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Vegetation Structure, Biomass, and Carbon Stock of Urban Forest of Bongohulawa National Wirakarya Campground Gorontalo Regency-Gorontalo Province

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ABSTRAK

Hutan kota perkemahan Wirakarya Nasional sangat asri, memiliki view pemandangan yang indah dan berada dekat dengan jalan serta mudah dijangkau oleh masyarakat. Penelitian ini bertujuan untuk mengetahui struktur vegetasi, biomassa, dan nilai karbon yang tersimpan di hutan Kota Perkemahan Wirakarya. Nasional Bongohulawa Kabupaten Gorontalo-Provinsi Gorontalo. Metode yang digunakan metode survey dengan desain penelitian deskriptif kuantitatif. Pengukuran struktur vegetasi menggunakan perhitungan terhadap KR, FR, DR, dan nilai INP. Stok karbon pada atas permukaan (batang) menggunakan *non destructive* sampling dengan menggunakan persamaan allometrik berdasarkan spesies tanaman. Hasil penelitian menemukan 13 famili, 20 spesies dan 824 individu. Struktur vegetasi, rata-rata memiliki INP diatas 15%, pohon didominasi *Gmelina arborea* dengan INP (98,36%), tiang didominasi *Swietenia mahagagoni* dengan INP (165,37%), pancang didominasi *Swietenia mahagagoni* dengan INP (160,99%), dan semai didominasi *Lantana camara* dengan INP (32,25%). Kandungan biomassa yang tersimpan dalam tegakan (1.190,45 ton/ha), dengan jumlah biomassa paling besar berada pada pertumbuhan tingkat pohon (1.135,43 ton/tahun) atau 95,43 persen, biomassa tingkat tiang (45,10 ton/tahun) atau 3,79 persen dan jumlah biomassa tingkat pancang (9,32 ton/tahun) atau 0,78%. C-Stock (559,37 ton/ha) dan mampu menyerap CO_2 (CO_2*eq)* 2.052,88 ton/ha serta menyediakan O_2 terkonversi 1.498,60 ton/ha.

Kata kunci: *Indeks Nilai Penting, Biomassa, Karbon Hutan Kota*

ABSTRACT

The urban forest of the National Wirakarya Campsite has an attractive and picturesque scenery. The urban forest is easily accessible by public since it is located near the main road. This study aimed to determine the structure of vegetation, biomass, and carbon values stored in the urban forest of the National Wirakarya Campsite, Bongohulawa, Gorontalo Regency, Gorontalo Province. The method used a survey method with quantitative descriptive research design. The structure of the vegetation measurement was carried out by using the number of sample plots that are placed regularly by calculating the Relative Density, Relative Frequency, and Relative Dominance. To measure the carbon stocks above ground (stems), a non-destructive sampling method was used with an allometric equation based on the plant species. The results showed there are 13 families, 20 species, and 824 individuals. The vegetation structure has an IVI above 15% on average with Gmelina arborea (beechwood) dominating the trees (IV = 98.36%); the pole and sapling level dominated by the Swietenia mahagoni (mahogany) with IVI of 165.37% and 160.99% respectively; and the seedling level dominated by Lantana camara (tembelekan) with an IVI of 32.25%. The content of biomass stored in the standing trees was 1,190.45 tons/ha, with the largest amount of biomass at the sawlog level of 1,135.43 tons/year or 95.43%. The total biomass at the pole level was 45.10 tons/year or 3.79%; the sapling level was 9.32 tons/year or 0.78%. The carbon stock stored (C-Stock) was 559.37 tons/ha and can absorb CO2 (CO2eq) of 2,052.88 tons/ha and provided converted O2 of 1,498.60 tons/ha.

Keywords: *Important Value Index, Biomass, Urban Forest Carbon.*

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1. Introduction

Physical development of urban areas pushes the concentration of inhabitants with a certain amount of density centered in urban areas, resulting in cities becoming the center of high-density populations that will cause various complex environmental and social problems (Baba & Asami, 2022; Khan et al., 2022). The problems that arise are environmental damage (Gao & Xin, 2022; Guo & Duan, 2022; Tognella et al., 2022)from the loss of green open space, damage to the function of water catchment, water, and air pollution caused by economic activity which is an implication of the growth of the population and infrastructure development (Vanhatalo & Partanen, 2022).

Based on the 2017 Regional Action Plan for Climate Change Adaptation (RAD API) of Gorontalo Regency document, it was stated that there was a decrease in Carbon reserves due to changes in land cover in Gorontalo Regency in the interval of 2009 to 2016. Carbon reserves were 10,317,622.98 tons/ha/year in 2009, but were reduced to 9,693,434.14 tons/ha/year in 2016. Furthermore, based on the results of the analysis of land cover change from 2009 to 2016, the emissions in 2016 were 2,674,145.11 CO_2 tons, whereas CO_2 uptake was 8,760,855.45 tons. The highest emissions came from dryland agricultural activities combined with shrubs, which contributed 1,324,661.25 CO_2 tons, and secondary forest emissions, which contributed 1,189,320.39 CO_2 tons. The smallest emission comes from primary forest emissions which reach 3.76 tons of CO_2 (RAD API of Gorontalo Regency, 2017).

