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Full Length Research Article

Plant Diversity and Carbon Stocks in Urban Green Open Space (Case Study in PT. Gajah Tunggal Tbk., Tangerang, Banten)

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ABSTRACT

Efforts to mitigate climate change, namely reducing greenhouse gas emissions, can be carried out, among others, by utilizing trees in urban areas, which have an important role as carbon sinks. In order to determine the potential of tree species in absorbing carbon, research was conducted in the green open space area of PT. Gajah Tunggal Tbk. in Tangerang, Banten Province. This study aimed to determine the potential of tree species in absorbing carbon by measuring the diameter and height of 150 plant species of 46 families, consisting of 8,636 tree stands and 5,254 bamboo stems. The average age of the tree is over 7 years. The results showed that the potential biomass, carbon content, and CO_2 absorption of plants with a diameter of 2 cm were dominated by *Eucalyptus deglupta*, *Roystonea regia*, and *Pterocarpus indicus*. The total biomass, carbon content, and CO_2 absorption of tree and bamboo species were 880.82 tons or 413.98 tons C, equivalent to 1,519.33 t.CO_2-eq. This company's CO_2 emissions in 2020 amounted to 406,073.72 t.CO_2-eq.

1. Introduction

Urban development is often followed by developments in technology, industry, an increase in population, and the addition of transportation facilities. Such conditions will have a negative impact on the environment, especially air pollution. Clean air is often polluted by polluting gases produced by natural processes or caused by human activities. Trees and vegetation will absorb and absorb pollutants that motor vehicles emit through their leaves (Al Fajar et al. 2014; Samsoedin and Waryono 2015), and vegetation plays an effective role in absorbing air pollutants and can clean these pollutants from the air.

The Law of The Republic Indonesia No. 26 of 2007 concerning spatial planning stated that open space area is spaces within a city or a wider area, both in the form of areas/areas and in the form of elongated areas where in use they are more open, basically without buildings. According to Samsoedin and Waryono (2015), up to know the types of plants used in green open spaces still depend on several species, including *Pterocarpus indicus*, *Canarium ovatum,* and *Mimusops elengi*. There is a tendency for the urban community to feel proud and happy to have plants with high aesthetics and very expensive, such as imported palms that look beautiful but do not have many roles in environmental control efforts (Subarudi and Samsoedin 2012).

The Indonesian government has targeted a 26% reduction in carbon dioxide (CO_2) emissions by 2020 (Samsoedin and Waryono 2015). Reducing CO_2 emissions is carried out by preventing deforestation and forest degradation as well as planting trees to absorb the greenhouse gases from the atmosphere, including through urban forest development programs and other green open spaces area development (Heriyanto and Samsoedin 2019; Imansari and Parfi 2015). Trees and vegetation, through their leaves/stems, can absorb gases and harmful components from the air and release oxygen so that the air becomes clean (Al Fajar et al. 2014; Samsoedin and Waryono 2015). Green open space area has an important role in supporting (bio filtering), controlling (biocontrol), and improving (bioengineering) the quality of the environment in urban areas (Basworo 2011).

The largest CO_2 emission in Indonesia occurred in 2006, amounting to 195 million tons CO_2, and the lowest in 2010 with 74 million tons CO_2 (INCAS 2015). Purwanta (2010) stated that carbon dioxide emissions from 2001–2006 amounted to 827.06 CO_2 Gg/year, originating from industrial processes or 6% of the total calculated sector. The greenhouse gases released into the atmosphere are reported to be very high. From 2000–2016, the average greenhouse gas emission from the forestry sector (logging and fires) reached 0.71 Gt CO_2 (Adinugroho et al. 2019).

Vegetation in urban environments must be properly managed as a CO_2 absorber. These trees in urban areas positively affect climate change but often receive less attention because their ecosystem services are poorly understood or not quantified. An area's carbon sink is obtained from the production of biomass density and tree species (Dharmawan and Samsoedin 2012; Krisnawati et al. 2021).

Estimating biomass and carbon content in green open spaces still needs to be carried out. It is needed because the potential of biomass plays a very important role in absorbing carbon. Furthermore, green open space reduces CO_2 levels through conservation and management (Heriyanto and Subiandono 2012; Onrizal and Kusmana 2009; Subiandono et al. 2013). In the clean development mechanism, developed countries must reduce carbon dioxide (CO_2) emissions. In contrast, developing countries, which are generally located in tropical areas, are required to prevent forest destruction to reduce global warming (Astiani et al. 2017; Lugina et al. 2011). This study aimed to determine the types of trees planted in the green open space of PT. Gajah Tunggal Tbk. in Tangerang, Banten and their contribution in storing carbon indicate the ability of plants to absorb CO_2. The research results were expected to become recommendations for developing green open spaces in industrial areas, among others, by selecting tree species capable of absorbing greenhouse gas emissions.

2. Materials and Methods

2.1. Study Area

PT. Gajah Tunggal Tbk. area in Tangerang, Banten Province, Indonesia (**Fig. 1**) was chosen with the consideration that the location had been designated as a part of a green open space area by the company. The study area has an altitude of 20 masl with a green open space area of 29.84 ha, or 25.4% of the total factory area of 117.47 ha. This location was originally in the form of rice fields, a garden, and vacant land. Green open space area of PT. Gajah Tunggal Tbk. was built simultaneously with the establishment of the tire factory in 1951; according to the Law of The Republic Indonesia No. 26 of 2007, the area of open green space for large companies is 20%.

