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Integrated utilization of land and vegetation in secondary forest areas

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Abstract

Local community's activities around Labanan forest area for specific purposes already make the area unsafe. Responding to this, land productivity optimization with agroforestry patterns might be applied in the area. Hopefully, through these systems, utilization and productivity of natural forests in Labanan forest area might be optimized in producing food, energy and water conservation, outside its regular function as forestry area. The purpose of this study was to determine the condition of the land under treeing forest; generate analytical data of vegetation in the research plots; and determine carbon stocks undergrowth. The research method was soil sampling, vegetation analyzes and sampling of undergrowth plant biomass. Based on laboratory analysis result, soil pH ranging between 5-7, N Total <0.3%, P Total <49 mg $P_2O_5.100g^{-1}$, K Total between 2-8 mg $K_2O.100g^{-1}$, and the organic carbon content on soil <2.1%. The vegetations dominated by cunday (*Saraca declinata*) as many as 43 trees/ha with basal area 21.55 m^2. ha^{-1}. The highest important value index (IVI) shown by the type of vegetation cunday (*Saraca declinata*) amounted to 51.43% and the lowest was shown by bintangur (*Callophyllum* sp) amounted to 2.89%. Stock carbon undergrowth on research area ranged from 1.470 to 1.752ton C. ha^{-1}.

Keywords: important value index (IVI), carbon, labanan, vegetation

1. Introduction

Forestry development program in Indonesian government today already committed to provide the greatest benefit for the prosperity of the people to keep the preservation and function of the forest. The development program in Forest Area for Specific Purposes will collaborate with community activities in improving and fulfill their needs. Forest management in Indonesia today is still trapped in two issues, as poverty among villagers around the forest and forest resources destruction. These two issues affected on the sustainability of forest biodiversity itself. Based on the record by CIFOR, Indonesia has at least 48 million of people living in and around forests; most of them are generally depend on forest resources in the surrounding areas.

Ministry of Environment and Forestry is always looking for strategic breakthroughs. One breakthrough that allows community empowerment is agroforestry. People in Indonesia have long practiced agroforestry with various characteristics concerning local wisdom [1].

Food and Agriculture Organization – FAO [2] defines agroforestry as a dynamic natural resource management system based ecology by integrating the planting of trees on agricultural land in one unified landscape. Agroforestry can diversify and preserve the farm production to increase social benefits, economic and ecological land at all levels. Through this agroforestry patterns, utilization and productivity of forestland can be further optimized using land under the trees to increase food security, energy security, water sufficiency and increased revenues forest communities. Widyati [3], reported that optimizing the land planted with'sengon' (albizia) and teak in Central Java and East Java province by growing crops and plantations, as well as the application of agrosilvopastora system shows that people can improve their welfare through PLBT (land use under the tree). In 2001, Kahayan Office of Watershed Management in Central Kalimantan provide community assistance for migrants from Central Java to plant growing vegetables and crops on peat land area of Jelutung Non Timber Forest Product (NTFP). After seven years treatment by given fertilizer, ameliorant and controlled technical assistance, agroforestry on peatland can become the main livelihood for surrounding people [4].

Part of the Forest Area for Specific Purposes already been abandoned arable land and left to recover themselves through the process of secondary succession. The forest area have been used by local people to plant food crops, especially vegetables, are being managed intensively, include the provision of fertilizers, pesticides, herbicides and weeding. Remaining residual fertilizer left on abandoned arable lands are acted as stimulus for the growth of bushes and tree saplings. Therefore, the abandoned arable lands easy to be covered with vegetation. Soil which still containing fertilizers also allow tree seeds growing quickly and have high vitality [5]. Generally, the land turned into a marginal area where conditions are less productive because of overgrown trees less commercial. As the area usually located close to local people activities around the forest, it might be wise for the marginal areas that are less productive is empowered with agroforestry patterns in order to improve food security, energy security, water sufficiency and income generation of forest communities [3]. The lack of information regarding the marginal region, should be improved by identifying the condition of the land, vegetation and biomass stock / carbon as the basis for the possibility of the development of agroforestry pattern in Labanan. The purpose of research is to determine the condition of the land, producing vegetation data analysis on early stage, and under tree the biomass and carbon stocks in secondary forest of Labanan, Berau.

