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Research Article

Tree Composition and Carbon Sequestration Potential of A University Campus in Bangkok, Thailand

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Abstract

Trees play important roles in atmospheric carbon dioxide (CO_2) absorption and climate change mitigation. The objective of this study was to assess tree characteristics and carbon sequestration potential at Ramkhamhaeng University (Hua Mak Campus), Bangkok, Thailand. Tree attributes, including species compo-sition, abundance, diameter at breast height (DBH), and tree height, were recorded. Tree biomass, carbon storage, and CO_2 sequestration were estimated using appropriate allometric equations. A total of 2,149 trees were recorded in the study area, corresponding to a tree density of 45.8 trees ha^{-1}. The tree community was dominated by the palm family (Arecaceae), while *Terminalia ivorensis* was the most abundant species. The overall mean DBH and tree height were 34 cm and 8.6 m, respectively. The total estimated biomass, carbon storage, and CO_2 sequestration were 26.56 t ha^{-1}, 12.48 tC ha^{-1}, and 45.77 tCO_2e ha^{-1}, respectively. *Tabebuia rosea* contributed the most to total biomass, carbon storage, and CO_2 sequestration at the species level, whereas *Samanea saman* presented the highest average values on a per-tree basis. These findings provide valuable information for green space planning and tree management on university campuses and serve as essential baseline data for estimating net CO_2 emissions and supporting the development of low-carbon universities.

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Introduction

Carbon dioxide (CO_2) is a primary greenhouse gas that is driving global climate change (IPCC, 2023; Nunes, 2023), prompting international collaboration to reduce its concentration in the atmosphere. The mitigation of atmospheric CO_2 involves both reducing emissions and enhancing CO_2 removal. Plant communities, particularly trees, play a critical role in CO_2 uptake through photosynthesis and the subsequent storage of assimilated carbon in biomass. Accordingly, increasing tree cover and expanding green spaces can increase CO_2 absorption and contribute to climate change mitigation. The capacity for CO_2 uptake and carbon storage varies among plant and tree species. Fujimoto et al. (2016) reported that the average annual carbon storage of trees in public parks in Bangkok was approximately 9 kgC $tree^{-1}$ $year^{-1}$, whereas street trees stored approximately 12 kgC $tree^{-1}$ $year^{-1}$. The IPCC (2003) reported default values of annual carbon storage by trees ranging from 3.3 to 14.2 kgC $tree^{-1}$ $year^{-1}$. In addition, Kliangsaard et al. (2020) reported that annual CO_2 sequestration by trees in a public park in Bangkok ranged from 1.5 to 252.8 kgCO_2 $tree^{-1}$ $year^{-1}$. The carbon content in tree biomass also varies among species. Poosaksai et al. (2018) reported carbon contents ranging from 45.12% to 48.79% (dry weight basis) for four tree species, whereas the Thailand Greenhouse Gas Management Organization (2016) recommended a carbon fraction of 41.3% for

Arecaceae. The IPCC (2006) proposed a default carbon fraction of 47% for tree biomass on a dry weight basis.

Thailand is committed to achieving carbon neutrality by 2050 and net-zero greenhouse gas emissions by 2065. Achieving these targets requires coordinated efforts across all sectors, including the government, private organizations, and educational institutions. In the near future, organizations, including Ramkhamhaeng University, will be required to report their carbon footprints and implement measures to reduce CO_2 emissions in accordance with national targets. Therefore, the primary objective of this study was to assess tree characteristics and carbon sequestration potential at Ramkhamhaeng University (Hua Mak Campus). The results of this study provide insight into the CO_2 absorption capacity of trees within the campus and offer essential baseline data for estimating net CO_2 emissions, enhancing green space planning, and advancing the university toward becoming a green university and a low-carbon institution.

Materials and methods

1) Study area

This study was conducted at Ramkhamhaeng University (Hua Mak Campus), which is located in the Bang Kapi District of eastern Bangkok, Thailand (13°45′22.42″N, 100°37′8.00″E; approximately 3 m above sea level; Figure 1). Established in 1971, the university provides education from the kindergarten to the doctoral level and is one of the largest universities in Thailand. The study area covered 46.88 ha (293 rai) and was surrounded by a highly urbanized environment. Land use within the campus is dominated by educational and office buildings, together with multipurpose facilities, resulting in limited green space. Trees were planted during different periods and were distributed along roads and scattered across the campus. Climatic data, including rainfall, relative humidity, and air temperature, were obtained from the Bangkok Meteorological Station (Code 455201; 13°43′ 28.5″N, 100°33′48.0″E), which is located approximately 7 km from the study site, for the period 1993–2022 (30 years), with support from the Thai Meteorological Department. The mean annual cumulative rainfall was 1,751 mm. The lowest mean monthly rainfall occurred in December (19 mm), whereas the highest was recorded in September (349 mm). The mean monthly relative humidity ranged from 64% to 80%, with an overall average of 73%, corresponding to the driest and wettest months, respectively. The mean monthly air temperature ranged from 27.3°C to 30.7°C, with the highest average in April and the lowest in December.

2) Surveying and data collection

The tree survey was conducted across the university campus from November 2023 to February 2024. All trees with a diameter at breast height (DBH, measured at 1.3 m above ground) ≥ 4.5 cm and a total height ≥ 1.3 m were included (Kliangsaard et al., 2020). For each individual, species identity, girth at breast height (GBH), total height, and geographic location were recorded. Tree height was measured using a Nikon Forestry Pro II laser rangefinder, and the GBH was converted to the DBH using the formula DBH = GBH/π.

