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# Contribution of KWT Gardens to Plant Biodiversity and Carbon Stock in Bogor City

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## *ABSTRACT*

***Keywords:*** agroforestry; carbon stock; biodiversity; women farmers group

**Abstrak**

The phenomenon of urban sprawl in Bogor City has led to land-use changes and the expansion of residential areas, resulting in the reduction of green and agricultural lands that function as ecological buffers and providers of urban landscape services. KWT (Kelompok Wanita Tani or Women Farmer Groups) Gardens represent existing Green Open Spaces (Ruang Terbuka Hijau/RTH) in Bogor City that adopt a mixed garden or agroforestry system. This study aims to analyze the contribution of KWT gardens to plant biodiversity and carbon stock in Bogor City as a means of enhancing urban landscape services. Data were collected from six KWT gardens located in six districts across Bogor City. Plant composition and carbon stock data were obtained through field inventory and analyzed using a web-based tool, MyTree. The results show that vertically, the plant composition in KWT gardens is dominated by Stratum I vegetation (0–1 m) at 87.95%, while horizontally, the gardens are dominated by vegetable crops, accounting for 42.63% of the total. The highest tree carbon stock was found in KWT MM at 928.49 kg on a land area of 0.14 ha, while the lowest was in KWT AZ at 233.08 kg on a land area of 0.06 ha. KWT gardens using agroforestry systems contribute to enhancing plant biodiversity and carbon storage, which benefit urban communities both directly and indirectly.

## INTRODUCTION

Bogor City is one of the cities within the Jakarta metropolitan area (Jabodetabek: Jakarta, Bogor, Depok, Tangerang, and Bekasi), and this status influences population mobility and migration. Inbound migration to Bogor City increased from 2019 to 2021, with a total of 20,678 new residents recorded in 2021 (Herawati *et al.*, 2022). As of 2023, the population of Bogor City reached 1,070,719 people (Badan Pusat Statistika 2024). This significant number is partly due to migration from other regions, driven by employment opportunities and the high cost of living in Jakarta. Consequently, urban sprawl has occurred in Bogor City, leading to changes in land use and expansion of residential areas (Bappeda Kota Bogor, 2022). This has impacted the availability of GOS, which functions as an ecological balancer and provider of urban landscape services. Landscape services refer to the benefits and functions derived from ecosystems, obtained by humans either directly or indirectly to support their survival and development (Huang et al., 2024). These services are categorized into four components: supporting services, provisioning services, regulating services, and cultural services. Beyond their ecological functions, landscape services are also linked to human well-being, particularly in terms of health, safety, quality of life, and economic benefits (Millennium Ecosystem Assessment, 2005).

One form of landscape service manifested through GOS is agroforestry. Agroforestry is a sustainable land-use system that integrates perennial and seasonal crops to provide economic, social, and ecological benefits. This system yields socio-economic advantages such as enhanced food security and sustainable income diversification, while also providing essential landscape services. Ecologically, the multi-strata vegetation structure of agroforestry systems can control flooding and prevent soil erosion. Rainwater does not fall directly onto the soil surface but is intercepted by the canopy strata, reducing surface runoff. Furthermore, the diversity of vegetation species contributes to climate regulation by sequestering carbon (Qurniati, 2023). Gardens managed by Women Farmer Groups (KWT) represent existing GOS in Bogor City that utilize mixed garden or agroforestry systems. These gardens comprise various vegetation strata and a combination of annual and perennial plant species. Agroforestry landscapes support sustainability from both ecological and social perspectives by facilitating effective biological interactions among organisms within the system (Kaswanto, Filqisthi, & Choliq, 2016).