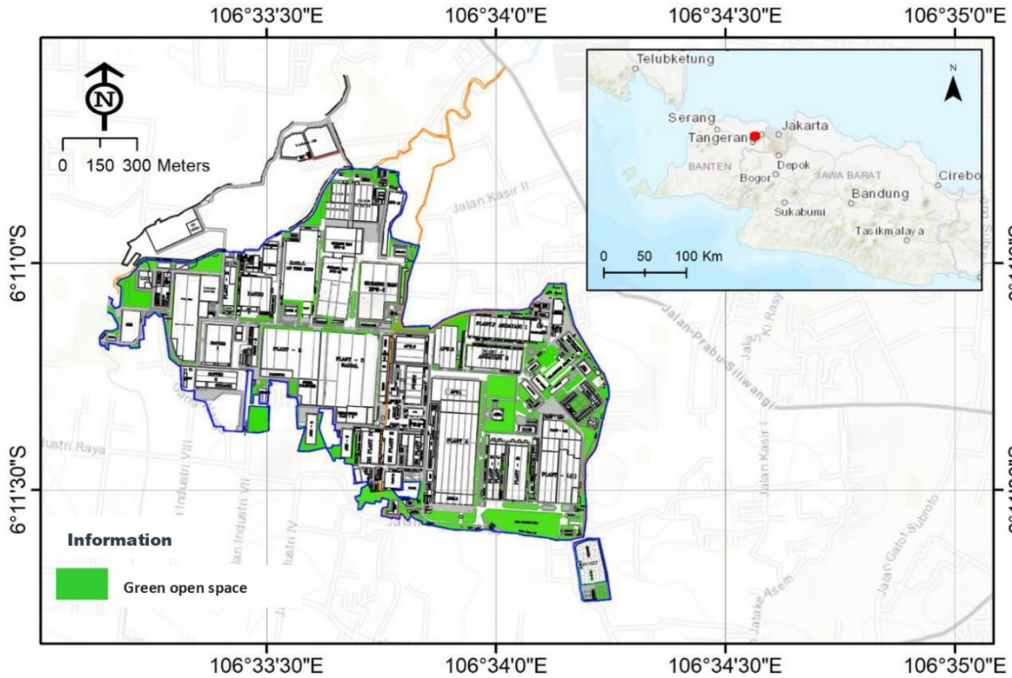

Fig. 1. Study area at PT. Gajah Tunggal Tbk. area in Tangerang, Banten.

The study area is located in two administrative cities, namely Tangerang City and Tangerang Regency. The topography is flat, with a slope between 0–3%. The soil in the study area includes the alluvial – red yellow podzolic – reddish brown podzolic association (Balittanah 2018; Soil Survey Staff 2003). The raw material consists of acid tuff, sandstone, and sand deposits. The soil solum is thick, red to yellow with consistently variable texture, acidic, low nutrient content with low to medium permeability, and highly eroded.

According to the classification of Schmidt and Ferguson, the climate of this area includes climate type B with a 2020 rainfall of 1,855.76 mm, a monthly average of 154.64 mm, and an average number of rainy days of 15 days. The average air temperature is a minimum of 22ºC and a maximum of 35ºC, and an average humidity of 75.76% (BPS 2021). The study was conducted in August–November 2021.

2.2. Tree Inventory and Measurement

The census observed tree inventory to determine the number and types of trees found in the research location. Initially, trees were planted as seedlings with a height between 60–100 cm and 200 cm, specifically for palm species. Then, physical measurements of trees were observed to obtain the following data and information.

2.2.1. Stem diameter

The stem diameter at breast height (DBH) of the tree was measured at 130 cm from the ground surface. If the tree has buttresses, the diameter measurement is carried out at 20 cm above the buttresses using the phi band.

2.2.2. Tree height

Measurement of tree height was classified into two strata, based on their nature, including strata 1 trees (< 10 meters high) and strata 2 trees (height ≥ 10 meters). The measuring instrument used is a digital Hagloof Vertex II with a sensitivity of 10 cm.

2.2.3. Identification of tree species

Identification of tree species (unclear species) by taking herbarium samples and carried out at the Herbarium of the Forest Research and Development Center, Bogor. Plant criteria followed previous studies (Heriyanto et al. 2020a; Kartawinata 2016):
- Trees are woody plants with DBH > 10 cm. The data collected were species, diameter, and height.
- Sapling is a woody plant with a height of ≥ 1.5 m and a DBH between 2 cm and < 10 cm. The data collected were species, diameter, and height.
- Seedlings, i.e., rejuvenation starting from sprouts to < 1.5 m high. The data collected were species and their amount.

Density was measured at each location for each plant species to evaluate the structure and composition of plant species (Heriyanto et al. 2020b).

2.3. Data Analysis

Data analysis was performed to calculate above-ground tree biomass and greenhouse gas sequestration potential using the following formulas.
The tree biomass was calculated using the formula (Chave et al. 2014).

$$Y = 0.0673(\rho D^2H)^{0.976} \quad (1)$$

The palm biomass was calculated using the formula (Goodman et al. 2013).

$$Y = \rho D^2H \quad (2)$$

The bamboo biomass was calculated using the formula (Chave et al. 2014).

$$Y= 0.4524(D)^{2.0347} \quad (3)$$

where Y is the total above-ground biomass (kg), D is the diameter at breast height (cm), ρ is the wood density (g/cm^3), and T/H is the height (m). Wood density data referred to the previous studies (Hairiah and Rahayu 2007; ICRAF 2017).

The carbon content in plants was calculated using the following equations (IPCC 2013; SNI 2011; Martin and Thomas 2011):

$$\textit{Carbon content} = \textit{Oven-dried weight} \times 47\% \quad (4)$$

$$\textit{Carbon dioxide absorption } (CO_2) = 44/12 \times \textit{carbon content} \quad (5)$$

3. Results and Discussion

3.1. Species and Physical Conditions of Trees

The planted tree species in the study area were generally a combination of local species from the Malesia region and introduced from abroad (exotic species). This planting of local species in the open space area shows that the company responsible for the management and maintenance of the park has incorporated the concept of ex-situ conservation or conservation outside its habitat by planting rare or lesser-known tree species that represent various bio-regions in Indonesia as has been proposed by many parties (Andry et al. 2017; Samsoedin and Waryono 2015). The green open space area also introduces exotic tree species that have the potential to support animal feed in the research location, such as capes whose fruits are used for animal feed (birds and squirrels) and angsana as animal/bird nesting sites.