3) Estimation of biomass, carbon storage and CO_2 sequestration

The aboveground biomass (AGB) of individual trees was estimated using allometric equations recommended by the Thailand Greenhouse Gas Management Organization (Thailand Greenhouse Gas Management Organization, 2016). Although several allometric equations have been developed for specific urban tree species (Dung et al., 2012; IPCC, 2003; Hung et al., 2012), these models typically use DBH as the sole predictor variable. In urban environments, however, trees are frequently subjected to canopy pruning, resulting in reduced heights that are not proportional to the DBH. Consequently, the biomass estimates derived from the DBH-only models may be overestimated. To improve accuracy, this study employed allometric equations that incorporate both DBH and tree height as shown in Eqs. 1 to 5.

For Arecaceae (Pearson, 2005);

$$W_T = 6.666 + 12.826(H)^{0.5} \times \ln(H) \qquad \text{(Eq. 1)}$$

For all other trees (Ogawa et al., 1965);

$$W_S = 0.0396\ (D^2H)^{0.9326} \qquad \text{(Eq. 2)}$$

$$W_B = 0.003487\ (D^2H)^{1.027} \qquad \text{(Eq. 3)}$$

$$W_L = (28/(W_S + W_B + 0.025))^{-1} \qquad \text{(Eq. 4)}$$

$$W_T = WS + WB + WL \qquad \text{(Eq. 5)}$$

where

W_S = Biomass of the stem (kg)
W_B = Biomass of the branches (kg)
W_L = Biomass of the leaves (kg)
W_T = Total aboveground biomass (kg)
D = Diameter at breast height (cm)
H = Tree height (m)



Figure 1 Location and overview of the study area at Ramkhamhaeng University (Hua Mak Campus), Bangkok, Thailand.

Belowground biomass (BGB) was estimated using AGB and root–shoot ratios. For nonpalm tree species, the BGB was calculated as 27% of the AGB (BGB = AGB × 0.27), whereas for Arecaceae species, the BGB was estimated as 41% of the AGB (BGB = AGB × 0.41). These coefficients represent the standard root–shoot ratios recommended by the IPCC (2006) and the Thailand Greenhouse Gas Management Organi-zation (2016).

The carbon content in the tree biomass was calculated using default carbon fractions. A carbon fraction of 0.47 was applied to nonpalm species, as recommended by the IPCC (IPCC, 2006), while a value of 0.413 was used for Arecaceae, following the Thailand Greenhouse Gas Management Organization (2016). Carbon storage for each tree was then estimated on the basis of total biomass (AGB + BGB) multiplied by the appropriate carbon fraction as shown in Eqs. 6 and 7.

For Arecaceae;

$$\text{Carbon storage (kgC)} = \text{total biomass (kg)} \times 0.413 \quad \text{(Eq. 6)}$$

For all other trees;

$$\text{Carbon storage (kgC)} = \text{total biomass (kg)} \times 0.47 \quad \text{(Eq. 7)}$$

Carbon dioxide (CO_2) sequestration for all trees, including species in the Arecaceae family, was calculated by converting estimated carbon storage to its CO_2 equivalent using the ratio of the molecular weight of CO_2 to the atomic weight of carbon (44/12), as shown in Eq. 8.

$$CO_2 \text{ sequestration (kg}CO_2\text{e)} = \text{Carbon storage (kgC)} \times 44/12 \quad \text{(Eq. 8)}$$

The relationships between biomass and structural variables (DBH, tree height, and the number of trees) were evaluated using Pearson correlation analysis in SigmaPlot version 14.0 (Systat Software, Inc., USA).

Results

1) Tree composition

In the study area at Ramkhamhaeng University, a total of 2,149 trees were recorded, corresponding to a density of 45.8 trees ha^{-1} (7.3 trees rai^{-1}). These trees represented more than 90 species, 73 genera, and 34 families (Table 1). The tree distribution was uneven, with the majority concentrated in the central zone of the study area (Figure 2). The family Arecaceae was the most abundant, comprising 459 individuals (21.4% of all trees). At the species level, the most dominant species were *Terminalia ivorensis* (8.3%), *Tectona grandis*

(7.1%), and *Tabebuia rosea* (6.6%). The mean GBH among species ranged from 27 cm (*Cananga odorata*) to 268 cm (*Samanea saman*), with an overall average of 107 cm. Similarly, the mean DBH ranged from 8.6 cm (*C. odorata*) to 85.4 cm (*S. saman*), with an overall average of 34 cm. Across all the recorded trees, most of the individuals fell within the 11–20 cm DBH class (27%), followed by the 21–30 cm (21%) and 31–40 cm (19%) DBH classes (Figure 3a). The mean tree height among species ranged from 3.4 m (*Ardisia elliptica*) to 17.9 m (*Casuarina junghuhniana*), with an overall average height of 8.6 m. The tallest individual recorded was *Dipterocarpus alatus*, reaching a height of 31.7 m. The height-class distribution revealed that most trees were 6–10 m tall (46%), followed by 11–15 m (24%) and 1.3–5 m (19%) (Figure 3b).