A study by Rachdian *et al.* (2016) reported a decline in landscape service values in Bogor City between 1990 and 2014. Their recommendation was to preserve and enhance landscape services by allocating space dominated by trees and mixed garden systems. Kaswanto *et al.* (2016) also found that home gardens in Bogor City, particularly in the Cisadane and Ciliwung watersheds, demonstrated plant biodiversity (H') values ranging from 0.77 to 3.57, indicating strong potential for providing plant biodiversity landscape services. These home gardens also had an average carbon sequestration of over 20 Mg/ha. Their recommendation emphasized the optimization of home gardens through planting productive and local species, as micro-scale agroforestry landscapes can make tangible contributions to landscape service provision. Although several studies have explored the role of home gardens and agroforestry in biodiversity and carbon sequestration, specific research on the contribution of KWT gardens as urban GOS remains limited, particularly in the context of Bogor City.

The presence of KWT gardens is also aligned with local government programs promoting green urban development and community-based food security. These are regulated under Peraturan Daerah Kota Bogor Nomor 16 Tahun 2019 on the Protection of Sustainable Food Agricultural Land and Peraturan Wali Kota Bogor Nomor 161 Tahun 2021, which assigns the institutional role of the Food Security and Agriculture Agency in supporting programs such as Sustainable Food Yards (P2L), implemented by KWTs.

The expansion of residential areas resulting from urban sprawl has led to significant land-use conversion, thereby reducing the city's capacity to deliver essential landscape services such as carbon sequestration and the maintenance of biodiversity. This condition highlights the urgent need for micro-scale green spaces within urban areas. In this context, gardens managed by Women Farmer Groups (Kelompok Wanita Tani or KWT), which function as micro green spaces using agroforestry systems, offer a promising solution for providing landscape services in urban environments. KWT gardens can offer landscape services similar to those of productive home gardens or mixed-use agricultural lands. Therefore, it is essential to examine KWT gardens as a form of functional landscape in order to address the ecological challenges in urban areas. The objective of this study is to analyze the contribution of KWT gardens to plant diversity and carbon sequestration in Bogor City as part of an effort to enhance urban landscape services.

## RESEARCH METHODS

This study employed a quantitative descriptive approach and was conducted in Bogor City, West Java, from June to November 2024. Data were collected from six KWT gardens located across six subdistricts of Bogor City (Figure 1). The research sites were selected using purposive sampling, a technique involving deliberate selection based on specific criteria (Sugiyono, 2013). The criteria used to determine the research locations included accessibility to the gardens and the level of activity in KWT management practices. One KWT garden was selected from each subdistrict, resulting in six study sites (Table 1).

Table 1 Research Locations of KWT Gardens

| KWT Name | District | Code |
|---|---|---|
| Asri GWKP | West Bogor | AG |
| Azalea | Central Bogor | AZ |
| Flamboyan Bantarjati | North Bogor | FB |
| Flamboyan Empang | South Bogor | FE |
| Mawar Melati | Esst Bogor | MM |
| Srikandi | Tanah Sareal | SR |