Furthermore, according to data from the Ministry of Environment and Forestry of Gorontalo Province (2017), the 2017 average annual NO_2 and SO_2 concentrations referencing the Quality Standards regulated in Government Regulation Number 41/1999 concerning Air Pollution Control, NO_2 concentrations for transportation are 6, 60 g/Nm3, the industry is 3.17 g/Nm3, residential is 6.00 g/Nm3, offices are 5.65, and the district average is 5.35. This value is still below the manufacturer's declared quality standard of 400 g/Nm3. Furthermore, the concentration level of SO_2 for transportation is 2.47 g/Nm3, the industry has a concentration of 2.47 g/Nm3, residential has a concentration of 2.91 g/Nm3, offices have a concentration of 11.86 g/Nm3, and the district average has a concentration of 4.93 g/Nm3. This value is still below the manufacturer's declared quality standard of 900 g/Nm3. Limboto District, being the heart of government, trade, industry, education, and other activities, requires the availability of land, resulting in the reduction of the green open space. The construction of various facilities and infrastructure will need the acquisition of land for construction sites, reducing the amount of green open space in the city. Moreover, the reduced amount of vegetation in the area can affect the condition and quality of the surrounding air due to air pollution where air pollutant substances are not completely absorbed by vegetation because the amount of vegetation is decreasing.

High activity in urban areas will trigger an increase in fossil fuel consumption which will encourage an increase in CO_2 levels. One of the ecosystem traits that have a high-profile aspect of climate change mitigation initiatives is the storage of carbon in soil and vegetation (Davies, et al, 2013). One of the efforts to revitalize ecosystems in urban areas can be done through the development of urban forests (Balitbang, Ministry of Forestry, 2010). This strategic effort was carried out because trees naturally can absorb CO_2 gas which is stored in the form of carbon compounds and then released in the form of oxygen while also absorbing heat so that it lowers the ambient temperature. In addition, urban forests also function as a site for flora and fauna conservation (Lubis, et al, 2013). A similar thing was expressed by Gratimah (2014) that one way to reduce CO_2 in urban areas is to reduce carbon emissions and build urban forests. Furthermore, it is said that urban forests are the most effective carbon sinks so that they can reduce the increasing carbon emissions in the atmosphere.

Following the objectives of the management of urban forests, the implementation of urban forests is emphasized their functions as carbon dioxide absorbers and oxygen producers, pollutants (heavy metals, dust, sulfur) absorbers, noise reducers, preserving germplasms, supporting the diversity of flora, fauna and the balance of the ecosystem, windbreaks and beauty enhancement (PP 63 of 2002). Concerning the above, the development of urban forests is one of the real efforts of the Gorontalo Regency Government to increase resilience to the impacts of climate change. This effort was later confirmed by the stipulation of the Regent of Gorontalo's Decree Number 12 of 2013 concerning the Management of Urban Forests and City Parks in the Gorontalo Regency. The designated locations as urban forest areas are the Bongohulawa National Wirakarya Campground with a surface area of 90.92 Ha, the Ex Mall Limboto area with a surface area of 1.61 Ha, and the Gorontalo Regent's Office area with a surface area of 0.16 Ha.

To optimize the function of forest management as the carbon dioxide absorber, oxygen producer, and pollutants (heavy metals, dust, sulfur) absorber, the urban forest development planning must be arranged based on studies from technical, ecological, economic, social, and local cultural aspects (PP 63 of 2002). Furthermore, according to Government Regulation number 63 of 2002, in the management of urban forests, the government, provincial governments, and district/city governments must encourage community participation through the appointment, development, stipulation, management, guidance, and supervision. The Gorontalo Regency Government's efforts in planning the development of urban forests have not been fully arranged based on the studies of technical, ecological, economic, social, and local cultural aspects. This study aims to obtain a database related to vegetation structure, Important Value Index, and carbon stocks of the Urban Forest of Bongohulawa National Wirakarya Campground in Gorontalo Regency, Gorontalo Province.

2. Research Methods

2.1. Research Site

This study was conducted at the Urban Forests of Bongohulawa National Wirakarya Campground in Bohulawa Village, Limboto District, Gorontalo Regency (Figure 1). The method used in this research is a survey method with a quantitative descriptive research design. The sampling method used is purposive sampling based on land cover in urban forests. Non-destructive sampling is used to determine tree biomass in urban forests, with an allometric equation depending on plant species (Lubis et al, 2013). The allometric equation is used because it has the advantage that it does not cut or damage trees, it is more efficient in terms of time and cost.

The vegetation data was obtained using the double plot method and quadrants by following the Indonesian National Standard size (SNI 7724, 2011), namely:

a. Size 20 m x 20 m for sawlog level (woody vegetation with diameter ≥ 20 cm);
b. Size 10 m x 10 m for pole level (woody vegetation with diameter 10 cm to < 20 cm);
c. Size 5 m x 5 m for sapling level (vegetation with diameter 2 cm to < 10 cm); and
d. Size 2 m x 2 m for seedling level (vegetation with diameter < 2 cm and height ≤ 1.5 m).

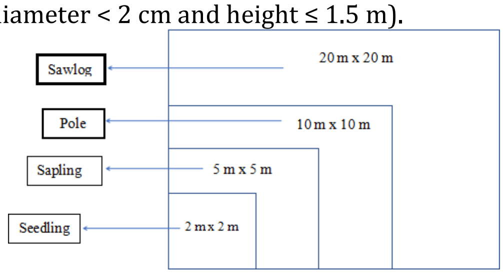


Figure 1. Map of the research location in the Urban Forest of Bongohulawa National Wirakarya Campground