2) Tree biomass, carbon storage and CO_2 sequestration

The total biomass, carbon storage, and CO_2 sequestration of trees in the study area at Ramkhamhaeng University were estimated to be 26.56 t ha^{-1}, 12.48 t C ha^{-1}, and 45.77 t CO_2e ha^{-1}, respectively (Table 2). Approximately 78% of the total biomass was attributed to aboveground biomass (stems, branches, and leaves), while belowground biomass (roots) accounted for the remaining 22%. Biomass was primarily stored in stems (approximately 60%), followed by roots (22%), branches (15%), and leaves (3%). Among the species, *T. rosea* contributed the greatest percentage of total biomass, carbon storage, and CO_2 sequestration (15.41%), followed by *Pterocarpus indicus* + *P. macrocarpus* (9.43%), *Ficus religiosa* (7.24%), *Tectona grandis* (6.48%), and *Peltophorum pterocarpum* (5.67%). These contributions were influenced by species-specific abundance, DBH, and tree height. However, when considered on a per-tree basis, *S. saman* presented the highest average biomass, carbon storage, and CO_2 sequestration, which is consistent with its relatively large mean DBH (Figure 4).

Table 1 Tree characteristics in the study area at Ramkhamhaeng University (Hua Mak Campus), including the number of individuals, girth at breast height (GBH), diameter at breast height (DBH), tree height, and tree density

No.	Tree species	Number of individual		Average GBH (cm)	Average DBH (cm)	Average tree height (m)	Density (tree ha^{-1})
		Number (tree)	Proportion (%)				
1	Arecaceae*	459	21.4	87.9	28.8	8.8	9.79
2	*Terminalia ivorensis* A.Chev.	179	8.3	76.5	24.3	7.4	3.82
3	*Tectona grandis* L.f.	152	7.1	96.9	30.8	13.9	3.24
4	*Tabebuia rosea* (Bertol.) Bertero ex A. DC.	141	6.6	157.5	50.1	12.5	3.01
5	*Pterocarpus indicus* Willd. and *Pterocarpus macrocarpus* Kurz	115	5.4	145.4	46.3	11.6	2.45
6	*Plumeria rubra* L.	90	4.2	112.0	35.6	5.1	1.92
7	*Alstonia scholaris* (L.) R.Br.	63	2.9	142.4	45.3	11.8	1.34
8	*Polyalthia longifolia* (Benth.) Hook.f.	59	2.7	68.7	21.9	8.5	1.26
9	*Tabebuia aurea* (Silva Manso) Benth. & Hook.f. ex S.Moore	58	2.7	75.0	23.9	5.8	1.24
10	*Mangifera indica* L.	48	2.2	102.8	32.7	8.0	1.02
11	*Cassia fistula* L.	46	2.1	94.6	30.1	9.3	0.98
12	*Mimusops elengi* L.	46	2.1	117.6	37.4	6.7	0.98
13	*Peltophorum pterocarpum* (DC.) Backer ex K.Heyne	46	2.1	209.7	66.7	9.2	0.98
14	*Swietenia macrophylla* King	44	2.0	155.0	49.3	11.8	0.94
15	*Tamarindus indica* L.	44	2.0	103.6	33.0	8.4	0.94
16	*Millingtonia hortensis* L.f.	42	2.0	99.5	31.7	9.5	0.90
17	*Artocarpus heterophyllus* Lam.	37	1.7	86.6	27.6	8.5	0.79
18	*Ficus* spp.**	30	1.4	246.7	78.5	9.2	0.64
19	*Lagerstroemia loudonii* Teijsm. & Binn.	30	1.4	72.0	22.9	7.2	0.64
20	*Cochlospermum regium* (Schrank) Pilg.	28	1.3	157.1	50.0	7.2	0.60
21	All other species	392	18	102.4	32.6	8.4	8.4
	Sum	**2,149**	**100**	**-**	**-**	**-**	**45.8**
	Average	**-**	**-**	**106.9**	**34.0**	**8.6**	**-**

Remark:

* Arecaceae includes *Areca* spp. (55%), *Roystonea regia* (Kunth) O.F.Cook (20%), *Wodyetia bifurcata* A.K.Irvine (13%), *Cocos nucifera* L. (4%), *Borassus flabellifer* L. (2%), *Caryota mitis* Lour. (1%) and others (5%).

** *Ficus* spp. includes *Ficus benjamina* L (ca. 90%) and other *Ficus* species except *F. religiosa* L. and *F. hispida* L.f. (ca. 10%).