Source: Processed primary data, 2024

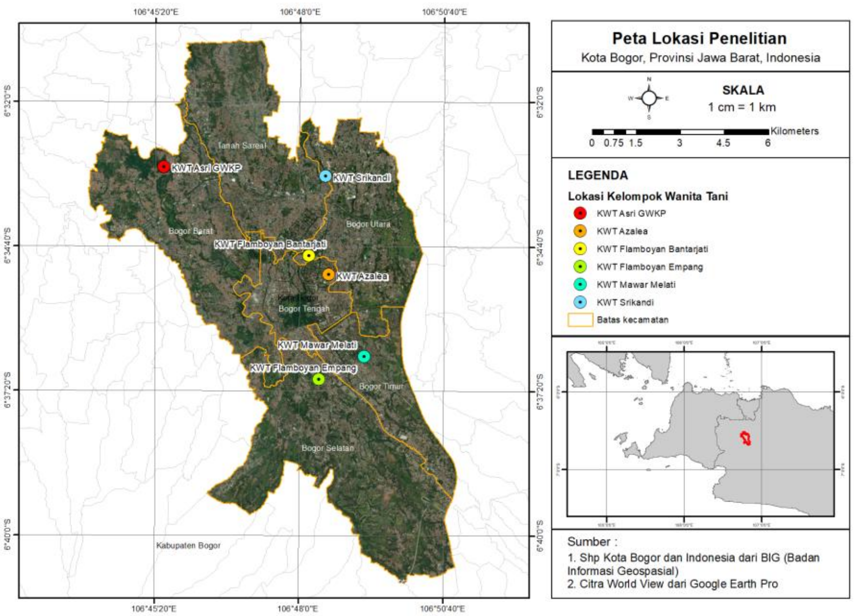


Figure 1 Research locations

The KWT gardens are situated in urban areas and vary in size. Plant diversity data were collected across the entire area of each KWT garden without establishing plots. The use of sampling plots is generally intended for large-scale areas (Utami & Putra, 2020). whereas in this study, the garden areas were small enough to be fully assessed. Initial information on the garden sizes was obtained directly from KWT garden managers. The estimated sizes of the KWT gardens are as follows: FE – 0.02 ha, FB – 0.05 ha, SR – 0.08 ha, AZ – 0.06 ha, MM – 0.1 ha, and AG – 0.35 ha. Exact measurements of garden size were conducted using a tape measure to determine the length and width of each site. The unit of analysis in this study was the plant species found within the KWT gardens, while the unit of observation was each plant identified. The tools and materials used for data collection included stationery, the PictureThis app for plant identification, the i-Tree MyTree web tool, a smartphone camera, a measuring tape, Microsoft Excel, Microsoft Word, and a phi band.

Vertical and horizontal plant data were collected through species inventory. The plant inventory was conducted by a team of 2–3 people: one person recorded data, while the others identified plant species in the KWT gardens. Plant identification in the field included the scientific name, local name, number of species per stratum, and plant function. Species identification was conducted on all plants found within the six KWT gardens included in this study. Plant composition was categorized vertically and horizontally. Vertical composition referred to plant height, while horizontal composition was based on plant function. The vertical composition was divided into five strata based on height, and the horizontal composition was divided into seven categories: ornamental, medicinal, vegetable, fruit, spice, industrial, and others, (Arifin, Sakamoto, & Chiba, 1998) as detailed in Table 2.

Table 2 Plant Composition Categories

| Vertical | | Horizontal | |
|---|---|---|---|
| Category | Description | Category | |
| Stratum I | 0-1 m | Ornamental plants | Industrial plants |
| Stratum II | 1-2 m | Medicinal plants | Others |
| Stratum III | 2-5 m | Vegetable plants | |
| Stratum IV | 5-10 m | Fruit plants | |
| Stratum V | >10 m | Spice plants | |

Source: Arifin et al., (1998), Processed data, 2024

The method used to analyze tree carbon sequestration involved the i-Tree web-based tool, MyTree, which is accessible via https://mytree.itreetools.org/. MyTree is one of the tools provided by i-Tree that estimates the benefits of individual trees. According to the measurement guidelines from the in USDA Forest Services (2021), the data input into the tool includes the scientific name, tree condition, diameter at breast height (DBH), and sunlight exposure. Only trees with a DBH greater than 10 cm were analyzed. DBH was measured at 1.3 meters above the ground using a phi band. Species identification was conducted using the *PictureThis* app and validated through local taxonomic literature.

## RESULTS AND DISCUSSION

### General Conditions of KWT Gardens

KWT gardens are plots of land owned by a community-based agricultural institution composed of 20–44 women aged between 22 and 70 years. KWTs hold roles and responsibilities in managing farming activities and initiating programs aimed at improving family welfare. One of their primary activities is increasing agricultural production. The functions of these farmer groups include serving as educational platforms, production units, and cooperative forums. KWTs provide a learning environment for members to enhance their knowledge and skills, enabling them to evolve into independent farming enterprises and thereby improve productivity and income. Additionally, KWTs facilitate cooperation among farmers, between farmer groups, farming enterprises, and other stakeholders. Such collaboration is essential to generate income and financial gains(Farahdiba *et al.*, 2020).