Table 1. The tree species with DBH of ≥ 2 cm in the study area

No.	Species	Amount	No.	Species	Amount
1	*Acacia auriculiformis*	7	76	*Jatropha integerrima*	51
2	*Albizia chinensis*	43	77	*Khaya anthotheca*	1
3	*Aleurites moluccanus*	2	78	*Kigelia africana*	1
4	*Allamanda cathartica*	4	79	*Lagerstroemia indica*	86
5	*Anacardium occidentale*	4	80	*Leucaena leucocephala*	107
6	*Annona muricata*	22	81	*Livistona saribus*	23
7	*Annona squamosa*	43	82	*Maesopsis eminii*	2
8	*Antidesma bunius*	10	83	*Mallotus* sp.	5
9	*Aquilaria malaccensis*	3	84	*Mangifera indica*	137
10	*Araucaria heteroplylla*	3	85	*Manihot glaziovii*	29
11	*Araucaria angustifolia*	1	86	*Manilkara kauki*	12
12	*Archidendron pauciflorum*	1	87	*Manilkara* sp.	1
13	*Artocarpus heterophyllus*	46	88	*Manilkara zapota*	2
14	*Artocarpus altilis*	61	89	*Maniltoa* sp.	1
15	*Artocarpus camansi*	16	90	*Maniltoa grandiflora*	14
16	*Artocarpus integer*	1	91	*Melaleuca leucadendra*	18
17	*Averrhoa bilimbi*	2	92	*Molinadendron hondurense*	2
18	*Averrhoa carambola*	18	93	*Monoon longifolium*	588
19	*Bambusa* sp.	4	94	*Morinda citrifolia*	2
20	*Bambusa vulgaris*	5.260	95	*Moringa oleifera*	4
21	*Bauhinia purpurea*	368	96	*Muntingia calabura*	31
22	*Bismarckia nobilis*	3	97	*Murraya paniculata*	2
23	*Bouea macrophylla*	3	98	*Mussaenda pubescens*	14
24	*Bougainvillea glabra*	13	99	*Myristica fragrans*	1
25	*Brachychiton rupestris*	2	100	*Neolamarckia cadamba*	383
26	*Brachychiton* sp.	4	101	*Nephelium lappaceum*	6
27	*Bridelia cathartica*	3	102	*Nerium oleander*	81
28	*Poincianella acapulcensis*	5	103	*Persea americana*	2
29	*Caesalpinia pulcherrima*	41	104	*Pachira aquatica*	5
30	*Cananga odorata*	4	105	*Parkia speciosa*	9
31	*Canarium ovatum*	57	106	*Phaleria macrocarpa*	1
32	*Casuarina equisetifolia*	127	107	*Phoenix roebelenii*	11
33	*Ceiba pentandra*	1	108	*Phyllanthus acidus*	1
34	*Cerbera manghas*	546	109	*Pinus albicaulis*	14
35	*Cinnamomum verum*	1	110	*Plumeria acuminata*	85
36	*Citrus aurantiifolia*	6	111	*Plumeria* sp.	6
37	*Citrus amblycarpa*	13	112	*Podocarpus neriifolius*	1
38	*Citrus hystrix*	5	113	*Polyalthia* sp.	19
39	*Citrus maxima*	2	114	*Pometia pinnata*	17
40	*Cnidoscolus aconitifolius*	14	115	*Pouteria campechiana*	3
41	*Cochlospermum religiosum*	4	116	*Psidium guajava*	23
42	*Cocos nucifera*	11	117	*Pterocarpus indicus*	119
43	*Cordia africana*	13	118	*Pterocarpus* sp.	13
44	*Cordyline australis*	3	119	*Ptychosperma macarthurii*	6
45	*Cordyline* sp.	49	120	*Quercus glauca*	1
46	*Cordyline fruticosa*	22	121	*Ravenala madagascariensis*	17
47	*Cycas aculeata*	3	122	*Rhapis excelsa*	40
48	*Cynometra cauliflora*	3	123	*Ricinus communis*	17
49	*Dalbergia latifolia*	1	124	*Roystonea regia*	976
50	*Delonix regia*	6	125	*Samanea saman*	110
51	*Dimocarpus lengkeng*	13	126	*Sandoricum koetjape*	17
52	*Dracaena marginata*	3	127	*Saribus rotundifolius*	10

No.	Species	Amount	No.	Species	Amount
53	*Dracaena* sp.	4	128	*Schefflera arboricola*	11
54	*Durio zibethinus*	12	129	*Senna alata*	11
55	*Dypsis lutescens*	10	130	*Sesbania grandiflora*	9
56	*Dypsis* sp.	16	131	*Spathodea campanulata*	164
57	*Erythrina crista-galli*	24	132	*Spondias dulcis*	2
58	*Erythrina variegata*	206	133	*Streblus asper*	2
59	*Eucalyptus deglupta*	1232	134	Swietenia macrophylla	91
60	*Euphorbia tirucalli*	6	135	*Syzygium aromaticum*	4
61	*Eusyderoxylon zwageri*	13	136	*Syzygium aqueum*	50
62	*Euodia suaveolens*	2	137	*Syzygium cumini*	27
63	*Ficus* sp.	16	138	*Syzygium malaccense*	7
64	Ficus abelii	16	139	*Syzygium paniculatum*	189
65	*Ficus benjamina*	358	140	*Syzygium polyanthum*	11
66	*Ficus elastica*	26	141	*Tabebuia acrophylla*	401
67	*Ficus lyrata*	31	142	*Tabernaemontana corymbosa*	3
68	*Filicium decipiens*	1	143	*Tamarindus indica*	2
69	*Garcinia mangostana*	2	144	*Tectona grandis*	191
70	*Gliricidia sepium*	4	145	*Terminalia catappa*	354
71	*Gnetum gnemon*	3	146	*Terminalia mantaly*	31
72	*Hevea brasiliensis*	36	147	*Theobroma cacao*	4
73	*Hibiscus tilliaceus*	9	148	*Trema orientale*	7
74	*Hura crepitans*	60	149	*Wodyetia bifurcata*	186
75	*Hyophorbe lagenicaulis*	2	150	*Ziziphus mauritiana*	1

Notes: = hybrid species, = general species.