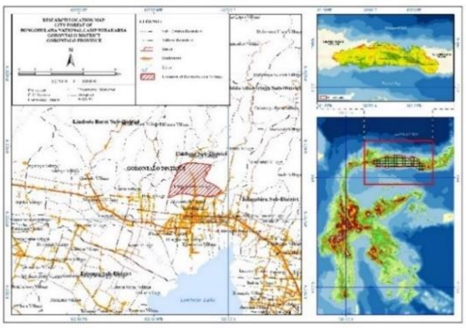


Figure 2. The shape of sample plots and sample quadrants

2.2. Data Analysis

Vegetation Analysis

According to Mueller-dombois (1974), the analysis of vegetation can be carried out using the following calculation formula:

a. Density

$$\text{Density} = \frac{\textit{Number of the Individual}}{\textit{the Area of Sample Square}}$$

$$\text{Relative Density} = \frac{\textit{D of a species}}{\textit{the Total D for all species}} \times 100\%$$

b. Frekuensi

$$\text{Frequency} = \frac{\textit{the total of sampling unit in which a species occurs}}{\textit{the Total for sampling unit}}$$

$$\text{Relative Frequency} = \frac{\textit{F of a species}}{\textit{the Total F for all species}} \times 100\%$$

c. Dominance

$$\text{Dominance} = \frac{\textit{Total basal cover of individual species}}{\textit{the Total for sampling unit}}$$

$$\text{Relative Dominance} = \frac{\textit{Do of individual species}}{\textit{Do for all species}} \times 100\%$$

d. Important Value Index (IVI)

Based on the parameter of density, frequency and dominance value, Important Value Index is obtained. In the sawlog, pole, and sapling level, the IVI calculation is IVI = RD + RF + RDo, while in the seedling level the formula for the IVI is IVI = RD + RF.

Biomass Analysis

The analysis of biomass value is calculated using the Allometric equation (Fradette et al., 2021) with the formula : BK = 0.11 ρ $D^{2,62}$ where:BK : Tree Biomass (in Kg)

ρ : Density (g/cm^3)
D : Diameter as high as the breast-height (130 cm from the ground surface)

Tree density (ρ) is obtained from the database *Wood Density Database Of Trees World Agroforestry*.

Analysis of Carbon Stock and Soil Organic Matter

a. Analysis of Carbon Stock from Biomass

Analysis of carbin stock uses the general formulation as follows: Cb = B x % C Organic, where:

Cb : Carbon content in biomass (Kg);
W : total biomass (Kg);
% C Organik : the percentage of the carbon content obtained from the result of laboratory measurement that is 0.47 (SNI 7724, 2011).

b. Analysis of Soil Organic Matter

Soil organic matter analysis was carried out after obtaining soil C-Organic values through laboratory tests using the Walkley and Black method, after C-organic values is obtained, to measure the value of organic matter a formulation is used (Steelink, 1985): Organic matter (%) = % C-Organic x 1.724, where the conversion factor of 1.724 is used assuming that organic matter contains 58% Carbon.Carbon dioxide absorption CO_2 (eq) is obtained using the formulation equation, namely: CO_2(eq) = Cn x 3.67, where CO_2(eq) is the amount of CO_2 absorbed (ton CO_2/ha) and Cn is the amount of stock carbon (tonnes C/ha). As for the calculation of converted oxygen is calculated by the equation, namely: converted O_2 = CO_2(eq) x 0.73.

3. Results and Discussions
3.1. Results
Vegetation Types

Table 1. Types of Vegetation based on the Growth Level

No	Growth Level	Family	Species	Number of Individual	Diameter (cm)	
					Range	Average
1.	Sawlog	7	8	170	20 -167	69,20
2.	Pole	5	6	117	10-19	14
3.	Sapling	7	7	75	4 - 9	6,99
4.	Seedling	10	15	462		

Table 2. Types of the Vegetation Identified in the Sampling Unit

No	Local Name	Species	Family
1.	*Jati putih*	*Gmelina arborea*	
2.	*Jati*	*Tectona grandis*	Verbenaceae
3.	*Tembelekan*	*Lantana camara*	
4.	*Mahoni*	*Swietenia mahagoni*	Meliaceae
5.	*Kemiri*	*Aleurites moluccanus*	
6.	*Akar Kucing*	*Acalypha indica*	Euphorbiacea
7.	*Ubi kayu*	*Manihot utilissima*	
8.	*Johar*	*Senna siamea*	Caesalpiniaceae
9.	*Lamtoro*	*Leucaena leucocephala*	Fabaceae
10.	*Kelapa*	*Cocus nucifera*	Arecaceae
11.	*Mangga*	*Mangifer odorata*	Anacardiaceae
12.	*Jambu air*	*Syzygium aqueum*	Myrtaceae
13.	*Jambu biji*	*Psidium guajava*	
14.	*Ketapang*	*Terminalia catapa L*	Combretaceae
15.	*Bandotan*	*Ageratum conyzoides*	Asteraceae
16.	*Gulma siam*	*Chromolaena odorata*	
17.	*Enau*	*Arenga pinnata*	Arecaceae
18.	*Sambiloto*	*Andrographis paniculata*	Acanthaceae
19.	*Coklat*	*Theobroma cacao*	Sterculiaceace
20.	*Kersen*	*Muntingia calabura*	Tiliaceae

Stand Biomass
Biomass in Sawlog Level

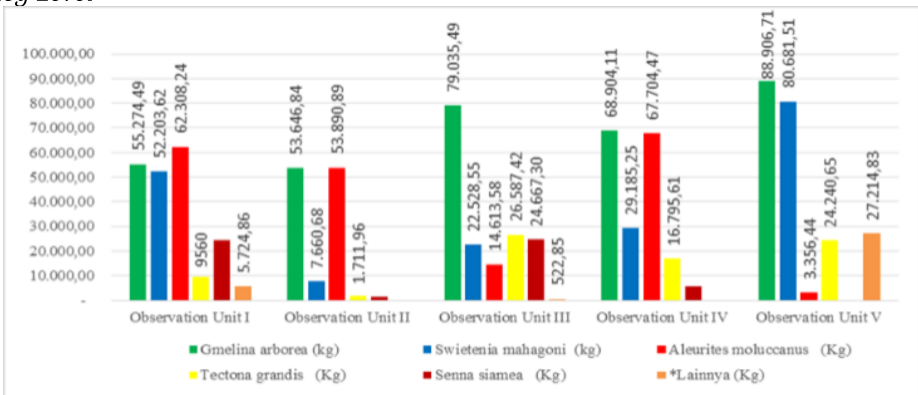


Figure 3. The value of Biomass for each Observation Plot
Note: * Others : *Spesies Leucaena leucocephala, Mangifer odorata dan Cocus nucifera*