Table 3 General Characteristics of KWT Gardens

| KWT | Area (ha) | LTS Cultivation | Fish Farming | Average Distance from Garden to Manager's Home (m) | Number of Member (people) | Year Established |
|---|---|---|---|---|---|---|
| FE | 0.02 | Yes | No | 955 | 30 | 2020 |
| FB | 0.04 | Yes | Yes | 302 | 20 | 2018 |
| SR | 0.06 | No | Yes | 441 | 44 | 2017 |
| AZ | 0.06 | Yes | Yes | 53 | 30 | 2021 |
| MM | 0.14 | No | No | 480 | 30 | 2020 |
| AG | 0.35 | No | No | 244 | 30 | 2020 |

Source: Processed primary data, 2024

The activities and social preferences of KWT members influence the landscape structure of the gardens. The landscapes of KWT gardens generally consist of both food and non-food crops. However, some KWTs have integrated agricultural practices with aquaculture, such as catfish or stingless bee (LTS) farming. KWT gardens adopt organic farming practices by using organic inputs throughout the cultivation process. Three of the six KWTs, including AZ, FB, and FE—have developed stingless bee cultivation and generate income through the sale of stingless bee honey (Table 3).

Table 4 Boundary Conditions of KWT Garden Sites

| KWT | Site boundary | | | |
|---|---|---|---|---|
| | Northern Boundary | Eastern Boundary | Southern Boundary | Western Boundary |
| FE | Road network | Residential area | Residential area | Residential area |
| FB | Dryland forest | Residential area | Residential area | Residential area |
| SR | River | River | Residential area | Residential area |
| AZ | Residential area | Residential area | Dryland forest | Livestock farming |
| MM | Residential area | Residential area | Roadside green strip | Reoad network |
| AG | Residential area | Dryland forest | Dryland forest | Residential area |

Source: Processed primary data, 2024

The KWT gardens are located in the urban areas of Bogor City and vary in size, ranging from 0.02 ha to 0.35 ha. All KWT gardens share boundaries with residential areas (Table 4). These gardens are managed by local community members, typically within the same neighborhood (RT/RW), making them relatively accessible. The distance between members' residences and the gardens ranges from 53 meters to 955 meters, with an average distance of approximately 400 meters. This proximity allows members to monitor and manage the gardens conveniently, which is considered advantageous. The physical condition of the KWT gardens is illustrated in Figure 2.

Figure 2 General Conditions of KWT Gardens

The biophysical characteristics of each KWT garden differ, as evidenced by the varying number of species and individual plants present (Table 5). Generally, there is a tendency for gardens with larger areas to host a greater number of plant individuals. For example, KWT AG, with an area of 0.35 ha, has the highest number of individuals (1,939), while KWT FE, with only 0.02 ha, has the fewest (202 individuals). However, the planting strategies and preferences of KWT managers also significantly influence the diversity of plant species within the gardens.

Table 5 Number of Plants in KWT Gardens

| No | KWT Name | Area (ha) | Total Number of Species | Total Number of Individuals |
|---|---|---|---|---|
| 1 | FE | 0.02 | 44 | 202 |
| 2 | FB | 0.04 | 104 | 474 |
| 3 | SR | 0.06 | 117 | 1570 |
| 4 | AZ | 0.06 | 40 | 1678 |
| 5 | MM | 0.14 | 83 | 1341 |
| 6 | AG | 0.35 | 106 | 1939 |

Source: Processed primary data, 2024

**Plant Diversity in KWT Gardens**

The landscape of the KWT gardens consists of mixed gardens that include various types of plants arranged both vertically and horizontally. Vertical diversity is categorized into five strata: Stratum I (0–1 m), Stratum II (1–2 m), Stratum III (2–5 m), Stratum IV (5–10 m), and Stratum V (more than 10 m). Horizontal diversity is classified into eight functional categories: ornamental, medicinal, vegetable, fruit, spice, industrial, starch-producing, and others (Arifin et al., 1998). Other functions found in KWT gardens include fodder, shade, natural pesticides, and boundary plants.