The condition of trees with DBH ≥ 2 cm observed in the green open space was generally good. There are 150 species consisting of 46 plant families planted (**Table 1**). The most planted plant species were *Eucalyptus deglupta* (1,232 individuals), *Roystonea regia* (976 individuals), and *Polyalthia longifolia* (588 individuals). The plants planted with green open space consisted of 8,636 belonging to the category of trees and 5,254 including types of bamboo; 10 dominant plant species were recorded with an average diameter and height, as shown in **Table 2** and **Table 3**.

Table 2. The diameter of the ten largest plant species in the study area

No.	Tree species	Diameter (cm)	Number of trees
1	*Eucalyptus deglupta*	14.91	1232
2	*Roystonea regia*	18.61	976
3	*Polyalthia longifolia*	6.03	588
4	*Cerbera manghas*	16.80	546
5	*Tabebuia acrophylla*	15.56	401
6	*Neolamarckia cadamba*	20.04	383
7	*Bauhinia purpurea*	12.02	368
8	*Ficus benjamina*	19.01	358
9	*Terminalia catappa*	16.20	354
10	*Erythrina variegata*	15.97	206

Table 3. The height of the ten largest plant species in the study area

No.	Tree species	Height (m)	Number of trees
1	*Eucalyptus deglupta*	10.70	1232
2	*Roystonea regia*	5.99	976
3	*Polyalthia longifolia*	4.35	588
4	*Cerbera manghas*	6.98	546
5	*Tabebuia acrophylla*	5.77	401
6	*Neolamarckia cadamba*	13.30	383
7	*Bauhinia purpurea*	6.41	368
8	*Ficus benjamina*	7.54	358
9	*Terminalia catappa*	9.04	354
10	*Erythrina variegata*	4.83	206

Based on tree height data from the 10 dominant trees and based on the measurement results (**Table 3**), it was shown that the average tree height at the study sites tended to vary. The graph of overall tree height (DBH ≥ 10cm) at the study site is presented in **Fig. 2**. The results showed that the dominance of tree height is less than 10 m (3,352 trees); in the tree height range between 10-15 m quite a lot (1,541 trees) and above 15 m relatively few (322 trees).

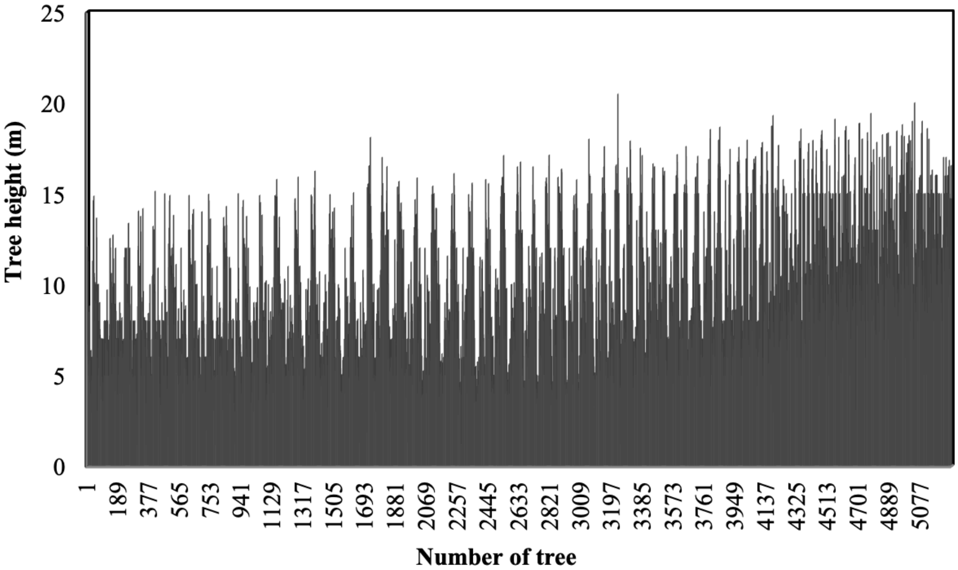

Fig. 2. The height of a tree with DBH ≥ 10 cm in the study area.

3.2. Stand Structure

Tree species at the study site with diameter or height parameters were dominated by *Neolamarckia cadamba*, *Eucalyptus deglupta,* and *Terminalia catappa*. Overall the tree stand structure is the relationship between the number of trees with diameter class in the research plot, distribution of trees with diameter class 2-9 cm, 10-19 cm, 20-29 cm, 30-39 cm, 40-49 cm, 50-59 cm, and ≥ 60 cm at the study site, as shown in **Fig. 3**.

