The ecological and economic values of secondary forest on abandoned land in Samarinda, East Kalimantan Province, Indonesia

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Short Communication: The ecological and economic values of secondary forest on abandoned land in Samarinda, East Kalimantan Province, Indonesia

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Abstract. *Karmini, Karyati, Widiati KY. 2020. Short Communication: The ecological and economic values of secondary forest on abandoned land in Samarinda, East Kalimantan Province, Indonesia. Biodiversitas 21: 5550-5558.* There is a large area of abandoned land in East Kalimantan Province. These abandoned traditional gardens which have been neglected for a long time have important ecological and economic values. This study aimed to assess the ecological and economic values of secondary forest on abandoned land in Samarinda, East Kalimantan Province. The ecological aspects assessed were stand structure, floristic composition, and species diversity. Meanwhile, the economic aspects analyzed were log price, harvesting cost, profit margin, and stumpage value. The vegetation survey was carried out on all woody trees with a diameter at breast height (DBH) $\geq$ 5 cm in 10 subplots, each measuring 20 m × 20 m. A total of 192 trees were recorded, belonging to 29 species, 19 genera and 17 families. The most dominant species were *Macaranga triloba* (Importance Value, IV of 46.16), *Macaranga tanarius* (IV of 22.97), and *Nephelium lappaceum* (IV of 20.94). The indexes of diversity, dominance, evenness, and richness in the studied plots were 1.33, 0.06, 0.40, and 5.33, respectively. The means of wood price, logging cost, profit margin, and stumpage value of the secondary forest were USD199.55 m^{-3}, USD69.01 m^{-3}, USD25.45 m^{-3}, and USD51.56 ha^{-1}, respectively. This study confirmed that the abandoned land had high ecological and economic values.

Keywords: Abandoned land, diversity, fallow land, stumpage value, tropic

INTRODUCTION

In East Kalimantan Province there is about 3 million hectares of abandoned land, consisting mainly of former coal mining land and fallow land of the shifting cultivation system which is no longer cultivated by the owners. The indigenous Dayak tribe usually replanted the land after rice harvesting with multipurpose species, such as fruit trees, rattan, and bamboo. Over time, the abandoned land will turn into secondary forest due to succession. After decades, the species richness and composition in the regrowth forests can approach old forest which can serve as biodiversity repositories (Karyati et al. 2018; Yirdaw et al. 2019).

The time required for vegetation recovery to original forest characteristics is influenced by several factors such as type of land use, cycle duration, and large cleared patches (Aththorick et al. 2012). The pioneer plant species dominate abandoned land indicated by an intermediate diversity, a low dominance index, and a high evenness index (Karmini et al. 2020; Karyati et al. 2013; Karyati et al. 2018). The rate of succession and thus the restoration of soil on abandoned land can be accelerated through plantation programs. These activities can reduce the expansion of forest conversion into cultivated areas (Klanderud et al. 2010).

Also, forest planting has an important role in providing ecological, economic, religious, and cultural functions of the secondary forest (Setiawan 2010). The average stumpage value in abandoned land was calculated to be 83.05 USD ha^{-1} and the total value 2,159.36 USD ha^{-1} (Karmini et al. 2020).

The calculation of the potential economic value of timber and non-timber forest products that can be used as onstruction materials for buildings or furniture will illustrate the potential income that might be achieved from managing abandoned land. Most of the previous studies reported information on the ecological and economic value of abandoned lands separately. The previous similar study reported the ecological and economic value of abandoned land where the previous land use was shifting cultivation (Karmini et al. 2020). However, study that provides comprehensive information on the ecological and economic value of abandoned land after being used as traditional gardens in the tropics is still very limited. The objectives of the study were to assess the ecological and economic values of secondary forest on abandoned land. The findings are expected to be used as the basis to make recommendation in managing the abandoned land in East Kalimantan and in other tropical areas.

MATERIALS AND METHODS

Study site

The research was carried out on a land area of abandoned traditional garden in Bukit Pinang area, in Samarinda Ulu Subdistrict, Samarinda City, East

Kalimantan Province, Indonesia. The research plot is located on land which is a traditional garden that has been left for more than 44 years based on land owner confirmation. The previous similar land use type of traditional gardening on this land was also reported based on interviews with land owners. The boundaries of the area are Kutai Kartanegara district at north, Samarinda Utara district at east, Air Putih Subdistrict at south, and Sungai Kunjang district at west. Samarinda City is the capital of East Kalimantan Province, Indonesia and the city with the largest population in the entire island of Kalimantan. The population of Samarinda is 812,597 people. Samarinda has an area of 718 km^2 with a hilly geographical condition with altitudes varying from 10 to 200 meters above sea level. Samarinda City is divided by Mahakan river and becomes the gateway to the area around by river, land, and air. The research plot lies at the coordinate points of 0°25′32.8″S 117°05′56.8″E (Figure 1).

