Advanced Studies in Biology, Vol. 9, 2017, no. 4, 205 - 216
HIKARI Ltd, www.m-hikari.com
https://doi.org/10.12988/asb.2017.7924

Biomass Density and Carbon Stock of Tropical Community Forest Area at FMU Lawu Manunggal-Panekan-Magetan District

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Abstract

Forest is a natural element that can absorb CO_2 in large quantities. This is due to the existing vegetation in the forests bind CO_2 while the process of photosynthesis and store it in the form of biomass. So that, the existence of forests affect the prevention and handling of global warming on earth. This research aims to measure the biomass density and carbon stock of tropical community forests area at Sumberdodol and Tapak Villages of FMU (Forest Managemen Unit) Lawu Manunggal – Panekan – Magetan District. The research method for inventory of individual trees in forest stands uses finger circle plot of 0.05 Ha. Its intensity is 5%. Destructive Biomass Measurements while analyzing carbon stock uses titration method of Wallky and Black. Result of research Biomass density of forests are Melia 61,288,649 kg/Ha, Mahogany 97,472,875 kg/Ha, Teak 88,925,376 kg/Ha, and Albicia 25,566,573 kg/ Ha. FMU Lawu Manunggal forest

area at Sumberdodol and Tapak is 276,33 Ha. Total Biomass density of Melia 1,225.77 tons, Mahogany 2,216.47 tons, Teak 1,778.51 tons, and albicia 511.33 tons. Total forest stands are 5,732.08 tons. The carbon stock average of Melia 28,806 ton/Ha, Mahogany 45,812 ton/Ha, Teak type 41,795 ton/Ha, and Albicia 12,016 ton/Ha. The total Carbon stock of Sumberdodol and Tapak Villages are 2,694.08 tons.

Keywords: Biomass density, Carbon stock, Tropical community forest area

1 Introduction

Issues of climate change due to the increasing concentration of greenhouse gases, especially carbon dioxide (CO_2) in the atmosphere is getting more serious. It certainly has implications for the balance of the natural carbon cycle on earth.

Related to the issue, the Government of Indonesia has committed to mitigate the impacts of climate change by contributing to reduce greenhouse gas emissions 26–41% by 2020. As a concrete action, the Government stipulates Presidential Regulation No. 61/2011 as the basis for preparing National Action Plan of GreenHouse Gas (NAP-GHG) [1].

Now, the impact of global warming is very real. It has reached levels that endanger the earth's climate and ecosystem balance [2]. This requires an immediate handling. The efforts can be classified into two major groups: first, reducing CO_2 emissions into the atmosphere, and secondly, removing CO_2 from the atmosphere and storing it on the land or in the oceans. Both efforts must be done simultaneously so that efforts to stabilize GHG concentration can be achieved.

One of the natural elements that can absorb CO_2 in large quantities is forests. This is because the existing of vegetation in the forest binds CO_2 in the process of photosynthesis and store it in the form of biomass. Consequently, the existence of forests affects the prevention and handling of global warming on earth. As [3] says that 50% of the biomass present in the forest is composed of carbon. Carbon pools are grouped into three main categories: living biomass, dead organic matter, and soil organic matter. The living biomass consists of two parts: Above Ground Biomass (AGB) and Below Ground Biomass (BGB) [4]. There has not been a fixed standard for measuring biomass density and carbon stocks. The several alternative methods are presented by [5], [6].

This study aims to estimate biomass density and carbon stock. It focuses on community forests of Forest Management Unit (FMU) Lawu Manunggal at on both Sumberdodol and Tapak villages – Panekan Subdistrict – Magetan district. For simplification reason, this research is limited to living plants only.

The different measurements with various methods and in many tropical areas have been done by [7]–[10].