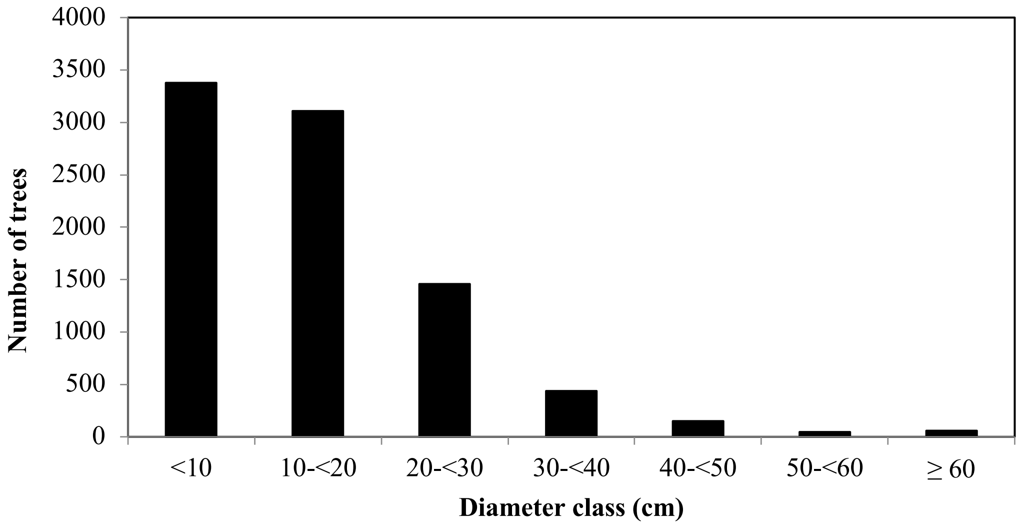

Fig. 3. Distribution of belta and tree-level diameter classes in the study area.

The distribution of plant diameter classes at the study site showed a decreasing number of individuals from the small to the large diameter class. In general, the distribution of stand diameter classes at the study sites shows these characteristics, this generally occurs on land that has not been planted for too long, and this situation is the opposite of natural primary forest. Stand structure is the distribution of individual plants in the canopy layer and can be interpreted as the distribution of plants per unit area in various diameter classes (Samsoedin and Heriyanto 2010).

In forest succession, there is always a change from time to time. This change in stand structure is likely due to differences in the ability of trees to utilize solar energy, nutrients/minerals, and water, as well as the nature of competition (Saharjo and Gago 2011). Therefore the arrangement of trees in the stand will form a distribution of various diameter classes. In **Fig. 3**, it can be stated that the diameter class at the study site dominated the belta level, namely the diameter of 2-9 cm and slightly different from the diameter of 10-19 cm (tree level).

3.3. Carbon Stock

Measurement of carbon potential was done using the Chave formula. Diameter and height data were generated from primary measurement data, while wood density data came from Pustekolah (2013) and ICRAF (2017). **Table 3** shows that the trees with the highest carbon stocks are *E. deglupta* trees, with 58.06 tons C or 213.09 t.CO_2-eq generated from 1,232 trees.

Table 3. Carbon stock potential of the ten largest plant species in the study area

No.	Tree species	Number of trees	Biomassa (ton)	Carbon stock (ton C)	CO_2 Absorption (t.CO_2-eq)
1	*Eucalyptus deglupta*	1232	123.54	58.06	213.09
2	*Roystonea regia*	976	103.91	48.84	179.23
3	*Pterocarpus indicus*	119	87.74	41.24	151.35
4	*Neolamarckia cadamba*	383	81.66	38.38	140.86
5	*Ficus benjamina*	358	71.66	33.68	123.61
6	*Cerbera manghas*	546	39.04	18.35	67.34
7	*Terminalia catappa*	354	33.81	15.89	58.33
8	*Ficus elastica*	26	29.98	14.09	51.72
9	*Albizia saman*	110	24.92	11.71	42.99
10	*Bambusa vulgaris*	5260	24.15	11.35	41.65

Rosalina et al. (2013) explained that biomass is the weight per unit area consisting of the weight of leaves, flowers, fruit, branches, twigs, stems, roots, and dead trees. Wood density, diameter, height, and soil fertility are variables that can affect the amount of biomass (Dharmawan 2013; Siregar and Heriyanto 2010). Biomass estimation influences the carbon cycle, especially in tropical plantation forests (Heriyanto et al. 2019; Putri and Wulandari 2015). Forest biomass contains carbon of approximately 47% (IPCC 2013). Furthermore, biomass data is very useful for evaluating the productivity of various existing ecosystems (Chave et al. 2014; Natalia et al. 2014).

Young trees, in their growth, have great potential to absorb and reduce carbon dioxide levels from the air. Older trees grow slower than younger trees. Through the process of nucleic acid metabolism, lipids and proteins will be converted into plant organs after the photosynthetic mechanism of carbon dioxide, and water is converted into carbohydrates (Campbell et al. 2002).

Dharmawan and Samsoedin (2012) stated that the carbon content of a tree species is highly dependent on the number, diameter and height, and specific gravity of the wood. **Table 3** shows that the number of trees is closely related to their biomass, except for the species of angsana, which is an old plant. The number of trees in the green open space area at PT. Gajah Tunggal Tbk. is 29.84 ha of the factory area of 117.47 ha totaling 8,636 trees with DBH ≥ 2 cm. The potential of biomass, carbon, and CO_2 absorption in the green open space (**Fig. 4**) is 880.82 tons or 413.98

tons C, equivalent to 1,519.33 t.CO_2-eq. This potential will still increase because, generally, the tree species in the RTH are still growing (the average age is 7 years, and many plants have just been planted 1 year old).

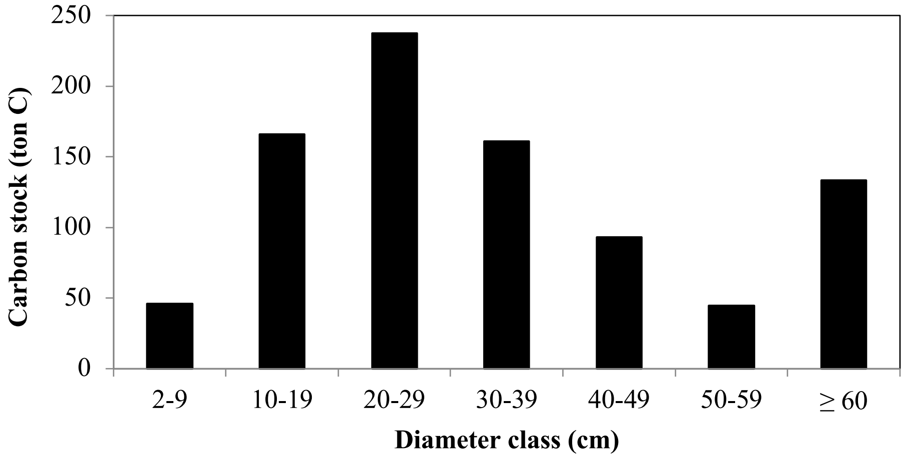

Fig 4. The relationship between diameter class and carbon content in the study area.