2. Material and Methods

The study was conducted at Km 35 Labanan Forest Area for Specific Purposes, Berau district, East Kalimantan Province on 2015. This location is about 70-100 m of roadside province of Samarinda - Berau side by side with the road to Dusun Indah village.

The materials used for these research activities are map of Labanan forest area and labeled trees. The equipments used are soil drill, roll meter, phi-band, a ruler, caliper, digital scales and digital cameras. Land survey conducted to identify the condition of the land with research plots. 3 plots with arrangement 50 m x 200 m distances are prepared. Locations for soil and plant biomass sampling performed on every study plot, with each plot sampling have 5 different sampling points, to provide appropriate samples distribution.

Vegetation analysis aims to determine the existence of a type of vegetation that is in research plots and in the surrounding forest research plots. Vegetation analysis done by creating an inventory of lines spaced 10 m path and the path length of 200 m, so in one plot contained 5 tracks inventory. Then record the condition of vegetation by considering the status level of the tree, which has reached the level of trees of trees with diameter> 20 cm in the plot.

In the analysis phase of natural vegetation, the research data in the field are processed by using a specific formula that refers to the goals and expectations in research. The processing of data for each of the elements described in the following explanation:

a. Relative Density (RD)

Relative Density (RD) depends on density of a species compared with density of all species and formulated as follow.

$$RD = \frac{density\ of\ a\ species}{density\ of\ all\ species} \times 100\% \tag{1}$$

b. Relative Dominance (D)

Relative Dominance (D) depends on domination of a species compared with domination of all species and formulated as follow

$$D = \frac{domination\ of\ a\ species}{domination\ of\ all\ species} \times 100\% \tag{2}$$

c. Relative Frequency (RF)

Relative Frequency (RF) depends on frequency of a species compared with frequency of all species and formulated as follow

$$RF = \frac{frequency\ of\ a\ species}{frequency\ of\ all\ species} \times 100\% \tag{3}$$

d. IVI (Importance Value Index)

Formulas are used to obtain parameter with respect to the processing of data dissemination and the species composition.

$$IVI\ (\%) = Relative\ Density\ (RD) + Relative\ Dominance\ (D) + Relative\ Frequency\ (RF) \tag{4}$$

b. Primary Sector Size

Primary sector size is a cross-sectional area of the diameter breast height (dbh) or 1.30 m above the ground.

$$Primary\ Sector\ Size\ (m^2) = \frac{1}{4}\ x\ \pi\ x\ d^2 \tag{5}$$

c. Tree Density

The density of trees (Hardadi, 2012) expressed as trees coverage per hectare (m^2 / ha).

$$Tree\ Density\ (m^2/ha) = \frac{Total\ Primary\ Sector\ Size}{Plot\ Coverage\ Area} \tag{6}$$

d. Diversity Index

Diversity index expressed the level of stability of trees, both the rate of growth or on the forest types. High stability of trees showed high levels of diversity trees. According to Odum [6], diversity of species determined by the formula:

$$\overline{\mathrm{H}} = -\Sigma\left(\frac{ni}{N}\right)\log\left(\frac{ni}{N}\right) \tag{7}$$

Where:
H = biodiversity index
ni = Number of individuals of each type
N = Number of individuals of all species

e. Evenness Index (e)

To determine whether individuals are distributed evenly on the types that are present at a level of growth, Evenness Index Odum (1993) formula used as follow:

$$\bar{e} = \frac{\overline{\mathrm{H}}}{\log s} \tag{8}$$

Where:
e = evenness index
H = diversity index
s = number of species

f. Dominance Index (C)

To determine whether individuals were more concentrated in one or several types of a growth rate, then use the amount of Dominance Index (C) according to Odum [7] with the following formula:

$$C = \Sigma(ni/N)^2 \tag{9}$$

Where:
C = Dominance Index
ni = Number of individuals of a species
N = Number of individuals of all species

$$Biomass = f(DBH)$$

Biomass allometric equation obtained by connecting between Diameter at Breast Height (DBH) sample tree (X) is expressed in centimeters (cm) as total biomass estimated with all parts of the tree or plant samples (Y) is expressed in kilograms (kg).

Bush biomass calculated by using allometric equation available from the research results. Through the conversion of areal extents, the potential forest biomass value for the tree will be known.