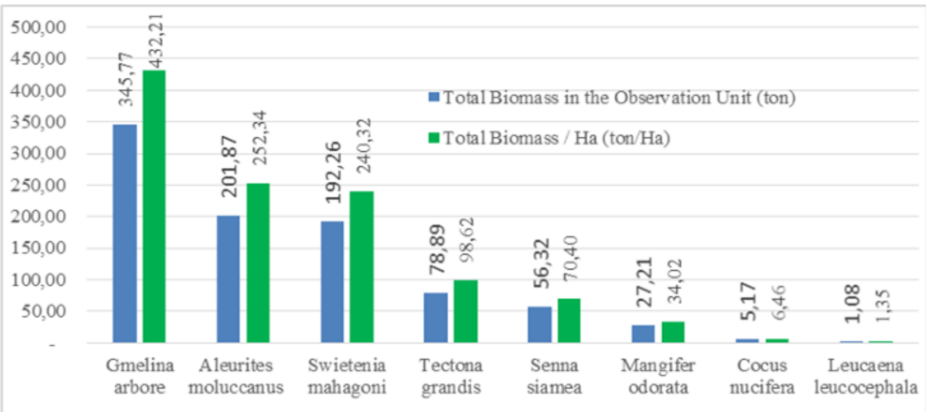


Figure 4. The Value of Biomass in Sawlog Level

Biomass in Pole Leve

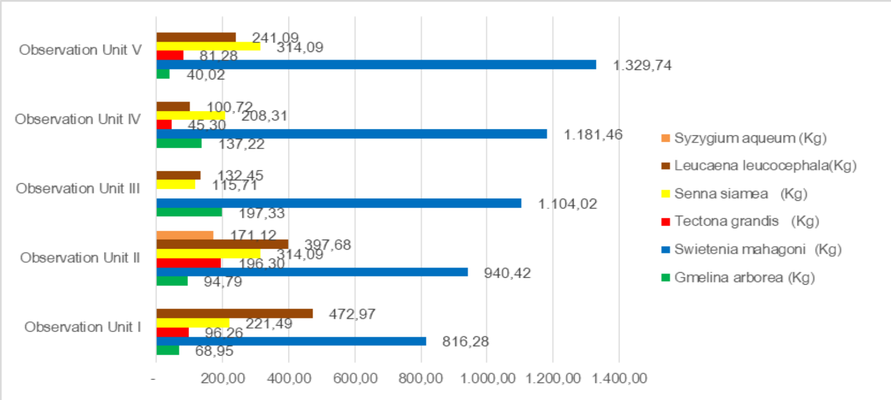


Figure 5. The Value of Biomass in Pole Level for each Observation Plot

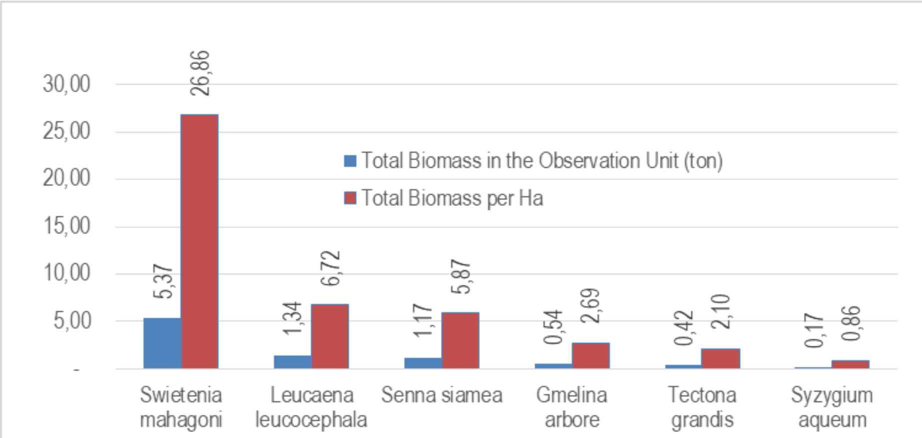


Figure 6. The Value of Biomass in Pole Level

Biomass in Sapling Level

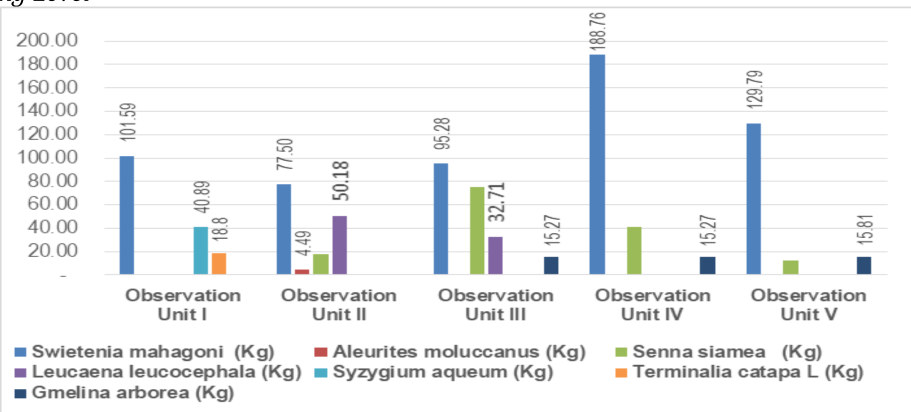


Figure 7. The Value of Biomass in Sapling Level for each Observation Plot

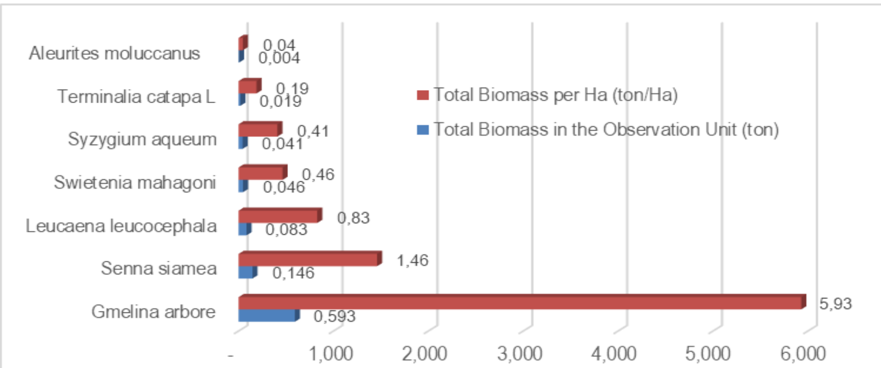


Figure 8. The Value of Biomass in Sapling Level

Important Value Index

Table 3. IVI in the Urban Forest of the Bongohulawa National Wirakarya Campground

No.	Growth Level/Species	Number of Individual	IVI
Sawlog Level			
1	*Gmelina arborea*	68	98,36
2	*Swietenia mahagoni*	53	83.38
3	*Aleurites moluccana*	19	42,5
4	*Tectona grandis*	14	25,24
5	*Senna siamea*	11	20.48
6	*Leucaena leucocephala*	3	5,41
7	*Cocus nucifera*	1	3,45
8	*Mangifer odorata*	1	3,45
Pole Level			
1	*Swietenia mahagoni*	73	165,37