Procedures

Data collection

The vegetation survey was conducted from March to September 2020. A total of 10 subplots, each measuring 20 m × 20 m, were established in the study site (Fachrul 2007; Kusmana 2017). Sub plots were established within a same abandoned land. All woody trees with a diameter at breast height (DBH) of ≥ 5 cm were measured for diameter and height, and their species were identified. The secondary data were obtained from reports and articles from previous researches (Forestry Department of Peninsular Malaysia (FDPM) (1997); Hanum et al. 2001; Noor et al. 1992; Noor and Shahwahid 1999).

Data analysis

Ecological characteristics

The following formulas were used to measure individual basal area (BA) and volume (V) (Husch et al. 1982):

Individuals BA = $\pi\ (\text{DBH}/2)^2 .\ 10^{-4}$ (1)

Individuals V = $\frac{1}{4}\ \pi \times \text{DBH}^2 .\ 10^{-4} \times \text{H} \times f$ (2)

Where: DBH is diameter at breast height (cm), 'H' is tree height (m), and 'f' is form factor.

The importance value index (IVi) was used to determine the dominant species of community within the studied plots in (Fachrul 2007):

RF = (Frequency of a species/Total of frequencies of all species) × 100 (3)

Rd = (The number of individual of a species/Total number of individuals) × 100 (4)

RD = (Total basal area for a species/Total basal area for all species) × 100 (5)

IVi = RF + Rd + RD (6)

Where: RF is relative frequency, Rd is relative density, and RD is relative dominance.

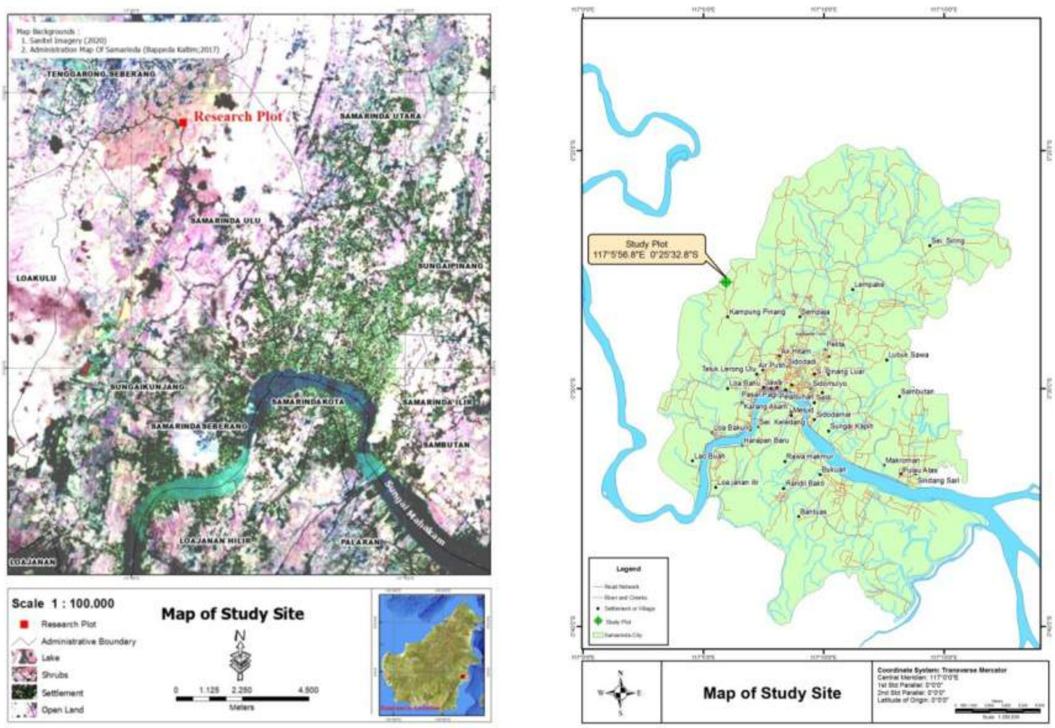

Figure 1. Map of study site in Bukit Pinang area, in Samarinda Ulu Subdistrict, Samarinda City, East Kalimantan Province, Indonesia