The carbon content tree is known by using the approach of carbon stored per area calculation using adapted equation from Hairiah and Rahayu [7]:

$$SC = DW\ x\ 0{,}46 \tag{10}$$

Where:
SC = The amount of stored carbon (kg.ha-1)
DW = dry weight biomass ((kg.ha-1)
0.46 = Concentration C in biomass

Through the conversion of areal extents, the potential carbon content value for the tree will be known.

3. Results and Discussion

3.1 . Land Condition

Based on ergonomic accessibility for continues monitoring, classification area as secondary forest, and undulated topography (5% - 25% gradient), the suit location chosen is KM 35 of Labanan Area for Specific Purposes. The location of the research is about 70-100 m from Samarinda - Berau in parallel side of the road to Nyapa Indah village. Permanent research plots prepared for 3 areas for 1 ha per plot, with design size of 50 m x 200 m. Available contour map on each plots are presented in Figure 1.

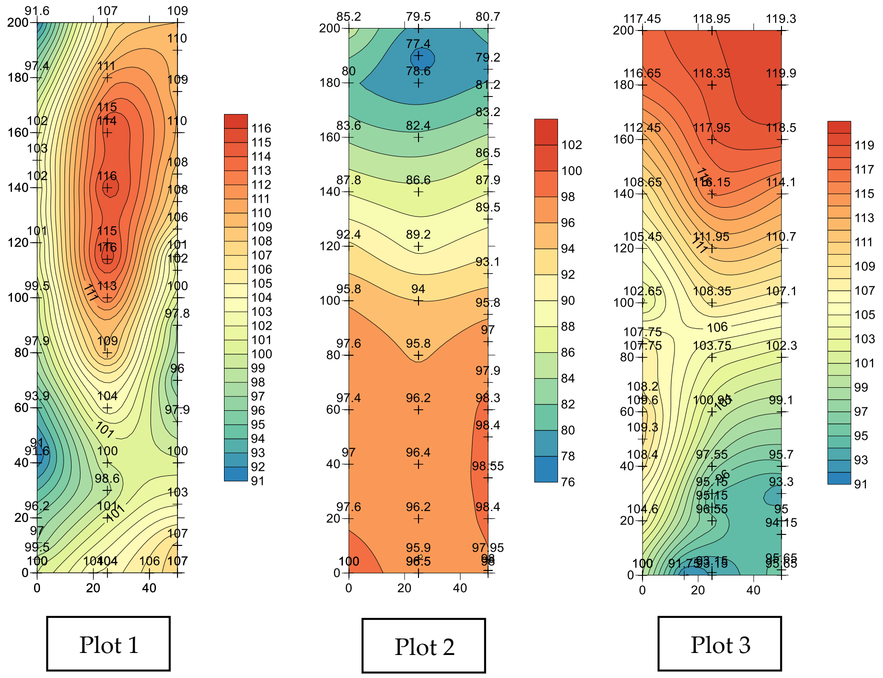

Figure 1. Contour map on research area

Shape of research plots are elongated from main road directions for several reasons, as (1) aside the plot area already been blocked by other plot areas research and local people land claims; (2) existence of ponds or natural lake on the plot 1; (3) village road crossing on plot 2; (4) rocky hills on plot 3 makes the plot area become tight.

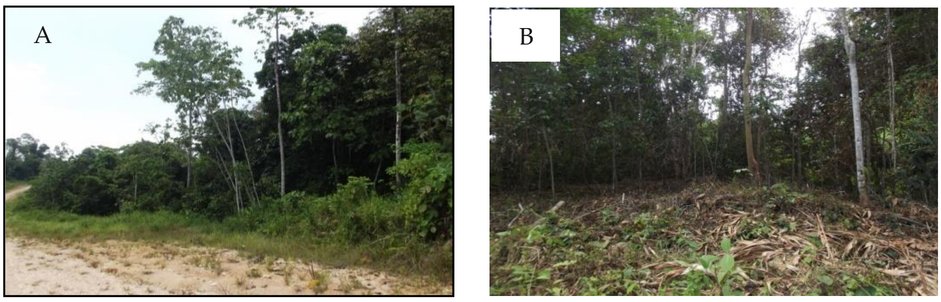

Figure 2 Research area in Labanan. (A) Plot condition as seen from side road to village; (B) Trees condition inside plot area

Based on laboratory analysis result, soil pH range on research plots ranging between 5-7, with the value of N Total <0.3%, P Total <49 mg P205.100g^{-1}, K Total in general ranging from 2-8 mg K20.100g^{-1}, and C-organic soil <2.1%. Results of soil analyzes in the laboratory for samples of three research plots are presented in Table 1.