As the previous study, the estimation of biomass volume and carbon stock average of five years old Teak plant (Case at Superior Teak Plantation Area of Jati

Unggul Nusantara (JUN)) at Krowe village, subdistrict of Lembeyan, Magetan district is 183,870 kg/ tree. The total potential biomass volume was 27.30 tons/ hectare [7].
The estimation of biomass volume and the carbon stock of five years old Jati Unggul Nusantara in Trosono village, Parang subdistrict, Magetan District is 56.2 tons, or the average is 17.295 tons/hectare [8].
Biomass volume in community forest of Jati Unggul Nusantara (JUN) at Dungus Village of Dagangan Subdistrict of Madiun district said 27,30 tons/hectare [9].
The estimation of Biomass volume and Carbon stock of Teak forest of community Forest in Adsorbing Carbon Dioxide (CO_2) at Kare Village, Kare Subdistrict, Madiun District biomass content is 196.74 kg/tree or 27.30 tons/Ha [10].
The similar studies on peat soils in Sumatra island have been done by [11]. He said that the carbon mass is considered to be equal to 50% of the volume of biomass or its conversion factor equal to 0.5 in estimating the carbon mass volume of forest stands. This measurement is done regardless of the type of biomass and stand age [11].

2 Research Method

2.1 Make a Measuring Field

The first step is to make a measuring field at both of community forest of Sumberdodol and Tapak villages. The measuring field is circular shapes. The area is 0.05 Ha, or the diameter is 12.61 meters. Implementation of data retrieval is done by systematic sampling with a random start.

2.2 Calculate The Standing Tree Volume

The standing tree volume is the multiplication of the ground-based area, the height of the tree and the factor of shape [5].

$$V = lbds_{1,3} \, x \, h \, x \, f_{1,3}. \quad (1)$$

Note:
V = Volume of tree (m^3)
h = Height of tree (m)
$lbds_{1,3}$= Ground based area at the height of 1.3 m
$f_{1,3}$ = Factor of shape

Next, to calculate trunk volume, the tree is subdivided into a series segments. The observed diameters are at the bottom and top of the segment. The formula Eq calculates the volume of each segment. (2).

$$V = \left(\frac{lbds_b + lbds_t}{2} \right) . l \quad (2)$$

Note :
V = Volume of segment
$lbds_p$ = wide of bottom segment area = $¼d\pi$ (bottom segment diameter)^2
$lbds_u$ = wide of top segment area = $¼d\pi$ (top segment diameter)^2
l = length of segment.

The total sum of the volume of each segment of the base up to the top of the rod is the actual volume of wood of a tree.

$$V_{total} = V_1 + V_2 + ... + V_n \quad (3)$$

3 Measurement of Biomass Weight

3.1 Sampling

Measurements were made on above ground level biomass in all villages of FMU Lawu Manunggal. We use a destructive sampling method to select a tree of biomass sample. The next step is to measure and weigh the wet weight of trees, stem components, branches, leaves, and roots. Furthermore is the measurements for dry weight to determine moisture content and biomass density. This is done by drying the sample using a temperature oven of 103±2°C to obtain the constant weight [6]. The total weight of tree biomass can be calculated by summing the entire biomass of the tree component. We use Eq. (4) as the formula to measure Total Weight of tree biomass (W_T)

$$W_T = W_S + W_B + W_L + W_R \quad (4)$$

Weight of Stem (W_S)= (100%–water content (%)).Total Wet Weight of Stem
Weight of Branch (W_B)= (100 %–water content (%)).Total Wet Weight of Branch
Weight of Leaf (W_L) = (100%–water content (%)).Total Wet Weight of Leaf
Weight of Root (W_R) = (100%–water content (%)).Total Wet Weight of Root

3.2 Carbon weight measurement

We measure carbon content in plants using titration method. This taken step uses the Walkley and Black method that apply the stages of total carbon content (C-total).

4 Results and Discussion

4.1 Real Situation of Teak Forest Community at Panekan

Area Panekan Subdistrict about 64.23 Km^2 or about 9.32% of the total area of Magetan district. Area Sumberdodol village 2.44 Km^2, village Tapak 7.16 Km^2 and Sukowidi 4.35 Km^2. Panekan District average temperature ranges from 16°C to 26°C and the rainfall 1500 mm / year. The widest village in Panekan is Tapak Village, and the area is 716 Ha. About 28% of Panekan area is State Forest. Panekan consists of an administrative area and 16 villages. Suberdodol and Tapak villages are located on the slopes of Mount Lawu. In the north bordering Kendal

subdistrict of Ngawi district. In the eastern is Karas subdistrict of Magetan district. In the south is Sidorejo subdistrict of Magetan district and in the west is Tawangmangu subdistrict of Karang Anyar district.