The four diversity indices were analyzed to describe species diversity of standing trees in the studied plots. These diversity indices were Shannon-Wiener's diversity index (*H'*), Simpson's dominance index (D_s), Pielou's evenness index (*J'*), and Margalef's richness index (*R*) (Odum and Barrett 2005):

$$H' = -\sum_{i=1}^{s}\left(\frac{n_i}{N}\right)\ln\left(\frac{n_i}{N}\right) \quad (7)$$

$$D_s = \sum_{i=1}^{s}\left(\frac{n_i}{N}\right)^2 \quad (8)$$

$$J' = \frac{H'}{\ln(S)} \quad (9)$$

$$R = \frac{(S-1)}{\ln n} \quad (10)$$

Where: n_i: number of individuals of the *i*- th species, N: total number of all the individuals in a unit area, and S: number of species in each plot.

Economic literature

Data in Table 1 shows number of logs that produced from tree diameter up to 75 cm. Based on diameter class and number of logs, the equivalent merchantable height was determined.

Reduction factor of log price was determined based on size class of DBH (Table 2). This research used assumption that the reduction factor of log price with size class of DBH < 15 cm was 0.6.

Profit ratio was fixed at 30% according to Noor and Shahwahid (1999).

Equation of profit margin was calculated as follows (Noor and Shahwahid 1999):

Table 1. Merchantable tree heights

Diameter class (cm)	Number of logs (5 m long)	Equivalent merchantable height (m)
< 15	0.5	2.5*
15 - 30	1	5
+30 - 60	2	10
+60 - 75	3	15
75 ke atas	4	20

Note: *Analyzed data; FDPM (Forestry Department of Peninsular Malaysia) (1997)

Table 2. Reduction factor of log price

DBH size class (cm)	Reduction factor
< 15	0.60*
15 - 29	0.45
30 - 44	0.30
45 - 49	0.15
50 - 54	0.025
≥ 55	0.00

Note: *Analyzed data; Noor et al. (1992) and Hanum et al. (2001)

$$PM_{ij} = \sum_{i=1}^{n}\sum_{j=1}^{k}(P_{ij} x PR)/(1+PR) \quad (11)$$

Where:

PM_{ij} : profit margin;

P_{ij} : log price for each species at sawmill and diameter class;

PR : profit ratio;

i : an index for each species (i = 1, 2, 3, 4, ..., n);

j : an index for diameter class (i = 1, 2, 3, 4, ..., n).

Logging cost of all species was USD68.03 m^{-3} (except logging cost of *Eusideroxylon zwageri* was USD102.04 m^{-3}) in research location when the research was done. The exchange rate of 1 USD was 14,740 IDR on 8 October 2020. The equation of stumpage values is presented below:

$$S_{ij} = \sum_{i=1}^{n}\sum_{j=1}^{k}V_{ij}(P_{ij} + C + PM) \quad (12)$$

Where:

S_{ij} : stumpage value for each species and diameter class (USD ha^{-1});

V_{ij} : volume of timber for each species and diameter class (m^3);

P_{ij} : log price for each species at sawmill and diameter class (USD m^{-3});

C : average logging cost (USD ha^{-1});

PM_{ij} : profit margin (USD m^{-3});

i : an index for each species (i = 1, 2, 3, 4, ..., n);

j : an index for diameter class (i = 1, 2, 3, 4, ..., n).

RESULTS AND DISCUSSION

Ecological characteristics

Diameter at Breast Height (DBH) and height distributions

The diameter distribution in the research plots shows an inverted J shape where an increase in diameter class is followed by a decrease in the number of trees (Figure 2). The number of trees in the DBH class of 5.0-15.0 cm was 134 (70%), the DBH class of 15.1-25.0 cm 32 (17%), the DBH class of 25.1-35.0 cm 20 (10%), and the DBH class of > 35.0 cm 6 (3%). Meanwhile, most of the trees (59%) belong to the 5-10 cm height class (Figure 3). The tree heights were distributed in height classes of 0.0-5.0 m (9 trees or 5%), 5.1-10.0 m (114 trees or 59%), 10.1-15.0 m (53 trees or 28%), and > 15 m (16 trees or 8%). In general, the diameter distribution of trees in secondary forest has an inverted J-shape (Feldpausch et al. 2007; Álvarez-Yépiz et al. 2008) while the distribution of height class is slightly positively skewed (Ohtsuka 1999). The The similar trends in trees diameter class and height class were also reported on abandoned land after cultivation (Karmini et al. 2020).