Most areas of Labanan soil types dominated by haplic podzolic and chromic podzolic cromik. Those soils have loam texture, sandy clay loam to yellowish brown clayey loam [8]. From those facts, the soil can not be categorized as fertile ground. The analysis of soil testing result needed to evaluate the condition of soil and nutrients content. The analysis result needed to determine the treatment of the plants that become the object of study to give maximum effect on plants growth.

Table 1. . Soil samples analysis result from three plots in research area

No	Soil Condition	pH (H_2O)	Water content (%)	N Total (%)	P Total (mg (P_2O_5.(100g)$^{-1}$)	K Total (mg (K_2O.(100g)$^{-1}$)	C Organic (%)	Cation Exchange Capacity	
								Al^{3+}	H^+
								(cmol.(+)kg^{-1})	
1	Plot 1	6.27	6.89	0.13	26.70	3.98	1.45	1.18	1.94
2	Plot 2	6.41	5.75	0.12	35.75	4.98	1.71	0.50	0.81
3	Plot 3	5.97	4.93	0.09	24.35	3.34	1.60	0.37	0.67

In general, nutrient content and chemical properties of soil in plot areas are in the range of very low to low, according to the Soil Chemical Properties criteria issued by the Bogor Institute of Soil Research Center [9]. The low P content in the soil believed to be caused by the relatively acidic soil pH. According to Hakim et al. [10], in acidic conditions, lack of P content caused by a relatively small number of P and P factor have been tied up by Al and Fe. These results are similar to Yamani [11], as done in the protected forest of Mount Sebatung. According to Yang et al. [12], Phosphorus is a nutrient with most limited availability in the tropical area. The conditions directed by the parent material that can release phosphorous through weathering are very low. Yet according to Goll et al. [13] P has an important role in carbon sequestration in tropical forests. Low biological phosphorus in the soil will cause reduction in the ability of forests to absorb carbon, which will ultimately affect the ability of tropical forests as the lungs of the world.

Secondary forest in Labanan forest generally a former cultivated land generated by local communities, where land clearing technique is done by burning. According to Verma and Jayakumar [14], the impact of fire on forest land can be good or bad, depends on several things, including the intensity of the fire, availability of materials and soil moisture. At a low intensity fire, burning litter and organic matter will lead to an increase in the release of nutrients to the soil and will directly affect the deposits of nutrients in the soil. While high-intensity fire that will destroy the availability of organic material, causing volatilization of a variety of important nutrients like N, P, S and K, as well as killing the microorganisms in the soil.

According to Iwara et al. [15] there is a relationship of interdependence between soil and vegetation in secondary forest as they influence one another. Organic content in the soil will affect the composition and diversity of vegetation. On the other side, tree size and tree density gives considerable influence on organic matter and total nitrogen in the soil.

3.2. Vegetation Conditions

Based on vegetation identification in the plot areas, most existing species are less commercial type. This condition is appropriate for carrying out research activities in these locations, in conjunction with social and economic factor of local people.

In Figure 3, density of the vegetation is dominated by cunday (*Saraca declinata*) as many as 43 pohon.ha-1. A density indicates suitability place for species with high density value [5] on coverage area 21.55 m2.ha-1 as presented in Figure 4.

From the above results, the area can be used as a study location as part of Labanan forest area whose condition is less productive. For further assessment on the condition of vegetation in research area, vegetation analysis conducted as presented in Table 2.