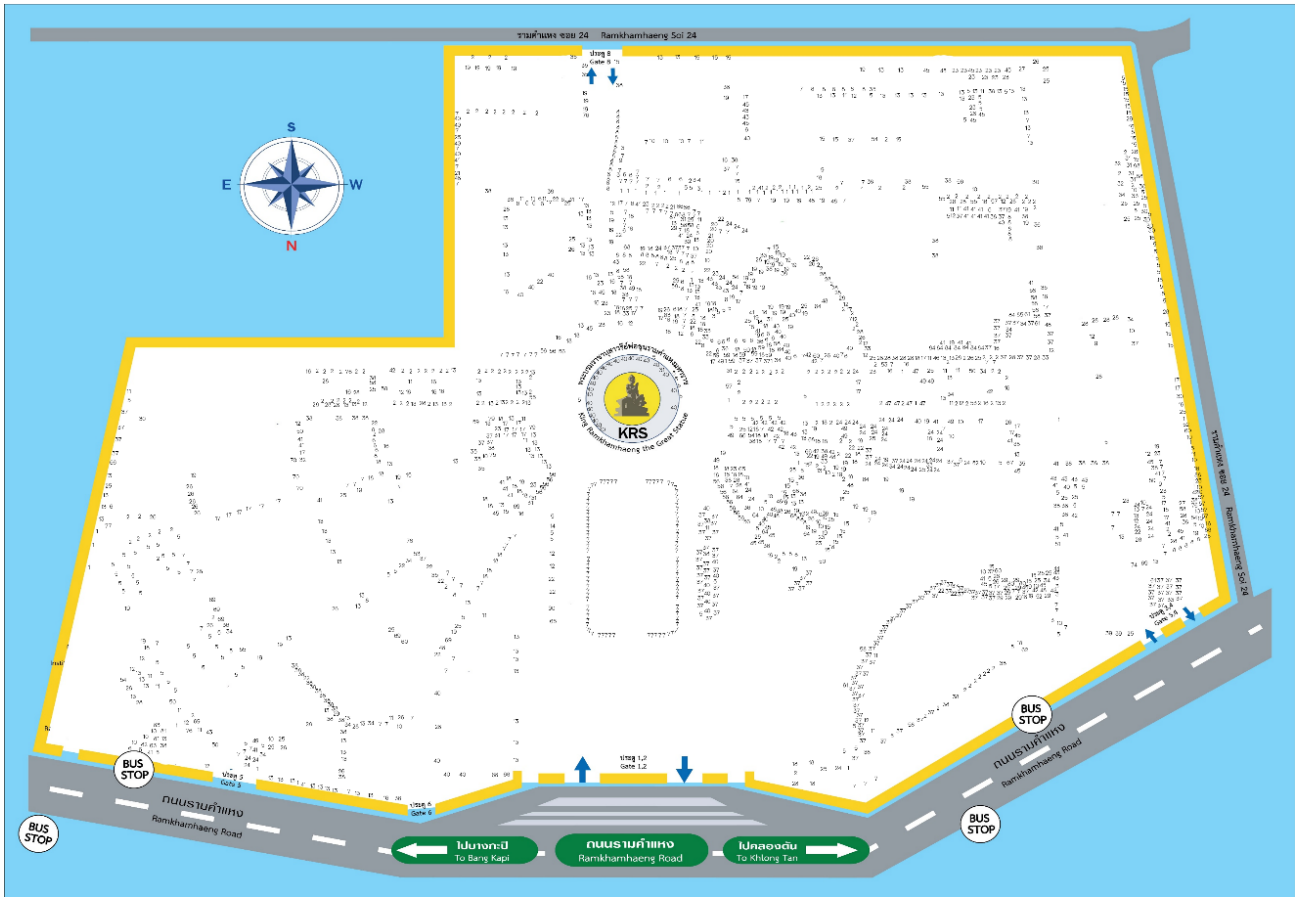


Figure 2 Spatial distribution of all 2,149 trees within the study area at Ramkhamhaeng University (Hua Mak Campus), Bangkok, Thailand
(The map was modified from https://www.ru.ac.th/th/aboutUs/page?view=Map).

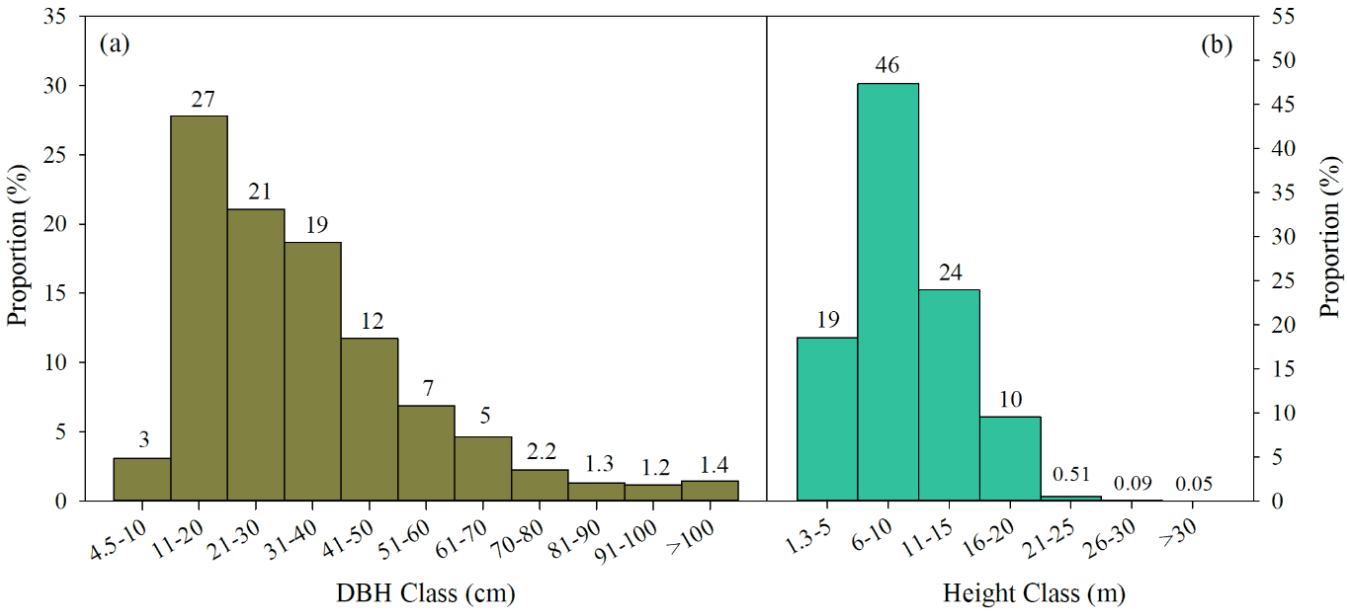


Figure 3 The distribution of diameter at breast height (DBH, a) and total height (b) among 2,149 trees in the study area at Ramkhamhaeng University (Hua Mak Campus), Bangkok, Thailand.