Density, basal area, and volume

The number of individuals recorded in the research plots was 192 trees, belonging to 29 species, 19 genera, and 17 families. There were 8 tree species of Moraceae, 5 tree species of Euphorbiaceae, 3 tree species of Anacardiaceae, and 2 tree species of Phyllanthaceae. Each of the other 11 families consisted of 1 tree species. The density, basal area, and volume of species in the study site are presented in Table 3. The DBH of trees in the study plots ranged from 6.4 cm to 29.1 cm with an average DBH of 16.3 cm. Meanwhile, the tree height ranged from 6.0 m to17.4 m with an average height of 10.4 m. The total BA and volume of trees in the study plot were 9.44 and 76.86, respectively. These values are smaller than the total BA (9.75) and the total volume (91.97) in abandoned land after cultivation (Karmini et al. 2020).

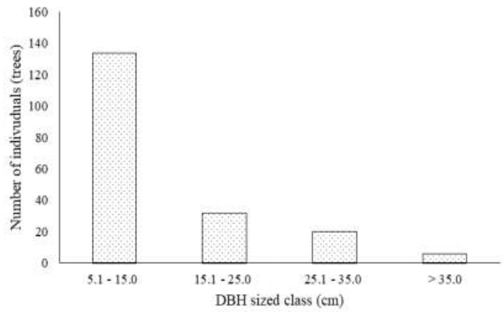

Figure 2. Distribution of diameter at breast height (DBH) in 0.4 ha at the study plot

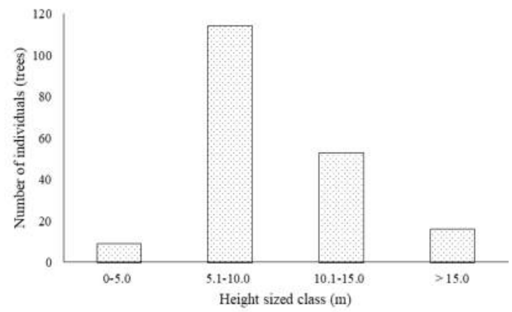

Figure 3. Distribution of height in 0.4 ha at the study plot

Table 3. Density, basal area, and volume of species (DBH of ≥ 5 cm) in the study plots

Species	Family	N	Average of DBH (cm)	Average of height (m)	Total of BA (m^2 ha^{-1})	Total volume (m^3 ha^{-1})
Macaranga tanarius	Euphorbiaceae	13	18.3	12.0	0.91	7.86
Mangifera indica	Anacardiaceae	4	29.1	17.4	0.67	7.49
Nephelium lappaceum	Sapindaceae	12	15.0	9.5	0.77	6.37
Macaranga triloba	Euphorbiaceae	48	9.7	8.7	1.00	6.05
Artocarpus integer	Moraceae	4	26.4	14.0	0.62	5.63
Trema orientalis	Cannabaceae	8	16.6	13.8	0.51	5.51
Artocarpus dadah	Moraceae	3	28.2	15.5	0.47	4.74
Artocarpus anisophyllus	Moraceae	9	14.1	9.5	0.48	4.70
Vernonia arborea	Asteraceae	4	23.6	12.1	0.46	3.69
Artocarpus odoratissimus	Moraceae	5	21.2	9.6	0.48	3.22
Homalanthus populneus	Euphorbiaceae	7	12.4	8.2	0.35	2.69
Mallotus paniculatus	Euphorbiaceae	15	9.8	8.4	0.33	2.21
Artocarpus tamaran	Moraceae	2	22.0	11.5	0.23	2.06
Ficus uncinata	Moraceae	16	10.2	8.5	0.35	2.01
Symplocos fasciculata	Symplocaceae	5	16.5	7.1	0.31	1.74
Durio zibethinus	Malvaceae	2	15.2	12.4	0.13	1.49
Macaranga gigantea	Euphorbiaceae	2	18.9	9.8	0.19	1.43
Artocarpus elasticus	Moraceae	4	15.2	8.4	0.23	1.43
Archidendron pauciflorum	Fabaceae	10	9.5	8.7	0.19	1.19
Glochidion obscurum	Phyllanthaceae	1	27.5	12.0	0.15	1.16
Baccaurea parvifolia	Phyllanthaceae	2	17.0	14.0	0.11	1.05
Cratoxylum arborescens	Hypericaceae	3	12.5	7.0	0.12	0.64
Oroxylum indicum	Bignoniaceae	2	13.7	11.3	0.08	0.60
Couroupita guianensis	Lecythidaceae	2	12.0	11.2	0.06	0.52
Artocarpus heterophyllus	Moraceae	2	13.2	11.1	0.07	0.50
Mangifera sp.	Anacardiaceae	1	18.5	10.0	0.07	0.44
Eusideroxylon zwageri	Lauraceae	2	11.8	6.0	0.05	0.21
Alstonia scholaris	Apocynaceae	3	7.9	7.4	0.04	0.20
Mangifera odorata	Anacardiaceae	1	6.4	7.3	0.01	0.04
Total		192.0	472.5	302.3	9.44	76.86
Average		6.6	16.3	10.4	0.33	2.65
Minimum		1.0	6.4	6.0	0.01	0.04
Maximum		48.0	29.1	17.4	1.00	7.86