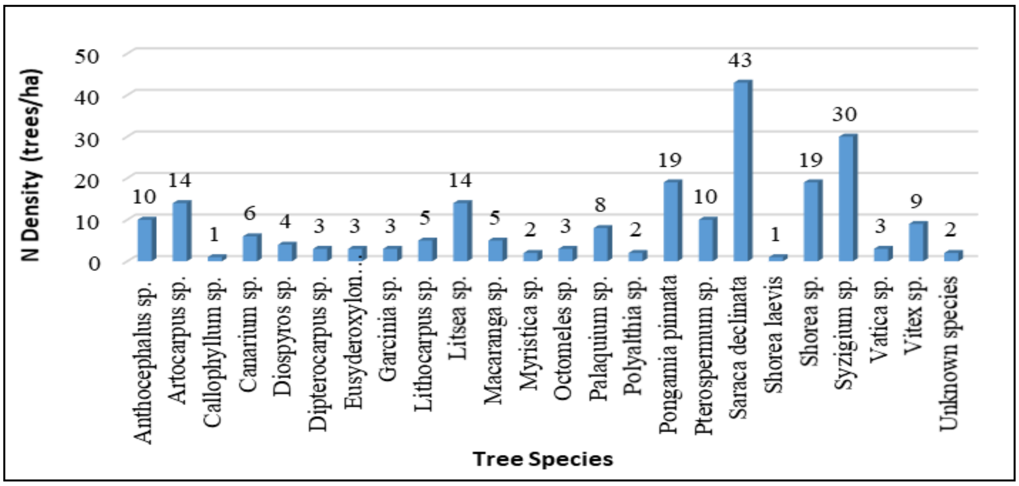

Figure 3. Trees density per hectar in research area

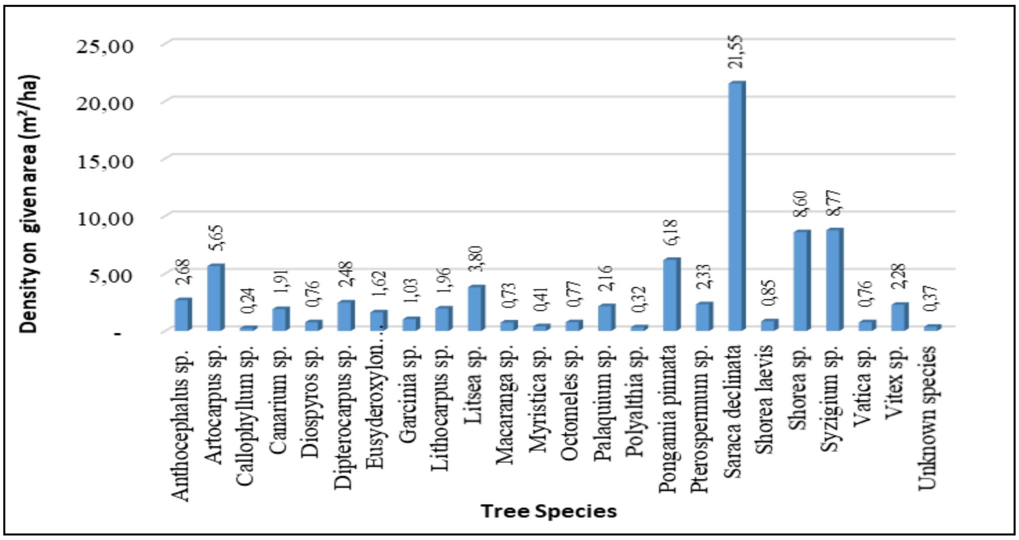

Figure 4. Density on given research area (in hectares)

Vegetation analysis results in Table 2 indicate that there are 24 species identified in the study area. The highest Important Value Index (IVI) is cunday (*Saraca declinata*) vegetation with 51.43% while the lowest is bintangur (*Callophyllum* sp) with 2.89% of total population. The results give the information of uneven condition on distribution and composition of population. Most trees dominated by species that are not commercial. Vegetation on the secondary forest areas in each region generally indicated differences in species composition constituent, as samples of data results from Saharjo and Gago [16] that the natural post-fire succession in secondary forests in the area of East Timor dominated by the family Rubiaceae and species of Eucalyptus.

Some plants species such as meranti (*Shorea* sp.), Mahang (*Macaranga* sp.), Tassel (*Syzigium* sp.), and *medang* (*Litsea* sp.) can be found in research plots with a relatively small density value. The same species also found in secondary forest area in Batang Gadis National Park, with bigger relative density [17]. On the other side, on the agroforestry area of Badui, *mahang* (*Macaranga* sp.) became the second species after *aren* (*Arenga pinata*) that dominate the pioneer forest's vegetation on tree level [18].