2	*Leucaena leucocephala*	17	55,24
3	*Gmelina arborea*	11	36,48
4	*Senna siamea*	10	35,43
5	*Tectona grandis*	5	19,28
6	*Syzygium aqueum*	1	4,65
Sapling Level			
1	*Swietenia mahagoni*	51	160,99
2	*Senna siamea*	9	45,85
3	*Leucaena leucocephala*	7	31,1
4	*Gmelina arborea*	4	23,45
5	*Syzygium aqueum*	2	8,69
6	*Terminalia catapa L*	1	7,38
7	*Aleurites moluccana*	1	5,89
Seedling Level			
1	*Lantana camara*	92	32,25
2	*Leucaena leucocephala*	91	31,77
3	*Ageratum conyzoides*	75	28,48
4	*Arenga pinnata*	45	20,36
5	*Chromolaena odorata*	32	17,4
6	*Psidium guajava*	26	16,28
7	*Swietenia mahagoni*	26	17,53
8	*Andrographis paniculata*	14	15,26
9	*Acalypha indica*	6	16,6
10	*Tectona grandis*	23	13,82
11	*Theobroma cacao*	9	14,48
12	*Syzygium aqueum*	8	13,86
13	*Termenilia catapa*	3	12,26
14	*Manihot utilissima*	9	11,16
15	*Muntingia calabura*	3	8,53

C-Stock, CO_2 (eq) and Converted O_2

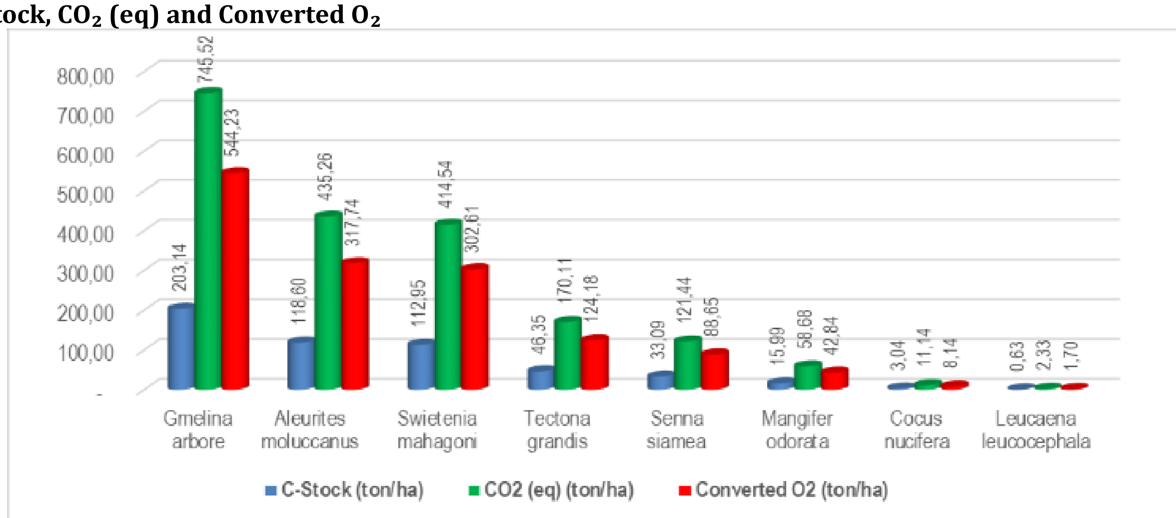


Figure 9. The Value of C-Stock, CO_2(eq) dan Converted O_2 in Sawlog Level.