Note: N: number of individuals (trees), DBH: diameter at breast height, BA: basal area

The five dominant species based on total basal area and volume were *Macaranga tanarius* (total BA=0.91 m^2 ha^{-1} and volume=7.86 m^3 ha^{-1}), *Mangifera indica* (total BA=0.67 m^2 ha^{-1} and volume=7.49 m^3 ha^{-1}), *Nephelium lappaceum* (total BA=0.77 m^2 ha^{-1} and volume=6.37 m^3 ha^{-1}), *Macaranga triloba* (total BA=1.00 m^2 ha^{-1} and volume=6.05 m^3 ha^{-1}), and *Artocarpus integer* (total BA=0.62 m^2 ha^{-1} and volume=5.63 m^3 ha^{-1}). The common species in abandoned land were dominated by fast growing species, such as *Macaranga* spp. and *Artocarpus* spp. as also reported by Karyati et al. (2018) and Karmini et al. (2020). The recorded fruit trees showed that the studied plot was abandoned garden. These fruit species planted were *Artocarpus anisophyllus* (Mentawa), *Artocarpus elasticus* (Benda), *Artocarpus heterophyllus* (Nangka), *Artocarpus integer* (Cempedak), *Artocarpus odoratissimus* (Terap), *Mangifera indica* (Mangga), *Mangifera odorata* (Kuweni), *Durio zibethinus* (Durian), and *Nephelium lappaceum* (Rambutan). *Artocarpus odoratissimus* is a native tree species, while *Artocarpus tamaran* is an endemic tree species.

Importance value index (IVi)

Most of the dominant trees based on importance value index (IVi) were also dominant trees based on total BA and volume. The light demanding pioneer and fast growing species dominated the studied site (Table 4). The most dominant species in terms of IVi was *Macaranga triloba* (IVi of 46.16) followed by *Macaranga triloba* (IVi of 22.97), *Nephelium lappaceum* (IVi of 20.94), *Ficus uncinata* (IVi of 18.64), and *Mallotus paniculatus* (IVi of 17.93). Twelve of 29 species recorded had an IVi of more than 10.00 and 5 species of them had an IVi of 5.00-10.00. Meanwhile the other 12 species had an IVi of less than 5.00. Four dominant species of Euphorbiaceae (*Macaranga triloba*, *Macaranga tanarius*, *Mallotus paniculatus*, and *Homalanthus populneus*) reached a total IVi of 99.72. These four species were included in the 10 most dominant types based on IVi. Similar studies also reported that tree species from Euphorbiaceae were important and dominating tropical fallow lands (Karyati et al. 2018; Karmini et al. 2020). The total IVi of 8 species including Moraceae reached 84.75. Moraceae was the family that had the most species in the research location.

Table 4. Importance value index (IVi) of trees (DBH of > 5 cm) in 0.4 hectare of the study plots