The diversity of each individual trees or species appears to be low, causing unstable tree value and low-diversity trees. If the stability values of the trees are high, levels of diversity trees are as high; characterized by the stability of the trees, both the rate of growth or on the forest types with high diversities [6].

Evenness index of vegetation on the location of the research shows a value below 0.1 except for *cunday* species (*Saraca declinata*), so presence of other species are not distributed normally on the location of the study. The composition of a forest will have good Evenness Index value if the species have normal distribution on present species of certain level of growth [6]. Those conditions also affects the dominance index that only dominated by *cunday* species (*Saraca declinata*) with dominance index of 0.04, followed by tuft species (*Syzigium* sp) with dominance index value of 0.02. Dominance index information area important in vegetation analysis to determine if certain species were more concentrated in one or several species of a growth rate [6].

Table 2. Vegetation analysis result in research area

No.	Local Name	Species	Relative Density (RD, %)	Relative Dominance (D, %)	Relative Frequency (RF, %)	Important Value Index (IVI, %)	Biodiversity Index (H)	Evennes index (e)	Dominance index (C)
1	Jabon	*Anthocephalus* sp.	4,56621	3,42850	6,38298	14,37768	0,06121	0,04495	0,00209
2	Terap	*Artocarpus* sp.	6,39269	7,22334	6,38298	19,99901	0,07635	0,05607	0,00409
3	Bintangur	*Callophyllum* sp.	0,45662	0,31280	2,12766	2,89708	0,01069	0,00785	0,00002
4	Kenari	*Canarium* sp.	2,73973	2,43952	4,25532	9,43456	0,04280	0,03143	0,00075
5	Arang	*Diospyros* sp.	1,82648	0,96852	2,12766	4,92266	0,03175	0,02332	0,00033
6	Keruing	*Dipterocarpus* sp.	1,36986	3,16739	4,25532	8,79258	0,02552	0,01874	0,00019
7	Ulin	*Eusyderoxylon zwageri*	1,36986	2,07242	4,25532	7,69760	0,02552	0,01874	0,00019
8	Manggis-manggisan	*Garcinia* sp.	1,36986	1,31851	2,12766	4,81603	0,02552	0,01874	0,00019
9	Pasang	*Lithocarpus* sp.	2,28311	2,50312	6,38298	11,16920	0,03748	0,02752	0,00052
10	Medang	*Litsea* sp.	6,39269	4,86202	4,25532	15,51003	0,07635	0,05607	0,00409
11	Macaranga	*Macaranga* sp.	2,28311	0,93951	2,12766	5,35027	0,03748	0,02752	0,00052
12	Dara-dara	*Myristica* sp.	0,91324	0,52406	2,12766	3,56496	0,01862	0,01368	0,00008
13	Binuang	*Octomeles* sp.	1,36986	0,97968	4,25532	6,60486	0,02552	0,01874	0,00019
14	Nyatoh	*Palaquium* sp.	3,65297	2,75566	4,25532	10,66395	0,05251	0,03856	0,00133
15	Banitan	*Polyalthia* sp.	0,91324	0,41248	4,25532	5,58104	0,01862	0,01368	0,00008
16	Keranji	*Pongamia pinnata*	8,67580	7,90810	6,38298	22,96688	0,09211	0,06764	0,00753
17	Bayur	*Pterospermum* sp.	4,56621	2,98180	4,25532	11,80333	0,06121	0,04495	0,00209
18	Cunday	*Saraca declinata*	19,63470	27,54965	4,25532	51,43967	0,13881	0,10194	0,03855
19	Bengkirai	*Shorea laevis*	0,45662	1,08456	2,12766	3,66884	0,01069	0,00785	0,00002
20	Meranti	*Shorea* sp.	8,67580	11,00033	4,25532	23,93145	0,09211	0,06764	0,00753
21	Jambu-jambu	*Syzigium* sp.	13,69863	11,21382	6,38298	31,29543	0,11826	0,08685	0,01877
22	Resak	*Vatica* sp.	1,36986	0,97038	4,25532	6,59556	0,02552	0,01874	0,00019
23	Laban	*Vitex* sp.	4,10959	2,91597	4,25532	11,28087	0,05697	0,04183	0,00169
24	Tulang pedung	Unknown species	0,91324	0,46789	4,25532	5,63645	0,01862	0,01368	0,00008

3.3 Stock Biomass and Carbon Content

Biomass and carbon of bush need to know its current condition to give a picture of the cover of the forest floor. This will lead to addition or replacement of certain plant's species forest floor. Those conditions hopefully will not disturb the forest floor from erosion and damage the top soil. Initial data by sampling and testing in the laboratory are needed to get results on the dry weight (biomass) and carbon content of bush plants, as presented in Table 3.