Table 6. Composition of Plants in KWT Gardens by Vertical and Horizontal Categories

| Plant Category | Percentage |
|---|---|
| Vertical | |
| I (0-1 m) | 87.95% |
| II (1-2 m) | 7.21% |
| III (2-5 m) | 3.86% |
| IV (5-10 m) | 0.83% |
| V (>10 m) | 0.15% |
| Horizontal | |
| Vegetales | 42.63% |
| Ornamental | 22.02% |
| Fruits | 13.53% |
| Medicinal | 9.43% |
| Starch-producing | 5.21% |
| Spices | 4.16% |
| Others | 2.75% |
| Industrial raw materials | 0.28% |

Source: Processed primary data, 2024

The composition of plants in KWT gardens spans all five vertical strata (I–V). A total of 87.95% of the plants belong to Stratum I, and 42.63% of the plants are vegetables. Strata I to IV are found throughout all KWT gardens, while plants in Stratum V are only found in the FB KWT garden. Stratum V trees include *Persea americana* (avocado) and *Swietenia mahagoni* (mahogany), which have been present for approximately 10–15 years before the establishment of the KWT. Vegetation in the upper strata (III–V) contributes more significantly to the ecosystem's carbon stock compared to that in the lower strata (I–II). Plants in Strata III–IV generally have larger stem diameters than those in Strata I–II, which influences biomass and stored carbon. Thus, the presence of plants in Strata III–V is crucial due to their contributions to landscape services (Uthbah *et al.*, 2017). According to the data in Table 6, Stratum I plants are the most abundant and are distributed across all KWT garden sites. The most commonly found Stratum I plant species in three or more gardens include *Brassica rapa* (mustard greens), *Capsicum annuum* (chili), *Arachis hypogaea* (peanut), *Amaranthus caudatus* (red amaranth), and *Solanum melongena* (eggplant). The plant species in KWT gardens are rotated every few months, typically aligned with the harvest season, resulting in greater species variety.

The dominance of Stratum I is attributed to the food crop orientation (vegetables) of KWT gardens, which are generally under 1 meter in height. Additionally, these vegetables are easy for KWT members to manage, hence the preference for Stratum I food crops. Most of the plants grown in KWT gardens are edible, highlighting their orientation toward food production. One of the primary functions of farmer groups is to support agricultural production activities, including the cultivation of food crops with economic potential and contributions to household food security (Peraturan Menteri Pertanian Republik Indonesia 2016).

The horizontal composition of plants shows a dominance of vegetable crops, followed by ornamental plants (Table 6). A wide variety of plant species have been identified in KWT gardens. Food crop groups include vegetables (*Brassica rapa*, *Ipomea aquatica*), fruits (*Capsicum annum*, *Musa paradisiaca*), starch-producing plants (*Colocasia esculenta*, *Zea mays*), and spices (*Kaempferia galanga*, *Zingiber officinale*). Additionally, ornamental (*Alternanthera bettzickiana*, *Zinnia elegans*), medicinal (*Bidens pilosa*, *Curcuma longa*), and industrial raw materials (*Coffea arabica*, *Swietenia mahagoni*) are also present. Several plants with specific ecological functions were identified, such as natural pesticides (*Azadirachta indica*), landscape boundaries (*Acalypha siamensis*), shade providers (*Syzygium cumini*), and animal fodder (*Leucaena leucocephala*).

KWT gardens can be classified as agroforestry systems due to their multi-strata structure. Agroforestry is a land-use system that integrates trees with annual crops, livestock, or both. These systems incorporate various vertical and horizontal strata that interact in mutually beneficial ways (Gassner & Dobie, 2023). A study by Enkossa *et al.* (2023) found that species diversity has a positive and significant impact on both aboveground and belowground carbon stocks. Therefore, protecting trees for conservation is essential. This also highlights the role of biodiversity in enhancing ecosystem services through carbon sequestration and long-term carbon storage.