3.4. Implication for Emission Reduction Policy

Tree stands at sapling level have great potential in absorbing and reducing CO_2 levels in the air. It could be caused by the young trees growing relatively faster than old trees (Dharmawan 2013). During growth, photosynthesis occurs, which involves CO_2 and water converted into carbohydrates. Furthermore, through the process of carbohydrate metabolism is converted into lipids, nucleic acids, and proteins; then, it will be converted into plant organs (Widhi and Murti 2014). **Table 4** shows the carbon emissions data from the occupational safety, health, and environmental management or HSE department at PT. Gajah Tunggal Tbk.

Table 4. CO_2 emission contribution in the study area

Source of contribution	2016 (t.CO_2-eq)	2017 (t.CO_2-eq)	2018 (t.CO_2-eq)	2019 (t.CO_2-eq)	2020 (t.CO_2-eq)
Electricity	233.64	394.37	314.30	393.68	353.91
Diesel	958.78	1,081.01	1,128.26	1,088.67	969.82
Gas	53.13	62,481.14	62,557.92	59,656.41	50,768.30
Fuels	-	-	72.36	71.49	45.60
Oil	-	-	417.00	432.58	364.80
Total	287,730.78	457,934.56	378,477.34	459,929.71	406,073.72

The data presents the annual contribution of CO_2 emissions at PT. Gajah Tunggal Tbk. increased from 2016-2017, decreased in 2017-2018, increased in 2018-2019, and then decreased in 2020. CO_2 absorption by trees planted in green open space (29.84 ha) of 1,519.33 t.CO_2-eq (50.91 tons CO_2/ha), the contribution is still relatively small. The contribution of CO_2 absorption only accounts for 0.4% of the total emissions in 2020.

Ahead of the 2021 COP 26 in Glasgow, together with the submission of the Updated Nationally Determined Contribution (NDC) to the UNFCCC (currently revised by the Enhanced NDC), Indonesia also submitted the Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR) document with Forest and Other Land Uses (FOLU) Net Sink 2030 as one of the targets in the forestry sector (The Republic of Indonesia 2021). Through the 10 Mitigation Actions in the NDC, it is projected that GHG emissions in 2030 from the FOLU sector are 217

Mt.CO_2-eq (with its own capacity) and 64 M t.CO_2-eq (with international support). The forest rehabilitation target is 5.3 million ha in 2030 and 10.6 million ha in 2050, or 265,000 ha/year. The development of green open space in PT. Gajah Tunggal Tbk. plays a positive role in supporting the achievement of the NDC target because it is in line with FOLU Net Sink's actions in terms of reducing deforestation, conservation, sustainable forest management, peat protection and restoration, and increasing carbon absorption.

Further implications for increasing the role of the land-based sector to support CO_2 absorption and reduce the industry's own carbon footprint at PT. Gajah Tunggal Tbk. can be done by increasing the area of green open space and increasing its existing productivity so the vegetation growth is positive and maximizing space utilization for vegetation, for example, rooftops and vertical gardens. In addition, industries and factories such as PT. Gajah Tunggal Tbk can be encouraged to increase the role of the Industrial Process and Product Uses (IPPU) sector and the energy sector in reducing emissions so that they contribute more to reducing factory carbon footprint and to reducing national emissions in general.

One way to increase the absorption of CO_2 emissions at the location of PT. Gajah Tunggal Tbk. in Tangerang area is by carrying out greening activities on vacant land at the company location by planting fast-growing trees of local species. It can be implemented to help in reducing emissions.

The commitment of PT. Gajah Tunggal Tbk. to reduce the emissions by making a green area in three locations, including Tangerang, Bunder, and Karawang factory locations; in 3 years, CO_2 absorption can increase by 10%, and in five years, it can increase to 25% of the emissions produced by factories. Other efforts are energy-saving gas, diesel, and electricity programs which are the biggest contributors to greenhouse gases (CO_2).

4. Conclusions

The types of trees planted generally have the objective of conserving the germplasm of both ex-situ and in-situ types. Tree species can also be used as an important basic material in developing various urban forest models. The diversity of plants in the green open space of PT. Gajah Tunggal Tbk. has 150 species covered in 46 families consisting of 8,636 belonging to the tree category and 5,254 stems belonging to the bamboo species. Biomass potential, carbon content, and CO_2 absorption at the site DBH $\geq$ 2 cm are dominated by three species, namely *Eucalyptus deglupta*, *Roystonea regia,* and *Pterocarpus indicus*. The total biomass, carbon content, and CO_2 absorption of tree and bamboo species is 880.82 tons or 413.98 tons C, equivalent to 1,519.33 t.CO_2-eq, respectively. The types planted in green open spaces should be of local types so that germplasm preservation will be maintained.

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References

Adinugroho, W. C., Prasetyo, L. B., Kusmana, C., and Krisnawati, H. 2019. Contribution of Forest Degradation in Indonesia's GHG Emissions: Profile and Opportunity to Improve Its

Estimation Accuracy. *IOP Conference Series: Earth and Environmental Science* 399: 1-8. DOI: 10.1088/1755-1315/399/1/012025

Al Fajar, D. D., La Sina, and Rika, E. 2014. Fungsi Hutan Kota dalam Mangurangi Pencemaran Udara di Kota Samarinda. *Jurnal Beraja Niti* 3(9): 1-12.