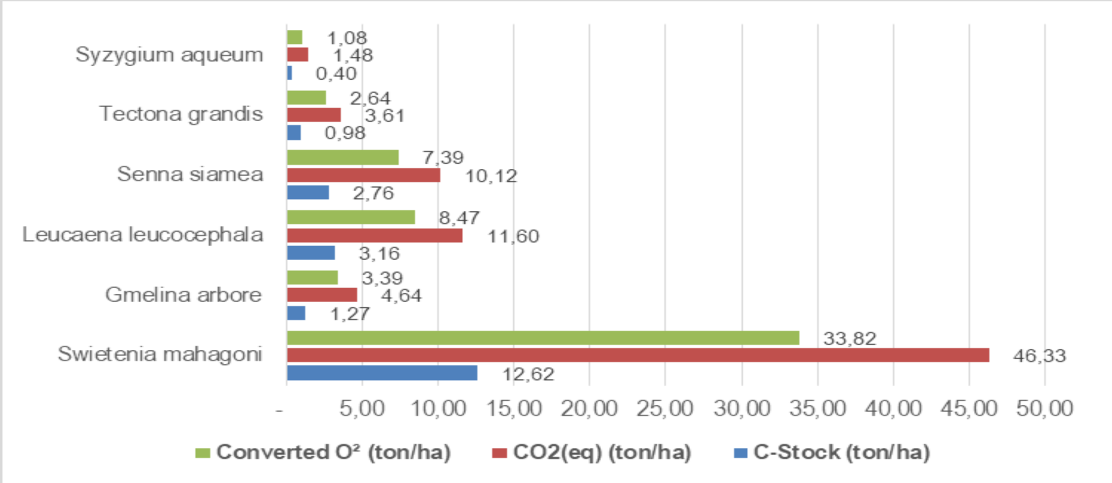


Figure 10. The Value of C-Stock, CO_2(eq) and Converted O_2 in Pole Level

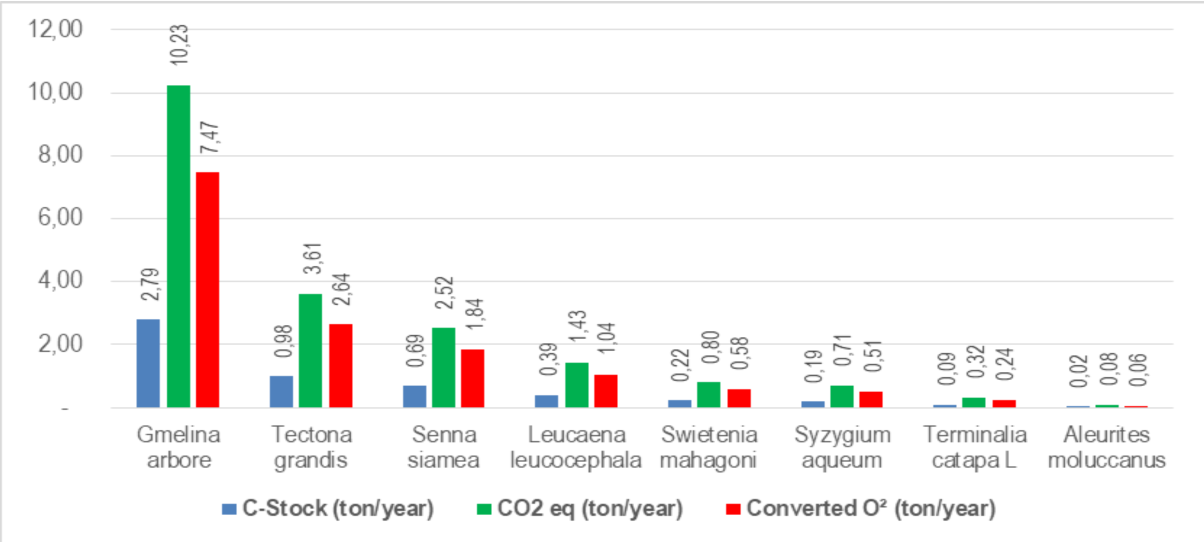
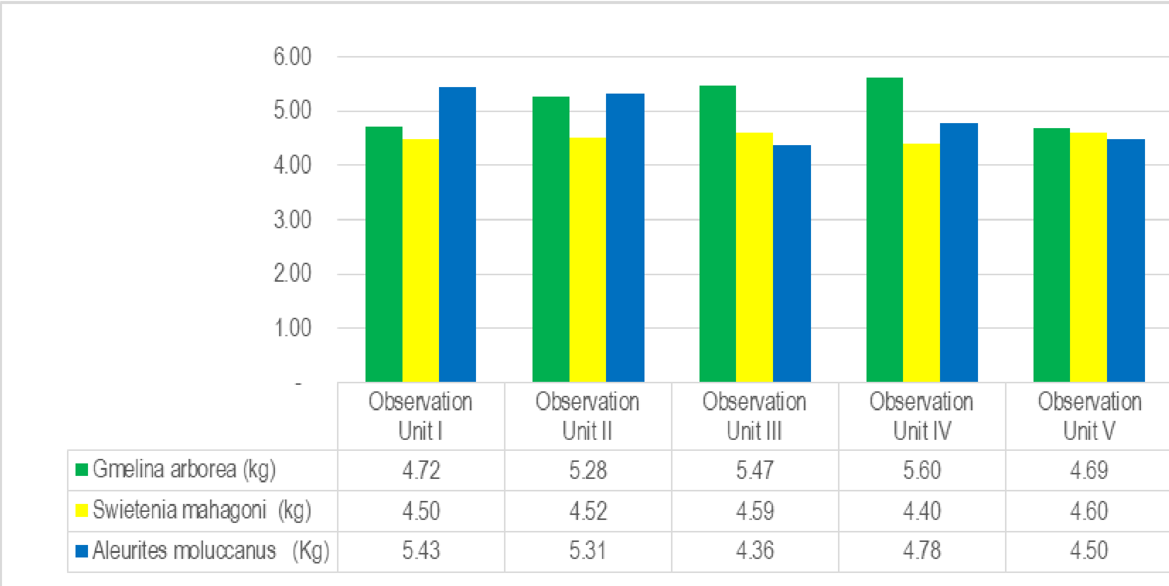