Species	Family	RF (%)	Rd (%)	RD (%)	IVi (%)
Macaranga triloba	Euphorbiaceae	25.00	10.53	10.63	46.16
Macaranga tanarius	Euphorbiaceae	6.77	6.58	9.62	22.97
Nephelium lappaceum	Sapindaceae	6.25	6.58	8.11	20.94
Ficus uncinata	Moraceae	8.33	6.58	3.72	18.64
Mallotus paniculatus	Euphorbiaceae	7.81	6.58	3.54	17.93
Artocarpus anisophyllus	Moraceae	4.69	6.58	5.11	16.37
Trema orientalis	Cannabaceae	4.17	5.26	5.44	14.87
Artocarpus odoratissimus	Moraceae	2.60	5.26	5.08	12.94
Homalanthus populneus	Euphorbiaceae	3.65	5.26	3.75	12.66
Mangifera indica	Anacardiaceae	2.08	2.63	7.05	11.77
Artocarpus integer	Moraceae	2.08	2.63	6.57	11.28
Archidendron pauciflorum	Fabaceae	5.21	3.95	2.07	11.22
Vernonia arborea	Asteraceae	2.08	2.63	4.84	9.56
Artocarpus dadah	Moraceae	1.56	2.63	4.99	9.19
Symplocos fasciculata	Symplocaceae	2.60	2.63	3.28	8.51
Artocarpus elasticus	Moraceae	2.08	2.63	2.46	7.18
Artocarpus tamaran	Moraceae	1.04	2.63	2.39	6.06
Baccaurea parvifolia	Phyllanthaceae	1.04	2.63	1.21	4.89
Macaranga gigantea	Euphorbiaceae	1.04	1.32	1.99	4.35
Eusideroxylon zwageri	Lauraceae	1.04	2.63	0.58	4.25
Cratoxylum arborescens	Hypericaceae	1.56	1.32	1.23	4.10
Durio zibethinus	Malvaceae	1.04	1.32	1.37	3.73
Glochidion obscurum	Phyllanthaceae	0.52	1.32	1.58	3.41
Alstonia scholaris	Apocynaceae	1.56	1.32	0.41	3.29
Oroxylum indicum	Bignoniaceae	1.04	1.32	0.81	3.16
Artocarpus heterophyllus	Moraceae	1.04	1.32	0.73	3.09
Couroupita guianensis	Lecythidaceae	1.04	1.32	0.66	3.02
Mangifera sp.	Anacardiaceae	0.52	1.32	0.71	2.55
Mangifera odorata	Anacardiaceae	0.52	1.32	0.09	1.92
Total		100	100	100	300

Note: RF: relative frequency, Rd: relative density, RD: relative dominance, IVI: importance value index.

Species diversity

The tree diversity index was categorized as 'intermediate' (*H*' of 1.33), indicating that there was a sufficient number of trees growing at the research location (Table 5). A very complex community is indicated by a high diversity of species (Brower et al. 1990). Meanwhile, the dominance index was at low criteria with a *D*s value of 0.06. A low dominance value indicates that no species is dominant in the region. The evenness index was in the high category (*J*' value of 0.91), meaning that the individuals of trees in the studied plots were evenly distributed among species. A species richness index of 5.33 showed that high number of tree stand exiting in the study site. There were 192 trees included in 29 tree species recorded in the studied plots. Species richness is calculated based on the number of species in an area (Krebs, 2001). The results show that high diversity (H '), evenness (J'), and wealth (R) will lead to low dominance (Ds). The similar results were reported for the diversity indices for trees with DBH of > 5 cm on plots with an abandoned field age of 5, 10, 20 years (Karyati et al. 2018) and on abandoned land after shifting cultivation (Karmini et al. 2020).

Economic value

Log price

This research found 7 trees species with higher log prices than the other 22 tree spesies (Table 6). Their log prices were in the range from USD122.12 m^{-3} to USD651.29 m^{-3}. The log price varies depending on the species and diameter class of log (Karmini et al. 2020). *Eusideroxylon zwageri* had the highest price, i.e., USD1,085.48 m^{-3}. The timber price is positively correlated with its demand in society. *Eusideroxylon zwageri* has good quality of wood, and people like to use this wood for contruction materials.

Table 5. Diversity indices of trees with DBH of ≥ 5 cm in the study plots

Diversity indices	Value
Shannon-Wiener diversity index (*H*')	1.33
Simpson dominance index (D_s)	0.06
Pielou evenness index (*J*')	0.91
Margalef species richness (*R*)	5.33

Table 6. Number of stems, log price, and wood price at the study site

Species	Family	Number (stems ha^{-1})	Log price (USD m^{-3})	Timber price (USD m^{-3})
Eusideroxylon zwageri	Lauraceae	8	651.29	1,085.48
Alstonia scholaris	Apocynaceae	13	488.47	814.11
Artocarpus anisophyllus	Moraceae	38	447.76	814.11
Oroxylum indicum	Bignoniaceae	8	427.41	814.11
Durio zibethinus	Malvaceae	8	151.37	288.33
Cratoxylum arborescens	Hypericaceae	13	130.60	237.45
Artocarpus heterophyllus	Moraceae	8	122.12	203.53
Artocarpus elasticus	Moraceae	17	74.80	142.47
Artocarpus dadah	Moraceae	13	64.11	142.47
Archidendron pauciflorum	Fabaceae	42	79.38	135.69
Nephelium lappaceum	Sapindaceae	50	64.11	122.12
Baccaurea parvifolia	Phyllanthaceae	8	54.95	122.12
Mangifera odorata	Anacardiaceae	4	30.53	50.88
Macaranga triloba	Euphorbiaceae	200	30.37	50.88
Ficus uncinata	Moraceae	67	30.05	50.88
Mallotus paniculatus	Euphorbiaceae	63	29.51	50.88
Homalanthus populneus	Euphorbiaceae	29	28.35	50.88
Symplocos fasciculata	Symplocaceae	21	27.48	50.88
Couroupita guianensis	Lecythidaceae	8	26.71	50.88
Trema orientalis	Cannabaceae	33	26.71	50.88
Macaranga gigantea	Euphorbiaceae	8	26.71	50.88
Macaranga tanarius	Euphorbiaceae	54	25.83	50.88
Artocarpus odoratissimus	Moraceae	21	24.42	50.88
Artocarpus tamaran	Moraceae	8	22.90	50.88
Artocarpus integer	Moraceae	17	22.90	50.88
Vernonia arborea	Asteraceae	17	22.90	50.88
Glochidion obscurum	Phyllanthaceae	4	22.90	50.88
Mangifera sp.	Anacardiaceae	4	22.90	50.88
Mangifera indica	Anacardiaceae	17	20.99	50.88
Total		801	3,198.52	5,786.97
Mean		28	110.29	199.55