Table 2 Aboveground biomass (AGB: stems, branches, and leaves), belowground biomass (BGB: roots), carbon storage, and CO_2 sequestration of trees in the study area at Ramkhamhaeng University (Hua Mak Campus), Bangkok, Thailand

No.	Tree species	Biomass (t ha^{-1})							Carbon storage (tC ha^{-1})			CO_2 sequestration (tCO_2e ha^{-1})		
		Stem	Branch	Leaf	AGB	BGB	Total	%	AGB	BGB	Total	AGB	BGB	Total
1	*Tabebuia rosea* (Bertol.) Bertero ex A. DC.	2.48	0.63	0.11	3.22	0.87	4.09	15.41	1.51	0.41	1.92	5.55	1.50	7.05
2	*Pterocarpus indicus* Willd. and *Pterocarpus macrocarpus* Kurz	1.53	0.37	0.07	1.97	0.53	2.50	9.43	0.93	0.25	1.18	3.40	0.92	4.31
3	*Ficus religiosa* L.	1.14	0.32	0.05	1.51	0.41	1.92	7.24	0.71	0.19	0.90	2.61	0.70	3.31
4	*Tectona grandis* L.f.	1.07	0.24	0.05	1.35	0.37	1.72	6.48	0.64	0.17	0.81	2.33	0.63	2.96
5	*Peltophorum pterocarpum* (DC.) Backer ex K.Heyne	0.91	0.23	0.04	1.19	0.32	1.51	5.67	0.56	0.15	0.71	2.04	0.55	2.60
6	*Ficus* spp.*	0.89	0.24	0.04	1.17	0.32	1.48	5.58	0.55	0.15	0.70	2.01	0.54	2.55
7	*Alstonia scholaris* (L.) R.Br.	0.84	0.21	0.04	1.09	0.29	1.38	5.21	0.51	0.14	0.65	1.88	0.51	2.38
8	Arecaceae**	-	-	-	0.89	0.36	1.25	4.70	0.42	0.17	0.59	1.53	0.63	2.15
9	*Swietenia macrophylla* King	0.63	0.16	0.03	0.82	0.22	1.04	3.91	0.38	0.10	0.49	1.41	0.38	1.79
10	*Terminalia ivorensis* A.Chev.	0.58	0.13	0.03	0.73	0.20	0.93	3.48	0.34	0.09	0.44	1.26	0.34	1.60
11	*Samanea saman* (Jacq.) Merr.	0.36	0.10	0.02	0.47	0.13	0.60	2.26	0.22	0.06	0.28	0.82	0.22	1.04
12	*Casuarina junghuhniana* Miq.	0.34	0.08	0.02	0.44	0.12	0.55	2.09	0.20	0.06	0.26	0.75	0.20	0.95
13	*Plumeria rubra* L.	0.32	0.07	0.01	0.41	0.11	0.52	1.94	0.19	0.05	0.24	0.70	0.19	0.89
14	*Mangifera indica* L.	0.30	0.07	0.01	0.39	0.10	0.49	1.85	0.18	0.05	0.23	0.67	0.18	0.85
15	*Terminalia catappa* L.	0.30	0.07	0.01	0.39	0.10	0.49	1.85	0.18	0.05	0.23	0.67	0.18	0.84
16	*Dipterocarpus alatus* Roxb. ex G.Don	0.29	0.08	0.01	0.38	0.10	0.48	1.82	0.18	0.05	0.23	0.65	0.18	0.83
17	*Hopea odorata* Roxb.	0.26	0.07	0.01	0.35	0.09	0.44	1.65	0.16	0.04	0.21	0.60	0.16	0.76
18	*Cochlospermum regium* (Schrank) Pilg.	0.27	0.06	0.01	0.34	0.09	0.44	1.65	0.16	0.04	0.21	0.59	0.16	0.75
19	*Tamarindus indica* L.	0.26	0.06	0.01	0.33	0.09	0.42	1.58	0.16	0.04	0.20	0.57	0.15	0.72
20	*Mimusops elengi* L.	0.25	0.06	0.01	0.32	0.09	0.41	1.53	0.15	0.04	0.19	0.55	0.15	0.70
21	All other species	2.42	0.54	0.11	3.07	0.83	3.90	14.67	1.44	0.39	1.83	5.29	1.43	6.72
	Total	**15.46**	**3.78**	**0.69**	**20.82**	**5.74**	**26.56**	**100**	**9.78**	**2.70**	**12.48**	**35.87**	**9.90**	**45.77**
	Proportion (%)	**60**	**15**	**3**	**-**	**22**	**100**	**-**	**78**	**22**	**100**	**78**	**22**	**100**

Rermark:

* *Ficus* spp. includes *Ficus benjamina* L (ca. 90%) and other *Ficus* species except *F. religiosa* L. and *F. hispida* L.f. (ca. 10%).

** Arecaceae includes *Areca* spp. (55%), *Roystonea regia* (Kunth) O.F.Cook (20%), *Wodyetia bifurcata* A.K.Irvine (13%), *Cocos nucifera* L. (4%), *Borassus flabellifer* L. (2%), *Caryota mitis* Lour. (1%) and others (5%).