Agroforestry contributes to landscape services by preserving biodiversity, reducing greenhouse gas concentrations in the atmosphere, and maintaining the sustainability of natural resources and the environment. These benefits are derived from the structure and composition of plants and trees arranged within a given land area. The presence of strata III, IV, and V plants in the KWT gardens provides shading benefits for strata I and II plants, as well as for nearby humans. The tree canopy in agroforestry systems functions to block direct exposure to sunlight and lower air temperature in the surrounding area, thus creating a cooler microclimate (Hairiah *et al.*, 2011).

**Carbon Storage in Trees within KWT Gardens**

Tree carbon storage refers to the amount of carbon sequestered within tree biomass. Plants absorb $CO_2$ from the atmosphere through photosynthesis, which is converted into carbohydrates and distributed throughout the plant, eventually being stored in plant tissue. This carbon accumulation process is known as carbon sequestration (C-sequestration). The measurement of carbon stored in plants indicates the amount of atmospheric $CO_2$ absorbed by the vegetation (Hairiah et al., 2011)

Table 7. Carbon Storage in Trees in KWT Gardens

| KWT | Garden Area (ha) | Carbon Stored | | Category |
|---|---|---|---|---|
| | | Per garden area (tons) | per Hectare (tons/ha)) | |
| FE | 0.02 | 0.50 | 24.94 | Low |
| FB | 0.04 | 2.45 | 61.31 | Medium |
| SR | 0.06 | 2.67 | 44.46 | Medium |
| AZ | 0.06 | 0.23 | 3.88 | Low |
| MM | 0.14 | 9.38 | 66.97 | High |
| AG | 0.35 | 0.93 | 2.65 | Low |

Carbon storage category: Low < 42.172 tons/ha; Medium = 42.172–64.150 tons/ha; High > 64.150 tons/ha (Rochmayanto et al., 2014).

Source: Primary data processed, 2024

The KWT garden with the highest tree carbon storage is KWT MM, with 9.38 tons stored in 0.14 hectares, while the lowest is KWT AZ, with only 0.23 tons stored in 0.06 hectares (Table 7). KWT MM contains 27 trees, whereas KWT AZ contains only 2 trees (Table 8). The most common trees in KWT MM are jamblang (*Syzygium cumini*) with an average DBH of 24.77 cm and salam (*Syzygium polyanthum*) with an average DBH of 37.37 cm. In contrast, the only trees in KWT AZ are mango (*Mangifera indica*) with a DBH of 24 cm and rambutan (*Nephelium lappaceum*) with a DBH of 19 cm. Tree carbon storage is influenced by trunk diameter; the larger the diameter, the greater the amount of $CO_2$ absorbed and stored (Istomo & Farida, 2017).

Table 8. Tree Carbon Storage in KWT MM (Highest) and KWT AZ (Lowest)

| KWT MM | | | | KWT AZ | | | |
|---|---|---|---|---|---|---|---|
| No | Tree Name | Scientific Name | Total | No | Tree Name | Scientific Name | Total |
| 1 | Jamblang | *Syzygium cumini* | 6 | 1 | Mangga | *Mangifera indica* | 1 |
| 2 | Salam | *Syzygium polyanthum* | 6 | 2 | Rambutan | *Nephelium lappaceum* | 1 |
| 3 | Kenari | *Canarium indicum* | 3 | | | | |
| 4 | Palem kuning | *Dypsis lutesense* | 3 | | | | |
| 5 | Kelor | *Moringa oleifera* | 3 | | | | |
| 6 | Pucuk merah | *Syzygium myrtifolium* | 2 | | | | |
| 7 | Mangga | *Mangifera indica* | 2 | | | | |
| 8 | Kiara payung | *Filicium decipiens* | 2 | | | | |
| | Total | | 27 | | Total | | 2 |

Source: Primary data processed, 2024

Most trees in KWT Mawar Melati serve as shade providers and path markers. Strategically placed seating beneath tree canopies demonstrates the use of vegetation for cultural ecosystem services such as recreation and aesthetics. The shade from the tree canopy plays a vital role in creating a comfortable and cool microclimate for visitors. Green open spaces with large trees can produce approximately 0.6 tons of oxygen per hectare, and a single large tree can generate 1.2 kilograms of oxygen per day. During the daytime, trees produce oxygen necessary for humans and other living beings while absorbing carbon dioxide from combustion emissions (KLHK, 2016).