Andry, S., Triana, D., Rivananda, R., and Iswoyo, H. 2017. Potensi Pengembangan Kawasan MOI sebagai RTH Hutan Kota dan Kawasan Agroeduwisata Perkotaan. *Hasanuddin Student Journal* 1(1): 22-33.

Astiani, D., Mujinaan, M., and Rafistanto, A. 2017. Forest Type Diversity on Carbon Stocks-Cases of Recent Land Cover Condition of Tropical Lowland, Swamp, and Peat Swamp Forest in West Kalimantan, Indonesia. *Biodiversitas* 18(1): 137-144. DOI: 10.13057/biodiv/d180119

Basworo, E. 2011. *Perluasan RTH DKI Jakarta Tanpa Biaya Pembebasan Lahan*. Dinas Pertamanan dan Pemakaman, DKI Jakarta.

Badan Pusat Statistik (BPS). 2021. *Tangerang dalam Angka*. Badan Pusat Statistik Kota Tangerang, Provinsi Banten.

Balai Penelitian Tanah (Balittanah). 2018. *Peta Tanah Pulau Jawa. Badan Penelitian dan Pengembangan Pertanian, Kementerian Pertanian*. Bogor.

Campbell, N. A., Reece, J. B., and Mitchell, L. G. 2002. *Biologi*. Penerbit Erlangga. Jakarta.

Chave, J., Mechain, M. R., Burqueez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B. C., Dugue, A., Eid, T., Fearnside, P. M., Goodman, R. C., Henry, M., Yrizar, A. M., Mugasha, W. A., Landau, H. C. M., Mencuccini, M., Nelson, B. W., Ngomanda, A., Noguiera, E. M., Malavessi, E. O., Pelissier, R., Ploton, P., Ryan, C. M., Soldarriaga, J. G., and Vieilledent, G. 2014. Improved Allometric Models to Estimate the Aboveground Biomass of Tropical Trees. *Global Change Biology* 20: 3177-3190. DOI: 10.1111/gcb.12629

Dharmawan, I. W. S. 2013. *Evaluasi Dinamika Cadangan Karbon Tetap pada Hutan Gambut Primer dan Bekas Terbakar di Hampangen dan Kalampangan, Kalimantan Tengah*. Disertasi Doktor. Sekolah Pasca Sarjana IPB, Bogor.

Dharmawan, I. W.S ., and Samsoedin, I. 2012. Dinamika Potensi Biomassa Karbon pada Landskap Hutan Bekas Tebangan di Hutan Penelitian Malinau. *Jurnal Penelitian Sosial dan Ekonomi Kehutanan* 9(1): 12-20. DOI: 10.20886/jpsek.2012.9.1.12-20

Goodman, R. C., Phillips, O. L., Del Castillo Torres, D., Freitas, L., Cortese, S. T., Monteagudo, A., and Baker, T. R. 2013. Amazon Palm Biomass and Allometry. *Forest Ecology and Management* 310: 994 - 1004. DOI: 10.1016/j.foreco.2013.09.045

Hairiah, K., and Rahayu, S. 2007. *Pengukuran Karbon Tersimpan di Berbagai Macam Penggunaan Lahan*. World Agroforestry Centre-ICRAF SEA Regional Office, Bogor & University of Brawijaya, Malang.

Heriyanto, N. M., Priatna, D., Kartawinata, K., and Samsoedin, I. 2020a. Struktur dan Komposisi Hutan di Kawasan Lindung Rantau Bertuah, Kabupaten Siak, Provinsi Riau. Buletin Kebun Raya 23(1): 69-81. DOI: 10.14203/bkr.v23i1.7

Heriyanto, N. M., Priatna, D., and Samsoedin, I. 2020b. Struktur Tegakan dan Serapan Karbon pada Hutan Sekunder Kelompok Hutan Muara Merang, Sumatera Selatan. *Jurnal Sylva Lestari* 8(2): 230-240. DOI: 10.23960/jsl28230-240

Heriyanto, N. M., and Samsoedin, I. 2019. Struktur Tegakan dan Stok Karbon di Ruang Terbuka Hijau PT. Toyota Motor Manufacturing di Sunter dan Karawang. *Buletin Kebun Raya* 22 (2): 143-150.

Heriyanto, N. M., Samsoedin, I., and Bismark, M. 2019. Keanekaragaman Hayati Flora dan Fauna di Kawasan Hutan Bukit Datuk Dumai Provinsi Riau. *Jurnal Sylva Lestari* 7(1): 82-94. DOI: 10.23960/jsl1782-94

Heriyanto, N. M., and Subiandono, E. 2012. Komposisi dan Struktur Tegakan, Biomassa dan Potensi Kandungan Karbon Hutan Mangrove di Taman Nasional Alas Purwo. *Jurnal Penelitian Hutan dan Konservasi Alam* 9(1): 023-032. DOI: 10.20886/jphka.2012.9.1.023-032

Imansari, N., and Parfi, K. 2015. Penyediaan Hutan Kota dan Taman Kota sebagai Ruang Terbuka Hijau (RTH) Publik Menurut Preferensi Masyarakat di Kawasan Pusat Kota Tangerang. *Ruang* 1(3): 101-110. DOI: 10.14710/ruang.1.3.101-110

Indonesia National Carbon Accounting System (INCAS). 2015. *Indonesia Luncurkan Alat Baru Hadapi Perubahan Iklim. Program REDD-I. Hutan dan Perubahan Iklim di Indonesia*. Kementerian Lingkungan Hidup dan Kehutanan Indonesia. Jakarta

International Panel on Climate Change [IPCC]. 2013. *Climate Change 2013 the Physical Basis Working Group I Contribution to the Fifth Assessment Report of the IPCC*. IPCC. Switzerland.

International Center Research in Agroforestry/ICRAF. 2017. *Database, Wood Density*. ICRAF. Bogor.