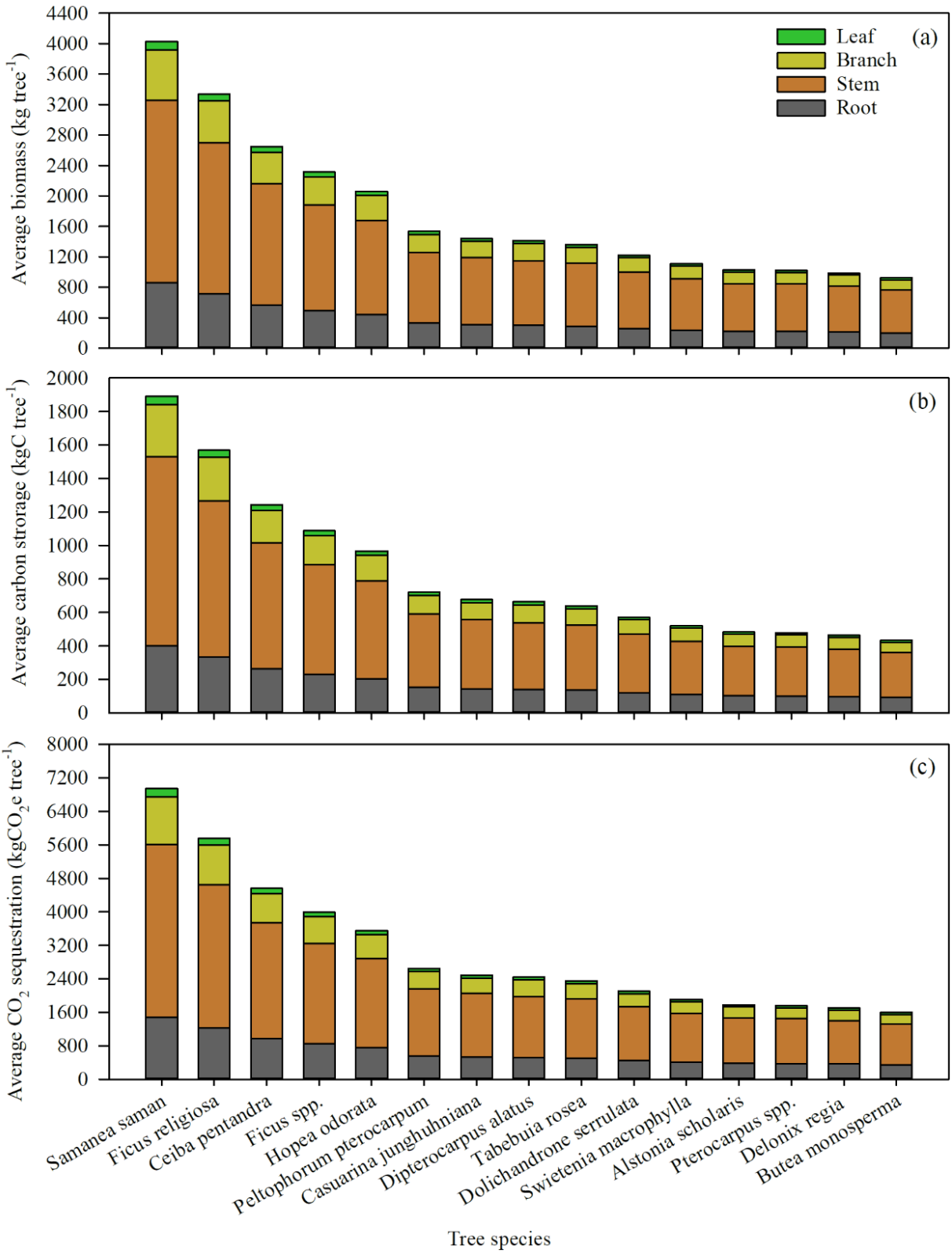


Figure 4 Comparison of the 15 tree species with the highest average aboveground biomass (a), carbon storage (b), and CO_2 sequestration (c) in the study area at Ramkhamhaeng University (Hua Mak Campus), Bangkok, Thailand. *Ficus* spp. includes *Ficus benjamina* (~90%) and other *Ficus* species except *F. religiosa* L. and *F. hispida* L.f. (~10%); *Pterocarpus* spp. includes *P. indicus* and *P. macrocarpus*.

Discussion

Tree composition and carbon storage were assessed at Ramkhamhaeng University (Hua Mak Campus). A total of 2,149 trees representing more than 90 species were recorded, corresponding to a tree density of 7.3 trees rai^{-1}. Kliangsaard et al. (2020) reported that the appropriate tree density for public parks is approximately 62.5 trees rai^{-1}, which is approximately 8.6 times greater than the current tree density at Ramkhamhaeng University. Although achieving the tree density recommended for public parks may not be feasible because of land use constraints within the campus, there remains substantial potential to increase tree density.