Figure 11. The Value of C-Stock, CO_2 (eq) and Converted O_2 in Sapling Level



	Observation Unit I	Observation Unit II	Observation Unit III	Observation Unit IV	Observation Unit V
Gmelina arborea (kg)	4.72	5.28	5.47	5.60	4.69
Swietenia mahagoni (kg)	4.50	4.52	4.59	4.40	4.60
Aleurites moluccanus (Kg)	5.43	5.31	4.36	4.78	4.50

Figure 13. Average Value of Soil Organic Matter Based on Species and Observation Plots

Table 4. C-Organic Test and Analysis of Total Organic Matter based on Special and Observational Plot

Observation Plot	Analysis results	Sample Code											
		K1	K2	K3	K4	M1	M2	M3	M4	JP1	JP2	JP3	JP4
I	Water content (%)	6,3	7,5	7,2	7,5	7.15	7	6,2	6,9	6,3	7,2	7,1	6,9
	Average	7,14				6,82				6,9			
	C-Organic (%)	3,2	2,8	3,4	3,2	2,6	2,5	3,2	2,1	2,5	2,3	3,1	3,1
	Average	3,15				2,61				2,74			
	*Organic Ingredients (%)	5,43				4,5				4,72			
II	Water content (%)	7,5	7	7	6,7	6,8	6,5	6,9	6,9	7,1	7,1	7,1	6,6
	Average	7,05				6,79				6,97			
	C-Organic (%)	3,2	3,3	2,7	3,1	2,5	2,7	2,5	2,9	2,5	3,2	3,3	3,2
	Average	3,08				2,62				3,06			
	*Organic Ingredients (%)	5,31				4,52				5,28			
III	Water content (%)	7,1	6,6	6,3	7	7,1	7,3	6,5	7	7,5	6,8	6,9	7,2
	Average	6,76				6,98				7,11			
	C-Organic (%)	2,4	3	2,6	2,1	2,5	2,3	3,3	2,9	3,2	3	3,1	3,4
	Average	2,53				2,72				3,17			
	*Organic Ingredients (%)	4,36				4,59				5,47			
IV	Water content (%)	6,6	6,3	7,5	7	7,5	6,4	6,9	6,3	7,3	6,8	7,3	7,2
	Average	6,87				6,8							
	C-Organic (%)	2,5	3,2	2,1	3,2	2,6	2,1	3,2	2,5	3,2	3,3	3,2	3,2
	Average	2,77				2,6				3,24			
	*Organic Ingredients (%)	4,78				4,4				5,6			
V	Water content (%)	6	6,3	6,7	6,5	6,3	6,7	6,6	6,4	6,4	6,4	6,7	7,2
	Average	6,38				6,49				6,7			
	C-Organic (%)	2,7	2,5	2,9	2,5	2,5	3,2	2,3	2,7	2,3	3,3	2,5	2,9
	Average	2,61				2,67				2,72			
	*Organic Ingredients (%)	4,5				4,6				4,69			

Description: K = Candlenut; M = Mahogany; JP = White Teak
* Organic Material (%) = % C-Organic x 1.724 (constant)
Source: Primary Data, 2018

Based on the obtained C-Organic value, the soil organic matter content was calculated using the formulation (Steelink, 1985). The Average Value of Soil Organic Matter Based on Species and Observation.

3.2. Discussion

The overview of the Important Value Index in Table 3 above shows that for sawlog level, there are 3 species of plants with IVI < 15%, namely *Leucaena leucocephala, Cocus nucifera and Mangifer odorata*. For the pole level, there is one species with IVI < 15%, namely *Syzygium aqueum.* Meanwhile, for the sapling level, there are three species of plants that have IVI < 10% namely *Syzygium aqueum, Terminalia catapa* L *dan Aleurites moluccanas.* There is one species in the seedling level, that is *Muntingia calabura.*

According to the description of the Important Value Index in Table 4.3, there are three plant species in sawlog level with INP < 15%, namely *Leucaena leucocephala, Cocus nucifera, and Mangifer odorata*. For the pole level, there is one species with IVI < 15%, namely *Syzygium aqueum.* Meanwhile for the sapling level, there are three species of plants that have IVI < 10% namely *Syzygium aqueum, Terminalia catapa* L *dan Aleurites moluccanas.* There is one species in the seedling level, that is *Muntingia calabura.* Plots in presented in **Figure 13**.

The role of a plant in a community is expressed by the Important Value Index (%). The greater the Important Value Index of a plant species, the greater the role of that species in the measured community. In the concept of dominance, species that have the highest Importance Value Index value can compete in a certain area and have a high tolerance compared to other types (Haryanto, et al, 2015). Furthermore, it is said that the higher the Important Value Index of a species, the higher its dominance in a community where that species grows.