4.2 Stock Inventory Results

It based on the result of standing inventory on community forest of FMU Lawu Manunggal area. It obtained the largest potential is Mahogany stands, i.e., 849 trees/Ha and the standing stock volume is 102.159 m^3. While the smallest one is albicia stands, i.e., 370 trees/Ha and the standing stock volume is 88,740 m^3. Melia is 530 trees/Ha, and the standing stock volume is 81,317 m^3, and Teak is 667 trees/Ha, and the standing stock volume is 79,648 m^3.

Community forests of Sumberdodol and Tapak villages within the FMU Lawu Manunggal area are 279.33 Ha. The type of mahogany dominates the community forests of almost all hamlet in the village of the management target area. There are 8,492 trees, and total standing stock of mahogany volume is 1,021,595 m^3. The smallest one is albicia stands, i.e., 3,696 trees and the total volume of standing stock is 887.396 m^3. The stand of Melia is 5,302 trees, and the volume standing stock is 813.171 m^3. Teak standing is 6,666 trees and volumes is 796,476 m^3.

On community forest in Panekan subdistrict in FMU Lawu Manunggal area consists of four dominant type. It namely mahogany (*Swietenia mahagoni*), teak (*Tectona grandis* LF), Albicia (*Albicia falcataria*), and Melia (*Melia Azerdarach*).

4.3 Biomass Volume of the Standing of Community Forest

Forest biomass measurements for this study were conducted in all parts of the tree consisting of above-ground biomass including stems, branches and leaves, and below-ground biomass covering tree roots. It is done on four sample of tree species. It presented in Table 1.

Table 1. Wet weight (kg) Every Tree segment of Community Forest at Panekan – Magetan

Type	Tree Code	Dbh (cm)	H (m)	Vol (M3)	Gross Weight (Kg)				
					Root	Stem	Branch	Leaf	Total
Albicia	Af-1	14.38	15.63	0.0123	58.30	167.20	30.80	24.75	281.05
	Af-2	13.88	16.88	0.0129	51.15	137.50	34.10	35.75	258.50
	Af-3	16.13	14.38	0.0127	69.88	150.15	27.23	24.75	272.01
	Average	14.79	15.63	0.0127	59.78	151.62	30.71	28.42	270.52
Melia	Ma-1.	19.13	21.88	0.0230	71.40	347.84	88.20	60.90	568.34
	Ma-2	16.75	19.38	0.0178	59.85	208.15	73.50	46.20	387.70
	Ma-3	18.88	19.38	0.0201	105.00	315.17	98.70	86.10	604.97
	Average	18.25	20.21	0.0203	78.75	290.39	86.80	64.40	520.34
Teak	Tg-1	19.23	18.90	0.0200	90.33	323.18	81.51	43.62	538.64

Table 1. (Continued): Wet weight (kg) Every Tree segment of Community Forest at Panekan – Magetan

	Tg-2	22.23	24.30	0.0297	115.69	299.23	37.90	40.04	492.85
	Tg-3	24.21	25.70	0.0342	125.13	325.33	64.35	57.20	572.00
	Average	21.89	22.97	0.0280	110.38	315.91	61.25	46.95	534.50
Mahogany	Sm-1	21.29	23.20	0.0272	87.64	260.15	41.75	45.98	435.52
	Sm-2	24.61	24.40	0.0330	122.82	356.65	38.12	26.62	544.20
	Sm-3	27.66	25.00	0.0380	148.47	389.96	47.23	34.00	619.65
	Average	24.52	24.20	0.0327	119.64	335.59	42.36	35.53	533.12

Note: Dbh: Diameter breast High, H: High
Source: Primary data processed 2017

Information: Sm: mahogany (*Switenia mahagoni*)
Tg: teak (*Tectona grandis* LF)
Af : Albicia (*Albisia falcataria*)
Ma: Melia (*Melia Azerdarach***)**

The average water content Every segment is 50% of the wet weight in all components of the plant. They are presented in Table 2.