Previous studies have shown that jamblang and salam trees can store significant amounts of carbon. For instance, a *Syzygium cumini* tree in the United Tractors Head Office Urban Forest with a biomass of 3.478 tons stored 1.636 tons of carbon (Santoso et al., 2021). Another study reported that a jamblang tree at the Purwodadi Botanical Garden with a biomass of 68.86 kg could store 31.67 kgC per tree (Danarto & Yulistyarini, 2019). In addition to jamblang, the salam tree (*Syzygium cumini*) also shows high carbon sequestration potential (Trimanto et al., 2021). A salam tree in the PT Tirta Investama Wonosobo Biodiversity Park with a trunk diameter of 5 cm could store 3.1678 kg of carbon (Lestari, W, & Prijono, 2024), At the Purwodadi Botanical Garden, a salam tree with 62.12 kg biomass could store 28.58 kgC/tree (Danarto & Yulistyarini, 2019). In an agroforestry system, salam trees with a biomass of 0.12 tons/ha can store 0.25 tons of carbon per hectare (Nur, Setyawan, & Kusumaningrum, 2024). In Indonesia, *Syzygium cumini* is recommended as a priority species for restoration due to its carbon storage capability. Each tree has a unique capacity for carbon absorption and storage, depending on its biomass (Yulistyarini & Hadiah, 2022). Hence, jamblang and salam trees are recommended for planting in other KWT gardens.

The tree composition in KWT MM (highest carbon storage) and KWT AZ (lowest carbon storage) is detailed in Table 8. The diversity of tree species in KWT MM is greater than in KWT AZ. Higher tree diversity is associated with increased carbon storage and soil nutrient levels (Trimanto *et al.*, 2021). KWT gardens are part of an agroforestry system. As a form of simple agroforestry, KWT gardens that integrate trees with annual crops have a structural composition different from complex agroforestry systems that resemble forest ecosystems. This structural difference leads complex agroforestry systems to have a greater carbon storage capacity than simpler systems. The difference in carbon storage values between complex and simple agroforestry systems is attributed to variations in the number of trees, species types, tree diameters, and tree heights. Complex agroforestry systems can store an average of 127.6 tons/ha of carbon, whereas simple agroforestry systems store an average of 59.37 tons/ha (Wulandari, Harianto, & Novasari, 2021).

The carbon sequestration value in agroforestry land cover is 36.8416 tons/ha, which is slightly lower than that of secondary forest land cover, amounting to 37.2846 tons/ha. The variation in carbon sequestration values across different land covers is influenced by factors such as tree count, tree density, species composition, and environmental conditions including sunlight exposure, moisture levels, temperature, and soil fertility, all of which affect the rate of photosynthesis (Sugirahayu & Rusdiana, 2011). Urban green open spaces (GOS) provide relatively cooler environments, which can indirectly reduce energy consumption among urban residents, while also absorbing atmospheric $CO_2$. In 2021, GOS contributed to an estimated annual carbon saving of approximately 78 tons C/km$^2$, equivalent to 2.21 times the carbon sequestration in the same area (Yang et al., 2024). Recommended plants for cultivation in KWT gardens include *Dialium indum L.* (tamarind), *Syzygium aqueum* (water apple), *Caesalpinia pulcherrima* (peacock flower), *Samanea saman* (rain tree), *Artocarpus heterophyllus* (jackfruit), and *Delonix regia* (royal poinciana), due to their high ecological functions and potential to produce food or enhance aesthetics (KLHK, 2016).