The total carbon storage of all the trees in the study area at Ramkhamhaeng University was estimated at 12.48 tC ha^{-1}, corresponding to a total CO_2 sequestration of 45.77 tCO_2e ha^{-1}. These values are lower than those reported in other studies across various ecosystems and land use types in Thailand (Table 3). The differences are primarily attributable to variations in tree density, DBH, and tree height among the study sites. In general, areas with higher tree density, larger DBHs, and taller trees tend to exhibit greater carbon storage and CO_2 sequestration, as observed in dry evergreen forests (Uttaruk et al., 2024), mixed deciduous forests (Boontoon et al., 2020), and mangrove forests (Sribut et al, 2020); however, site-specific characteristics also play important roles. The carbon storage estimated in this study was most comparable to that reported for the Ban Ton Peung Community Forest in Chiang Mai Province (19.69 tC ha^{-1}; Laororn et al. (2018)) and municipal parks in Tak Province (25.20 tC ha^{-1}; Nualsri et al. (2024)). Fujimoto et al. (2016) reported that annual carbon uptake by trees in four public parks in Bangkok ranged from 1–26 kgC tree^{-1} year^{-1}, with an average of 9 kgC tree^{-1} year^{-1}, whereas street trees absorbed 2–15 kgC tree^{-1} year^{-1}, with an average of 12 kgC tree^{-1}. Annual carbon sequestration was not estimated in the present study and should be addressed in future research.

On a per-tree basis, *S. saman* presented the greatest carbon storage, with an average of 1.89 tC tree^{-1}. A previous study conducted in Santiphap Park, Bangkok, likewise reported *S. saman* as the species with the highest carbon storage, estimated at 4.24 tC tree^{-1}. Carbon storage among tree species is influenced more by biomass than by carbon content (Poosaksai et al., 2018), with biomass primarily determined by DBH and tree height. Pearson correlation analysis at the individual-tree level revealed strong positive relationships between biomass and DBH ($r=0.903$, $p<0.001$) and between biomass and tree height ($r=0.686$, $p<0.001$). At the stand level, total biomass was also significantly influenced by the number of trees, which was positively correlated with total biomass ($r=0.603$, $p<0.001$). Worawetchakun et al. (Worawetchakun et al., 2024) reported that canopy pruning plays an important role in regulating tree growth rates, thereby influencing variations in biomass accumulation and carbon storage. In the present study, most trees within the study area underwent regular canopy pruning, which likely contributed to the lower total carbon storage observed in this study than in other studies. Although pruning is necessary for infrastructure protection and public safety on an active university campus, the periodic removal of branches and foliage limits immediate aboveground biomass accumulation. To maximize the carbon mitigation potential of institutional green spaces, urban forestry management should adopt structured maintenance frameworks that minimize excessive biomass removal while maintaining necessary safety standards.

High tree abundance, large tree size, and high tree height increase carbon storage and CO_2 uptake. However, the establishment and management of trees in urban environments, particularly along streets, within institutional and educational campuses, and in public parks, must consider multiple constraints, including public safety and the protection of infrastructure and property. On the basis of the findings of this study, the tree density within the study area at Ramkhamhaeng University was relatively low. Therefore, increasing tree numbers and expanding green areas are recommended as effective strategies for enhancing carbon sequestration while maintaining appropriate urban safety standards. Expanding green areas within a university would not only increase carbon storage and CO_2 sequestration but also contribute to a reduction in air pollutants (e.g., PM2.5, PM10, and heavy metals), lower ambient air temperature, and increase relative humidity (McDonald et al., 2016; Nowak et al., 2006). These ecosystem services improve the campus microclimate, creating a more suitable environment for learning and working while promoting human health and well-being. Given its high carbon storage capacity, CO_2 sequestration capacity, structural strength, dense and broad canopy, evergreen foliage, and ability to provide shade and aesthetic value, *S. saman* is considered a suitable species for planting in the study area. In contrast, species with weak branches, such as *Alstonia scholaris*, are not recommended because of the increased risk of branch failure. Some tree species, such as *D. alatus*, *Hopea odorata*, *Pterocarpus macrocarpus*, and *T. rosea, typically exceed 20 m in height at maturity*. These species require special care and management because of safety concerns during strong winds and heavy rainfall. To improve safety in urban and institutional settings, maintaining the tree height below 20 m is strongly recommended.

Table 3 Comparison of the biomass, carbon storage, and CO_2sequestration of trees and forested areas across various regions in Thailand