The observation results at the research site in the Urban Forest of the Bongohulawa National Wirakarya Campground showed that although the *Gmelina arborea* species was the dominant species at the sawlog level, this species was not found at the seedling level. This shows that there are differences in the structure and composition of certain species that have disappeared or died and that there are also new types that appear in the observation plot. This condition is most likely caused by unfavourable environmental factors (Qi et al., 2021; Yang et al., 2017) and the species' adaptation to other species for growth (Tian et al., 2017). The types of species that can grow are those that can adapt to or are ideal for growing in the forest's environment. A species grows well in a favourable environment, according to (Ririhena, 2010). Furthermore, pioneer plants that grow densely on the forest floor will face competition for light, nutrients, and movement space; as a result of this competition, some vegetation will survive and adapt (Lorenz et al., 2022; Zobel et al., 2022).

Based on observations of all sample plots, the density of species in each level, from sawlog to seedlings, appears to be good. This could indicate that forest encroachment by the neighbouring community is still relatively small, even though aerial images show that some area is being used for agriculture.

Based on the results of the biomass calculation above, it shows that from the total biomass of 1,190.45 tons/year, it turns out that the largest amount of biomass is found at the sawlog level as big as 1,135.43 tons/year or 95.43%. Meanwhile, the amount of biomass at the pole level is 45.10 tons/year or 3.79% and the amount of biomass at the sapling level is 9.32 tons/year or 0.78%. The description of the proportion of vegetation biomass in the observation plot which is dominated by sawlog level is supported by (Wahyuni, 2014) who states that tree biomass is the main constituent of biomass value. Furthermore, it was emphasized that the correlation between the Important Value Index and tree biomass showed that the Important Value Index had a significant effect on biomass and there was a strong relationship between the Important Value Index and biomass. This means that the increase in the Important Value Index is proportional to the biomass.

According to Suwarna, et al, (2012) the different results that appear smaller or closer are due to differences in environmental conditions (Tian et al., 2017) where they grow and the method of biomass measurement. The smaller biomass content is closely related to the conditions in which it grows (Tian et al., 2017). Based on this comparison, the Urban Forest of Bongohulawa National Wirakarya Campground has a competitive biomass potential with other locations. Based on the area of the Bongohulawa National Wirakarya Campground Urban Forest, it shows that the forest has a large biomass potential to be optimized (Hashemi et al., 2022; Lange, 2022; Nguyen et al., 2023).

Gmelina arborea has the highest C-Stock, $CO_{2(eq)}$, and converted O_2 at the sawlog level, with C-Stock of 203.14 tons/ha, $CO_{2(eq)}$ of 745.52 tons/ha, and converted O_2 of 544.23 tons/ha. The species *Swietenia mahagoni* (mahogany) had the highest C-Stock, CO_2(eq), and converted O_2 at the pole level. This species has C-Stock of 12.62 tons/ha, $CO_{2(eq)}$ of 46.33 tons/ha, and converted O_2 of 33.82 tons/ha. The species *Gmelina arborea* (white teak) has the highest $CO_{2(eq)}$ and converted O_2 at the C-Stock at the sapling level with the C-Stock of 2.79 tons/ha, $CO_{2(eq)}$ of 10.23 tons/ha, and converted O_2 of 7.47 tons/ha for this species.

According to Rusdiana and Lubis (2012), the difference in the value of carbon stocks is influenced by the amount of composition and structure of tree stands (Tian et al., 2017). The greater the composition and structure of the forest stand, the greater the carbon stock is. Based on the comparison above, it shows that the Urban Forest of Bongohulawa National Wirakarya Campground has competitive C-Stock, $CO_{2(eq)}$ and Converted O_2 potential, so its management must be optimized.

Gmelina arborea has the highest biomass and carbon content at sawlog level compared to *Swietenia mahagoni* and *Aleurites moluccanus*, in line with the picture in Figure 12 which shows that the value of C-Organic in soil samples under the stands of *Gmelina arborea* is also higher than that of other species. Although in the observation plots I and II, *Aleurites Moluccana* has higher C-Organic than other types, this was because *Swietenia mahagoni* species had a higher density (24 individuals) compared to the relative density of *Gmelina arborea* (9 individuals).

Based on the average value of soil organic matter content in the observation plot which ranges from 4.36-5.60%, and then compared with the criteria for soil organic matter (Yost et al., 2022), it can be concluded that the soil organic matter content in the Urban Forest of Bongohulawa National Wirakarya Campground is considered to be in the high criteria. This is because the average soil organic matter content is in the interval from 4.30% to 6.00%.

According to Mainka et al., (2022) that the organic matter content is varied for one and the other, this is not only caused by differences in land use types and soil characteristics, it is also related to the decomposition process (Tian et al., 2017) that occurs in the soil. The decomposition process of the organic matter is influenced by factors such as the type of litter, humidity, oxygen, temperature, pH, application of organic fertilizer and the ease with which the plant litter is destroyed.

4. Conclusions

The Urban Forest of Bongohulawa National Wirakarya Campground as a type of Urban Green Open Space has stand potential which is indicated by the vegetation structure in the Urban Forest of Bongohulawa National Wirakarya Campground. Therefore, our new results demonstrated that the average has an IVI above 15% with sawlog level dominated by *Gmelina arborea* (white teak) with an IVI of 98.36%.

Furthremore, the pole level was dominated by the *Swietenia mahagoni* (mahogany) with an IVI of 165.37%, the sapling level was dominated by the *Swietenia mahagoni* with an IVI of 160.99 %, and the seedling level was dominated by *Lantana camara (tembelekan)* with an IVI of 32.25%.

Finally, based on the overall findings above, it is suggested that these results need to be interpreted as well as validated by foresters and agronomists for further research since the current study is limited to explore the urban forest planning and landscape designing to create forest adaptive planning.

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