Table 2. Water Content Every Segment of FMU Lawu Manunggal Forest Plants Panekan, Magetan.

Type	Tree Code	Dbh (cm)	H (m)	Vol (M3)	Average Water Content			
					Root	Stem	Branch	Leaf
Albicia	Af-1	14.38	15.63	0.0123	0.51	0.46	0.47	0.50
	Af-2	13.88	16.88	0.0129	0.50	0.49	0.47	0.50
	Af-3	16.13	14.38	0.0127	0.48	0.52	0.46	0.50
	Average	14.79	15.63	0.0127	0.50	0.49	0.47	0.50
Melia	Ma-1.	19.13	21.88	0.0230	0.50	0.60	0.62	0.48
	Ma-2	16.75	19.38	0.0178	0.48	0.56	0.55	0.44
	Ma-3	18.88	19.38	0.0201	0.49	0.58	0.60	0.46
	Average	18.25	20.21	0.0203	0.49	0.58	0.59	0.46
Teak	Tg-1	19.23	18.90	0.0200	0.64	0.45	0.53	0.51
	Tg-2	22.23	24.30	0.0297	0.51	0.51	0.49	0.50
	Tg-3	24.21	25.70	0.0342	0.50	0.49	0.52	0.49
	Average	21.89	22.97	0.0280	0.55	0.48	0.51	0.50
Mahogany	Sm-1	21.29	23.20	0.0272	0.49	0.48	0.53	0.50
	Sm-2	24.61	24.40	0.0330	0.51	0.54	0.50	0.50
	Sm-3	27.66	25.00	0.0380	0.52	0.50	0.50	0.50
	Average	24.52	24.20	0.0327	0.51	0.51	0.51	0.50

Note: Dbh: Diameter breast High, H: High
Source: Primary data processed 2017

Table 3. Biomass (kg) Every segment of community Forest FMU Lawu Manunggal

Type	Tree Code	Dbh (cm)	H (m)	Vol (M3)	Biomass (Kg)				
					Root	Stem	Branch	Leaf	Total
Albicia	Af-1	14.38	15.63	0.0123	28.63	90.41	16.18	12.39	147.62
	Af-2	13.88	16.88	0.0129	25.73	70.00	17.91	17.90	131.55
	Af-3	16.13	14.38	0.0127	36.31	72.51	14.68	12.36	135.87
	Average	**14.79**	**15.63**	**0.0127**	**30.23**	**77.64**	**16.26**	**14.22**	**138.35**
Melia	Ma-1.	19.13	21.88	0.0230	35.70	139.14	33.52	31.67	240.02
	Ma-2	16.75	19.38	0.0178	31.12	91.59	33.08	25.87	181.66
	Ma-3	18.88	19.38	0.0201	53.55	132.37	39.48	46.49	271.89
	Average	**18.25**	**20.21**	**0.0203**	**40.12**	**121.03**	**35.36**	**34.68**	**231.19**
Teak	Tg-1	19.23	18.90	0.0200	32.31	176.62	38.42	21.24	268.58
	Tg-2	22.23	24.30	0.0297	56.76	147.49	19.26	19.98	243.49
	Tg-3	24.21	25.70	0.0342	62.73	165.98	30.67	28.96	288.33
	Average	**21.89**	**22.97**	**0.0280**	**50.60**	**163.36**	**29.45**	**23.39**	**266.80**
Mahogany	Sm-1	21.29	23.20	0.0272	44.70	134.77	19.56	23.19	222.21
	Sm-2	24.61	24.40	0.0330	60.39	163.10	18.90	13.43	255.83
	Sm-3	27.66	25.00	0.0380	70.92	193.46	23.45	17.15	304.98
	Average	**24.52**	**24.20**	**0.0327**	**58.67**	**163.78**	**20.64**	**17.92**	**261.01**

Note: Dbh: Diameter breast High, H: High
Source: Primary data processed 2017

Based on Table 3, we calculate the volume of biomass per plant organ, every plant type/Ha. The largest biomass volume is in stem organs i.e. 162.045,383 kg / Ha, while the smallest in leaf organ is 26,310,946 kg/Ha. The average biomass volume of FMU Lawu Manunggal - Panekan - Magetan area consists of Mahogany plants 97,472,875 kg/ha, Teak of 88,925,376 kg/ha, Melia plants 61,288,649 kg/ha, and Albicia 25,566,573 kg/ha. This can be seen in Table 4.