**Contribution of KWT Gardens**

The KWT gardens are urban green spaces that apply agroforestry systems. The landscape services provided by these gardens can be experienced both directly and indirectly by urban communities. Landscape services refer to the benefits derived from ecosystems that are provided to humans. The stratified agroforestry system in KWT gardens supports plant biodiversity and delivers landscape services, including carbon sequestration. The existence of urban green open spaces (GOS) benefits human life by offering both tangible and intangible advantages. Direct benefits include aesthetics, thermal comfort, and the provision of economically valuable raw materials (wood, flowers, fruits, leaves), while indirect benefits include air purification, groundwater replenishment, and conservation of flora and fauna (KLHK, 2016). Carbon sequestration is associated with ecosystem services such as biodiversity conservation, water regulation, and natural beauty. Thus, changes in carbon storage levels significantly affect the provision of landscape services (Kementrian Lingkungan Hidup dan Kehutanan Republik Indonesia, 2023).

The plant diversity in KWT gardens forms a multistrata vegetation structure that enhances the provision of landscape services. This structural complexity creates habitats that support faunal diversity and ecological processes such as pollination. Strata I–II plants are primarily used for food and medicinal purposes, while strata III–V plants function as carbon sinks, provide shade, and absorb air pollutants (Hairiah et al., 2011). The KWT gardens serve as urban green patches that enrich the ecological and aesthetic mosaic of the urban landscape. Each plant species has the potential to store carbon in its biomass. The amount of carbon stored depends on species type, age, and tree dimensions. Trees in strata IV and V, which have larger biomass, store more carbon than those in strata I–III (Eggleston, Buendia, Miwa, Ngara, & Tanabe, 2006). According to Hairiah et al. (2011), agroforestry systems such as those in KWT gardens have the potential to store 30–60 tons C/ha, depending on tree density and plant species composition. Therefore, the existence of KWT gardens in urban areas plays a significant role in mitigating climate change by sequestering carbon and reducing greenhouse gas emissions.

This study recommends that city governments integrate KWT gardens into the planning and development of urban green open spaces as a model of community-based green space. This approach supports food security, environmental education, and strengthens the ecological functions of urban areas through sustainable landscape service provision. Additionally, KWT gardens have the potential to be developed into agro-edu-tourism gardens, serving as educational platforms to increase urban communities' knowledge of agriculture and awareness of the importance of maintaining green spaces in cities.

## CONCLUSION

KWT gardens contribute significantly to plant biodiversity and carbon storage in Bogor City. Vertically, the plant composition in KWT gardens is dominated by Stratum I species (87.95%), while horizontally, vegetable crops dominate (42.63%). The highest carbon sequestration value is found in the MM garden, which stores 928.49 kg of carbon on 0.14 ha of land, whereas the lowest is in the AZ garden, with 233.08 kg on 0.06 ha. Managed by women farmers through agroforestry systems, KWT gardens enhance plant diversity and provide carbon storage that benefits urban communities both directly and indirectly. These gardens hold great potential as learning spaces for local communities and may be further developed into agro-edu-tourism gardens in Bogor City. Such development would promote urban residents' knowledge of agriculture and raise awareness of the importance of preserving green spaces within the city.

## RECOMMENDATIONS

The development of agroforestry systems in KWT gardens should be carried out in an integrated manner, accompanied by an analysis of factors influencing carbon sequestration and the relationship between planting patterns and carbon storage capacity. Recommended strategies for optimizing KWT gardens include cultivating plants with high ecological functions that also produce food or enhance aesthetic value, such as *Dialium indum L.* (tamarind), *Syzygium aqueum* (water apple), *Caesalpinia pulcherrima* (peacock flower), *Samanea saman* (rain tree), *Artocarpus heterophyllus* (jackfruit), and *Delonix regia* (royal poinciana) (KLHK, 2016).

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