Study	Location (Province)	Study area/Land use/Ecosystem	Biomass (t ha^{-1})			Carbon storage (tC ha^{-1})			CO_2 sequestration (tCO_2e ha^{-1})		
			AGB	BGB	Total	AGB	BGB	Total	AGB	BGB	Total
This study	Bangkok	University green spaces	20.82	5.74	26.56	9.78	2.70	12.48	35.87	9.90	45.77
Tunnaket et al. (2025)	Chiang Mai	University green spaces	119.23	11.89	131.12	56.02	5.59	61.63	205.41	20.50	226.17
Singkran (2022)	Bangkok	25 public parks	-	-	-	38.20	-	-	141.70	-	-
Nualsri et al. (2024)	Tak	3 public parks	-	-	-	-	-	25.20	-	-	92.40
Kiriratnikom et al. (2025)	Phatthalung	Plantation forest	-	-	69.63	-	-	32.72	-	-	120.00
Chandaeng et al. (2020)	Nakhon Ratchasima	Plantation forest (Eucalypt)	59.58	11.70	71.28	28.08	5.50	33.58	102.96	20.17	123.13
Kongmeesup and Boonyanuphap (2019)	Lower Northern Thailand	Plantation forest (average 21-36 years old Teak)	-	-	-	23.70	5.08	28.79	86.90	18.63	105.56
Uttaruk et al. (2024)	Surin	Remnant forest (Dry evergreen forest and Teak plantation)	-	-	231.81	-	-	108.94	-	-	399.45
Dumrongrojwatthana et al. (2018)	Chanthaburi	Remnant forest (Tropical rainforest and swamp forest)	160.90	-	-	80.50	-	-	295.17	-	-
Ku-or et al. (2022)	Chiang Rai	Remnant forest (Mixed deciduous forest)	93.02	-	-	48.31	-	-	177.30	-	-
Temwut and Chaitieng (2021)	Kalasin	Remnant forest (Mixed deciduous forest)	-	-	77.35	-	-	38.67	-	-	141.93
Tokeeree et al. (2020)	Surin	Community forest (Dry dipterocarp forest)			163.31			76.76			281.44
Kanhom et al. (2019)	Sa Kaeo	Community forest (Dry dipterocarp forest)	54.55	-	-	25.64	-	-	94.01	-	-
Laororn et al. (2018)	Chiang Mai	Community forest (Dry dipterocarp forest)	-	-	41.88	-	-	19.69	-	-	72.19
Kanthawong et al. (2024)	Nakhon Sawan	Nature trail (Dry dipterocarp forest)	-	-	173.88	-	-	81.71	-	-	299.60
Kumros et al. (2018)	Uthai Thani	Dry dipterocarp forest (average from 5 plots with different fire interval)	148.66	-	-	71.36	-	-	261.64	-	-
Wattanasuksakul et al. (2012)	Chiang Mai	Dry dipterocarp forest (without fire)	-	-	128.3			63.4			232.47
		Dry dipterocarp forest (with fire)	-	-	106.6			52.6			192.87
Chandaeng et al. (2020)	Nakhon Ratchasima	Dry dipterocarp forest	51.91	7.68	59.59	24.45	3.61	28.06	89.65	13.24	102.89

Table 3 Comparison of the biomass, carbon storage, and CO_2 sequestration of trees and forested areas across various regions in Thailand *(continued)*

Study	Location (Province)	Study area/Land use/Ecosystem	Biomass (t ha^{-1})			Carbon storage (tC ha^{-1})			CO_2 sequestration (tCO_2e ha^{-1})		
			AGB	BGB	Total	AGB	BGB	Total	AGB	BGB	Total
Boontoon et al. (2020)	Kanchanaburi	Mixed deciduous forest (average from high, medium and low canopy density zones)	-	-	179.11	-	-	84.18	-	-	308.66
Chandaeng et al. (2020)	Nakhon Ratchasima	Mixed deciduous forest	63.00	8.49	71.49	29.68	3.99	33.67	108.83	14.63	123.46
Chandaeng et al. (2020)	Nakhon Ratchasima	Dry evergreen forest	95.49	16.43	111.92	44.99	7.72	52.71	164.96	28.31	193.27
Somprakon et al. (2024)	Phrae	Forest restoration	-	-	216.45	-	-	101.73	-	-	373.02
		Remnant forest	-	-	406.78	-	-	191.18	-	-	701.02
Sribut et al. (2020)	Prachuap Khiri Khan	Mangrove forest	159.63	75.25	234.88	75.02	35.37	110.39	275.09	129.68	404.77
Wongmuang et al. (2025)	Chon Buri	Mangrove forest (average from the rainy and dry seasons)	147.19	70.00	217.19	69.18	32.90	102.08	253.65	120.63	374.29
Meepol (2010)	Ranong	Mangrove forest	-	-	119.76	-	-	57.85	-	-	212.13

Remark: AGB = Aboveground biomass (stems, branches, and leaves), BGB = Belowground biomass (roots), Total = AGB + BGB

Most importantly, regular trimming, systematic monitoring, and structural stability assessments of all trees are strongly recommended to minimize risks, ensure public safety, and promote sustainable urban tree management. This study focused on the tree community; however, assessments of other plant communities, such as those associated with shrubs and herbaceous vegetation, are necessary to obtain a more comprehensive estimate of carbon sequestration within the university campus. In addition, Ramkhamhaeng University operates 24 additional campuses across Thailand. Estimating carbon sequestration across all campuses provides valuable baseline data for calculating and offsetting a university's CO_2 emissions.

Conclusions

A survey of tree composition and carbon sequestration conducted at Ramkhamhaeng University (Hua Mak Campus) revealed a total of 2,149 trees within the study area, corresponding to a tree density of 45.8 trees ha^{-1}. The tree community was dominated by the palm family (Arecaceae), while *T. ivorensis* was the most abundant species. The overall mean DBH and tree height were 34 cm and 8.6 m, respectively. The total estimated biomass, carbon storage, and CO_2 sequestration were 26.56 t ha^{-1}, 12.48 tC ha^{-1}, and 45.77 tCO_2e ha^{-1}, respectively. *T. rosea* contributed the most to total biomass, carbon storage, and CO_2 sequestration at the species level, whereas *S. saman* presented the highest average values on a per-tree basis. Biomass and carbon storage were strongly influenced by DBH and tree height. The findings of this study provide valuable information for green space planning and tree management on university campuses, supporting strategies aimed at achieving low-carbon institutional and societal goals while enhancing environmental quality and promoting human health and well-being.

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Data availability statement

Information and data used in the study will be disclosed upon request.

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Pawanrat Butrid: Methodology, Investigation,
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Conflicts of interest

The authors declare that there are no conflicts of interest in competing financial or personal relationships that could have appeared to influence the work reported in this work.

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