Kartawinata, K. 2016. *Diversitas Ekosistem Alami Indonesia*. Penerbit: Yayasan Pustaka Obor Indonesia.

Krisnawati, H., Adinugroho, W. C., Imanuddin, R., Suyoko, S., Weston, C. J., and Volkova, L. 2021. Carbon Balance of Tropical Peat Forests at Different Fire History and Implications for Carbon Emissions. *Science of the Total Environment* 779: 146365 DOI: 10.1016/j.scitotenv.2021.146365

Lugina, M., Ginoga, K. L., Wibowo, A., Bainnaura, A., and Partiani, T. 2011. *Prosedur Operasi Standar (SOP) untuk Pengukuran Stok Karbon di Kawasan Konservasi. Pusat Penelitian dan Pengembangan Perubahan Iklim dan Kebijakan*. Jakarta, Indonesia.

Martin, A. R., and Thomas, S. C. 2011. A Reassessment of Carbon Content in Tropical Trees. *PLoS ONE* 6(8): 1-9. DOI: 10.1371/journal.pone.0023533

Natalia, D., Yuwono, S. B., and Qurniati, R. 2014. Potensi Penyerapan Karbon pada Sistem Agroforestri di Desa Pesawaran Indah Kecamatan Padang Cermin Kabupaten Pesawaran Provinsi Lampung. *Jurnal Sylva Lestari* 2(1): 11–20. DOI: 10.23960/jsl1211-20

Onrizal, E. A., and Kusmana, C. 2009. Struktur dan Keanekaragaman Jenis Mangrove Pasca Tsunami di Pulau Nias. *Jurnal Berita Biologi* 9(4): 359-364. DOI: 10.14203/beritabiologi.v9i4.2005

Purwanta, W. 2010. Penghitungan Emisi Karbon dari Lima Sektor Pembangunan Berdasar Metode IPCC dengan Verifikasi Faktor Emisi dan Data Aktivitas Lokal. *Jurnal Teknologi Lingkungan* 11 (1): 71–77. DOI: 10.29122/jtl.v11i1.1224

Pustekolah (Pusat Penelitian dan Pengembangan Keteknikan Kehutanan dan Pengolahan Hasil Hutan). 2013. Atlas Kayu Indonesia Jilid 4. Badan Penelitian dan Pengembangan Kehutanan. Departemen Kehutanan. Jakarta.

Putri, A. H. M., and Wulandari, C. 2015. Potensi Penyerapan Karbon pada Tegakan Damar Mata Kucing (*Shorea javanica*) di Pekon Gunung Kemala Krui Lampung Barat. *Jurnal Sylva Lestari* 3(2): 13–20. DOI: 10.23960/jsl2313-20

Rosalina, Y., Kartawinata, K., Nisyawati, N., Nurdin, E., and Supriatna, J. 2013. Kandungan Karbon di Hutan Rawa Gambut Kawasan Konservasi PT. National Sago Prima, Kepulauan Meranti, Riau. *Buletin Kebun Raya* 16(2): 115-130.

Saharjo, B. H., and Gago, C. 2011. Suksesi Alami Paska Kebakaran pada Hutan Sekunder di Desa Fatuquero, Kecamatan Railaco, Kabupaten Ermera-Timor Leste. *Jurnal Silvikultur Tropika* 2(1): 40-45. DOI: 10.29244/j-siltrop.2.1.%25p

Samsoedin, I., and Heriyanto, N. M. 2010. Struktur dan Komposisi Hutan Pamah Bekas Tebangan Ilegal di Kelompok Hutan Sei Lepan, Sei Serdang, Taman Nasional Gunung Leuser, Sumatera Utara. *Jurnal Penelitian Hutan dan Konservasi Alam* 8(3): 299-314. DOI: 10.20886/jphka.2010.7.3.299-314

Samsoedin, I., and Waryono, T. 2015. *Hutan Kota dan Keanekaragaman Jenis Pohon di Jabodetabek*. Yayasan Kehati-Indonesia Biodiversity Foundation. Jakarta. 270 p.

Siregar, C. A., and Heriyanto, N. M. 2010. Akumulasi Biomassa Karbon pada Skenario Hutan Sekunder di Maribaya, Bogor, Jawa Barat. *Jurnal Penelitian Hutan dan Konservasi Alam* 8(3): 215-226. DOI: 10.20886/jphka.2010.7.3.215-226

Soil Survey Staff. 2003. *Keys to Soil Taxonomy, 9th Edition*. USDA Natural Resources Conservation Service. Washington DC.

Standar Nasional Indonesia (SNI 7724). 2011. Pengukuran dan Perhitungan Cadangan Karbon: Pengukuran Lapangan untuk Penaksiran Cadangan Karbon Hutan. Badan Standarisasi Nasional. Jakarta.

Subarudi, S., and Samsoedin, I. 2012. Kajian Kebijakan Hutan Kota: Studi Kasus di Provinsi Daerah Khusus Ibukota Jakarta (DKI). *Jurnal Analisis Kebijakan Kehutanan* 9(2): 144-153. DOI: 10.20886/jakk.2012.9.2.144-153

Subiandono, E., Bismark, M., and Heriyanto, N. M. 2013. Kemampuan *Avicennia marina* (Forsk.) Vierh. dan *Rhizophora apiculata* Bl. dalam Penyerapan Polutan Logam Berat. *Jurnal Penelitian Hutan dan Konservasi Alam* 9(1): 23-32. DOI: 10.20886/jphka.2013.10.1.93-102

The Republic of Indonesia. 2021. *Indonesia Long Term Strategy for Long Carbon and Climate Resilience 2050*. The Republic of Indonesia. Jakarta.

Widhi, S. J. K., and Murti, S. H. 2014. Estimasi Stok Karbon Hutan dengan Memanfaatkan Citra Landsat 8 di Taman Nasional Tesso Nilo, Riau. *Jurnal Bumi Indonesia* 3(2): 1-11.