Logging cost

The logging cost of *Eusideroxylon zwageri* species was higher than that of the other spesies in this research (Table 7). However, logging cost per hectare was determined by log volume, and this research found difference in logging cost per hectare among trees species. The total logging cost in abandoned land in this research (USD752.54 ha^{-1}) was lower compared to that in another research (USD1,212.24 ha^{-1}) (Karmini et al. 2020). This is relevant because the total log volume in abandoned land in this research location was 76.86 m^3 ha^{-1} (Table 3), lower than that in another research location, i.e., 91.97 m^3 ha^{-1} (Karmini et al. 2020).

Profit margin

The 3 trees species contributing big profit margin were *Eusideroxylon zwageri, Alstonia scholaris,* and *Artocarpus anisophyllus*. Those species also had high log and wood prices. This mean prices of buying and selling determine profit in marketing both log and wood. Data in Table 8 present profit margin of selling 29 trees species from abandoned land.

Stumpage value

The total stumpage value at the abandoned land was estimated as much as USD1,495.31 ha^{-1}. There were 29 trees species and each species contributed an average of USD51.56 ha^{-1}. The highest stumpage value was from *Artocarpus anisophyllus*, i.e., USD168.97 ha^{-1} and the lowest one *Mangifera odorata*, i.e., USD2.29 ha^{-1} (Figure 4).

Table 7. Logging cost of trees at the study site

Species	Family	Logging cost	
		(USD ha^{-1})	(USD m^{-3})
Eusideroxylon zwageri	Lauraceae	7.51	101.76
Artocarpus integer	Moraceae	83.25	67.84
Artocarpus tamaran	Moraceae	74.43	67.84
Mangifera indica	Anacardiaceae	61.13	67.84
Artocarpus dadah	Moraceae	57.68	67.84
Glochidion obscurum	Phyllanthaceae	54.70	67.84
Vernonia arborea	Asteraceae	41.96	67.84
Artocarpus odoratissimus	Moraceae	34.25	67.84
Macaranga gigantea	Euphorbiaceae	33.42	67.84
Nephelium lappaceum	Sapindaceae	30.83	67.84
Homalanthus populneus	Euphorbiaceae	30.55	67.84
Artocarpus anisophyllus	Moraceae	27.55	67.84
Mangifera sp.	Anacardiaceae	23.49	67.84
Macaranga tanarius	Euphorbiaceae	23.29	67.84
Durio zibethinus	Malvaceae	23.22	67.84
Trema orientalis	Cannabaceae	21.35	67.84
Baccaurea parvifolia	Phyllanthaceae	21.01	67.84
Artocarpus elasticus	Moraceae	20.02	67.84
Symplocos fasciculata	Symplocaceae	19.38	67.84
Cratoxylum arborescens	Hypericaceae	12.23	67.84
Oroxylum indicum	Bignoniaceae	11.75	67.84
Couroupita guianensis	Lecythidaceae	10.18	67.84
Artocarpus heterophyllus	Moraceae	6.32	67.84
Mallotus paniculatus	Euphorbiaceae	5.73	67.84
Ficus uncinata	Moraceae	4.59	67.84
Archidendron pauciflorum	Fabaceae	4.45	67.84
Macaranga triloba	Euphorbiaceae	4.39	67.84
Alstonia scholaris	Apocynaceae	2.38	67.84
Mangifera odorata	Anacardiaceae	1.48	67.84
Total		752.54	2,001.36
Mean		25.95	69.01