Table 4. Biomass (kg/ha) Every Segment of FMU Lawu Manunggal Forest Management Area at Panekan District

Organ	Biomass (Kg/Ha)				
	Root	Stem	Branch	Leaf	Total
Melia	10,637	32,085	9,373	9,193	61,288.649
Mahogany	21,911	61,162	7,706	6,693	97,472.875
Teak	16,864	54,449	9,816	7,796	88,925.376
Albicia	5,586	14,348	3,005	2,628	25,566.573
Total	54,997.494	162,045.383	29,899.650	26,310.946	273,253.473
%	20.13	59.30	10.94	9.63	100.00

Based on the result of recapitulation of the wide forest of 279,33 Ha. The total Biomass Potential of Lawu Manunggal FMU at Sumberdodol and Tapak Village Panekan Subdistrict- Magetan district is 5,732,08 tons. It as presented in Table 5 and Fig. 1.

Table 5. Biomass Volume of FMU Lawu Manunggal - Panekan – Magetan

Type	Number of Biomass/type (Kg)				
	Stem	Root	Branch	Leaf	Total (Ton)
Melia	641,710	212,737	187,463	183,863	1,225.77
Mahogany	1,390,794	498,234	175,236	152,204	2,216.47
Teak	1,088,982	337,285	196,311	155,930	1,778.51
Albicia	286,966	111,714	60,093	52,558	511.33
Amount (Ton)	3,408.45	1,159.97	619.10	544.55	5,732.08

Source: Primary data processed 2017

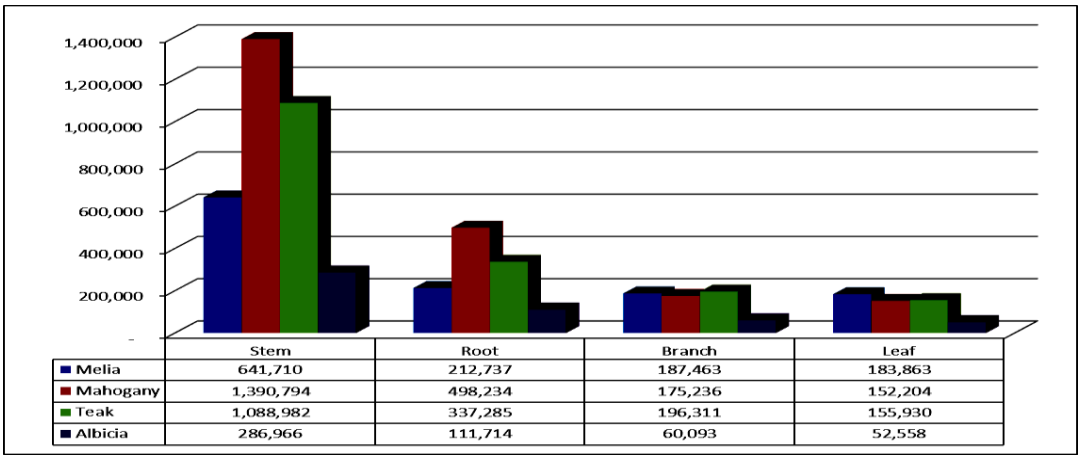

Figure 1. Biomass Volume (ton) of Community Forest Manage FMU Lawu Manunggal - Panekan subdistrict - Magetan district

4.4. Karbon Stock

The average percentage of carbon Stock in plant organ biomass in community forest of FMU Lawu Manunggal- Panekan is 47.33%. It presented in table 6.

