & Hero, Y. (2015). Financial and income analysis of pulai (*Alstonia sp*.) private forest in Musi Rawas Regency, South of Sumatera Province. *Journal of Tropical Silviculture*, 6(3), 148–159. https://doi.org/10.29244/j-siltrop.6.3.%25p

Wijayanto, N., & Briliawan, B.D. (2022). Study on the Growth of *Falcataria moluccana* at 14-Month-Old and the Productivity of Rice Plant (*Oryza sativa*) IPB 3S in Agroforestry System*. Jurnal Sylva Lestari* 10(3): 372–388. https://doi.org/10.23960/jsl.v10i3.573

Wijayanto, N., & Tsaniya, S.H. (2022). Evaluation of an Agroforestry System: The Growth of 14-Month-Old Solomon Sengon (*Falcataria moluccana*) and Rice (*Oryza sativa*). *Jurnal Sylva Lestari,* 10(2), 254-266. https://doi.org/10.23960/jsl.v10i2.572