Table 8. Profit margin

Species	Family	Profit margin	
		(USDm^{-3} ha^{-1})	(USDm^{-3})
Eusideroxylon zwageri	Lauraceae	626.24	150.30
Alstonia scholaris	Apocynaceae	469.68	112.72
Artocarpus anisophyllus	Moraceae	430.54	103.33
Oroxylum indicum	Bignoniaceae	410.97	98.63
Durio zibethinus	Malvaceae	145.55	34.93
Cratoxylum arborescens	Hypericaceae	125.57	30.14
Artocarpus heterophyllus	Moraceae	117.42	28.18
Archidendron pauciflorum	Fabaceae	76.32	18.32
Artocarpus elasticus	Moraceae	71.92	17.26
Nephelium lappaceum	Sapindaceae	61.65	14.79
Artocarpus dadah	Moraceae	61.65	14.79
Baccaurea parvifolia	Phyllanthaceae	52.84	12.68
Mangifera odorata	Anacardiaceae	29.35	7.05
Macaranga triloba	Euphorbiaceae	29.20	7.01
Ficus uncinata	Moraceae	28.90	6.94
Mallotus paniculatus	Euphorbiaceae	28.38	6.81
Homalanthus populneus	Euphorbiaceae	27.26	6.54
Symplocos fasciculata	Symplocaceae	26.42	6.34
Trema orientalis	Cannabaceae	25.69	6.16
Couroupita guianensis	Lecythidaceae	25.69	6.16
Macaranga gigantea	Euphorbiaceae	25.69	6.16
Macaranga tanarius	Euphorbiaceae	24.84	5.96
Artocarpus odoratissimus	Moraceae	23.48	5.64
Artocarpus tamaran	Moraceae	22.02	5.28
Artocarpus integer	Moraceae	22.02	5.28
Vernonia arborea	Asteraceae	22.02	5.28
Glochidion obscurum	Phyllanthaceae	22.02	5.28
Mangifera sp.	Anacardiaceae	22.02	5.28
Mangifera indica	Anacardiaceae	20.18	4.84
Total		3,075.50	738.12
Mean		106.05	25.45

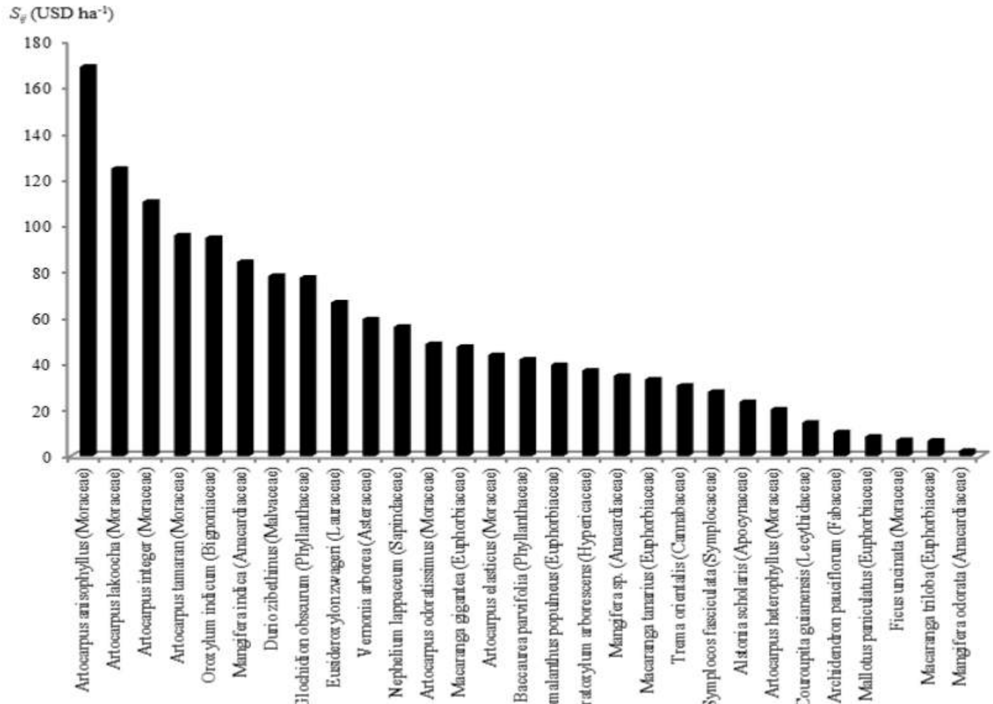

Figure 4. Stumpage value of trees at abandoned land

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