Table 6. Analysis of Total Carbon Stock Uses Titration Method for Type of Tree Forest Plant FMU Lawu Manunggal

No	Code	Weight Cup	Gross weight	Dry weight	Levels	Dry weight	Weight	Titrasi	Tirtasi	Levels C
			Weight Cup	Weight Cup	Moisture	Absolute	Sample	Sample	Control	Total
		Gr	Gr	gr	%	ml	Gr	Ml	ml	%
1	S- Albicia	61.2484	74.7008	74.5830	0.8832	25.0106	0.0252	4.6833	7.6667	46.8832
	S Teak	64.6619	78.7978	78.6724	0.9040	24.8730	0.0251	4.6333	7.6667	47.9448
	S- Mahogany	57.3473	70.0183	69.8913	1.0208	25.0417	0.0253	4.6667	7.6667	47.1519
	S- Melia	65.4554	79.7498	79.6238	0.8900	25.1189	0.0253	4.6556	7.6889	47.4703
	Average	62.1782	75.8167	75.6926	0.9245	25.0111	0.0252	4.6611	7.6722	47.3625
2	R- Albicia	68.1926	83.0368	82.9152	0.8320	25.0233	0.0252	4.5704	7.4667	45.4819
	R- Teak	63.3311	77.2000	77.0756	0.9071	25.1036	0.0253	4.6167	7.6667	47.7684
	R- Mahogany	69.7649	84.9237	84.8048	0.7941	24.9777	0.0252	4.5068	7.4889	48.4695
	R- Melia	65.4554	79.7498	79.6238	0.8900	25.1189	0.0253	4.6556	7.6889	47.4703
	Average	66.6860	81.7202	81.5985	0.8444	25.0348	0.0252	4.5646	7.5407	47.2399
	Average	64.4321	78.7684	78.6456	0.8844	25.0229	0.0252	4.6129	7.6065	47.3012

Note: S: Stem, R: Root
Source: Primary data processed, 2017

The average Carbon volume per Plant organ of community Forest is as the following. Stem organs carbon volume is 59.30%. The root organ is 20.13%. For the branch, the organ is 10.94%, and for leaf, the organ is 9.63%. It presented in Table 7.

Table 7. Carbon Sample Content (Ton) Every Type of Community Forest FMU Lawu Manunggal

Organ	Karbon (Kg)				
	Root	Stem	Branch	Leaf	Total
Melia	4,999	15,080	4,405	4,321	28,805.665
Mahogany	10,298	28,746	3,622	3,146	45,812.251
Teak	7,926	25,591	4,613	3,664	41,794.927
Albicia	2,625	6,744	1,412	1,235	12,016.290
Total	25,848.822	76,161.330	14,052.836	12,366.145	128,429.132
%	**20.13**	**59.30**	**10.94**	**9.63**	**100.00**

Source: Primary Data Processed 2017

The total volume of community forest standing of FMU Lawu Manunggal of Panekan Subdistrict of Magetan district is 2,694.08 tons. The width of forest management area of FMU Lawu Manunggal at Panekan Subdistrict of Magetan Regency is 279,33 Ha. Based on the type of forest standing within the management area, the of carbon volume is as the following. Tapak village that

has the greatest potential is 1,935.56 tons. This can be seen in Table 8 and Fig. 2.

Table 8. Carbon content of Community Forest, Forest FMU Lawu Manunggal

Village/Jenis	Carbon Amount per type (Kg)						
	N	V (M3)	Stem	Root	Branch	Leaf	Total (Ton)
			Sumberdodol				
Melia	1,386	281.154	78,842	26,138	23,032	22,590	150.60
Mahogany	3,553	479.639	273,493	97,975	34,459	29,930	435.86
Teak	4,939	760.793	310,809	96,265	56,030	44,504	507.61
Albicia	1,276	293.839	46,564	18,127	9,751	8,528	82.97
Amount - 1 (Ton)	**11,154**	**1,815.425**	**709.71**	**238.51**	**123.27**	**105.55**	**1,177.04**
			Tapak				
Melia	3,916	532.018	222,761	73,849	65,075	63,826	425.51
Mahogany	4,939	541.956	380,180	136,195	47,902	41,606	605.88
Teak	2,618	285.941	201,012	62,259	36,236	28,783	328.29
Albicia	2,420	593.557	88,310	34,379	18,493	16,174	157.36
Amount -2 (Ton)	**13,893**	**1,953.471**	**892.26**	**306.68**	**167.71**	**150.39**	**1,517.04**
Total	**25,047**	**3,768.896**	**1,601.97**	**545.19**	**290.98**	**255.94**	**2,694.08**
Average	**18,101**	**2,792.160**	**1,155.84**	**391.85**	**207.13**	**180.75**	**1,935.56**