Table 3. Analysis result of dry weight and bush plant carbon content

No	Location	Dry weight (%)	C-Organic (%)
1	Plot 1	90.53	39.45
2	Plot 2	89.58	42.51
3	Plot 3	88.95	37.44

Table 3 shows the results of the dry weight and the carbon content of the samples in the third bush research plots, where for the highest dry weight on plot 2 is 90.53% and the highest carbon content on plot 2 at 42.51%. This shows that the dry weight of bush plant cannot certainly have greater carbon content, because it influenced by the bush species that existed at that location. From the analysis of dry weight and carbon content from bush plant, the results used to understand the condition of biomass and carbon stocks per hectare. The following recapitulation of plant biomass under, carbon content and carbon stocks, as presented in Table 4.

Carbon stock of bush plant on research area in Labanan secondary forest area as development stage of agroforestry ranged from 1.47 to 1.64 tonnes C.ha-1, greater than the results of research conducted on land planted with "tembawang" (agroforestry model in West Kalimantan) that ranged from 0.47 to 1.19 tonnes C.ha-1 [19]. The results of these measurements are also greater than the measurement of carbon stocks of bush plant in Mandiangin forest education, around 0,031 tons Banjarbaru C.ha-1 [14]. However, when compared with the results of carbon stocks in the bush of Bukit Barisan Selatan National Park, showing the result of 1.47 mg.ha-1 [20], which is not much different from the conditions in Labanan secondary forest. Results greater than carbon stocks lower plants obtained from the research on the system logged forest land use PT Sikatan Wana Kingdom of 4.78 tons C.ha-1

[21], as well as in the area of natural succession dike area Ganda PT , Freeport Indonesia in Mimika District, Papua earn carbon stock ranged from 23.87 to 98.6 ton.ha-1 [22]. Condition of the carbon content and biomass of vegetation varies based on part of the plant was measured, growth stage, the level of plant and environmental conditions. The difference in carbon stocks and biomass bush plants can happen in each place as growing plants in the area influence it [23].

Table 4. Recapitulation of biomass, carbon content, and carbon stock from bush plant

No. Plot	Biomass (kg.ha^{-1})	Carbon Content (%)	Carbon Stock (ton.ha^{-1})
1	3771,951	39,17	1,470
2	4275,732	41,3	1,752
3	4104,475	39,78	1,640

According to Hilwan et al. [24], secondary succession, which occurs in rainforest areas that are cultivated and then abandoned, the growth will begin with vegetation of grass and small shrubs such as those found at the study site. With such conditions, it becomes necessary to perform the optimization of land under trees to become more productive. Such efforts able to develop annual crops at certain locations with agroforestry patterns, in addition to increasing the presence of vegetation to absorb and store carbon in a certain period. Expected circulation of crop cultivation can take place on an ongoing basis in order to empower land and increase productivity benefits for the environment, to reduce conflicts and improve the welfare of the people in the surrounding area of Labanan secondary forest. The development of agroforestry in the management of these areas are a feasible.

4. Conclusions

The results showed that “*cunday*” species (*Saraca declinata*) dominate the existence trees at the research plot as many as 43 trees.ha-1 with area space 21.55 m^2.ha-1. The highest Importance Value Index (IVI) achieved by “*cunday*” species (*Saraca declinata*) with 51.43% and the lowest IVI achieved by “*bintangur*“ (*Callophyllum* sp) with 2.89%. Bush conditions of carbon stocks achieved between 1.470 to 1.752 tons C.ha-1 dominated with grass and brushwood.

The less productive forest conditions with certain dominant species exist, recommend to be managed for agroforestry sector. Utilization and productivity of forestry area can be further optimized by the use of land under the trees with agroforestry to improve food security, energy security, water sufficiency and improve household incomes around Labanan forest.

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