Source: Primary Data Processed 2017

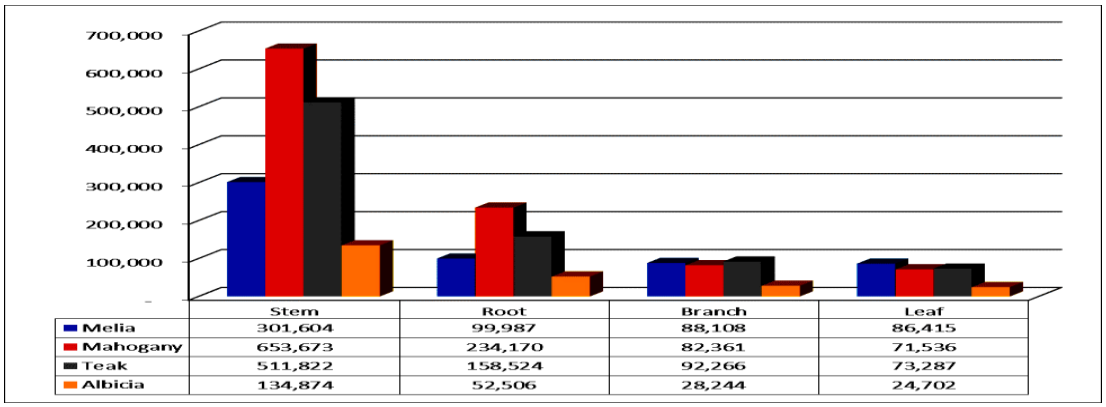

Figure 2. Carbon content (ton) of FMU Lawu Manunggal anekan Sub-district

5 Conclusion

1) Average potential volume of forest stands for community forest FMU Lawu Manunggal at Sumberdodol and Tapak Villages - Magetan regency as the following, i.e., albicia plant is 88,740 M^3/Ha, Mahogany 102.159 m^3/Ha, Melia 81.31 m^3/Ha and teak 79.648 m^3/Ha. while the management area is 276.33 Ha

consisting of 2 villages. The stand potential for albicia is 887.396 m3, Mahogany is 1,021,595 m^3, Melia is 813.171 m3, and Teak 786,476 m^3.

2) The average volume content of forest biomass at Sumber Dodol village and Tapak is as the following Melia 61,288,649 kg/Ha, Mahogany 97,472,875 kg / Ha, Teak type equal to 88,925,376 Kg /Ha, and Albicia 25,566,573 kg/Ha. While the forest area of FMU Lawu Manunggal at Sumberdodol and Tapak are 276,33 Ha, Total biomass for Melia 1,225.77 tons, Mahogany 2,216.47 tons, Teak 1,778.51 tons and 511.33 tons of albicia.The total forest stands are 5,732.08 tons.
3) Mean Carbon volume content of the sumber Dodol and Tapak villages is as the following : Melia 28,806 ton/Ha, Mahogany 45,812 ton/Ha, Teak type 41,795 ton/Ha and Albicia species 12,016 ton/Ha. While the forest area of FMU Lawu Manunggal of Sumberdodol and Tapak is 276,33 Hectares.Total Carbon of Melia 576.11 ton, Mahogany 1,041.74 ton, Teak 835.90 ton and albicia 240.33 ton. The total stands are 2,694.08 tons.

Acknowledgements. This research was funded by the Ministry of Technology research and higher education of Republic Indonesia on the applied product research scheme for 2017 Nomor 002/SP2H/HB-PT/Unmer.Mdn/LPPM/V/2017, date May 5, 2017.

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Received: September 25, 2017; Published: November 5, 2017