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# Urban Forests as Green Infrastructure: Linking Vegetation Composition, Spatial Distribution, and Environmental Functions

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**ABSTRACT**

**Purpose of the study:** This study aimed to analyze the species composition, vegetation structure, spatial distribution patterns, and ecological functions of urban forest vegetation in supporting environmental quality improvement and sustainable urban development.

**Methodology:** A field survey using a complete census approach was conducted to inventory all tree and pole vegetation. Data collection included species identification, diameter measurement, and GPS coordinate recording. Vegetation structure was analyzed using density, dominance, and Importance Value Index, while spatial distribution patterns were mapped using GIS and ArcGIS 10.1. Ecological functions were evaluated based on carbon sequestration and air pollution mitigation capacities of dominant species.

**Main Findings:** The study recorded 35 vegetation species with 1,389 individuals, consisting of 1,250 trees and 139 poles. *Swietenia macrophylla* was identified as the dominant species with the highest density and IVI values. Spatial analysis revealed a heterogeneous distribution pattern with high-density clusters dominated by *Swietenia macrophylla* and *Terminalia catappa*. Dominant species significantly contributed to ecosystem services, including carbon sequestration, pollution reduction, microclimate regulation, and ecosystem stability. *Samanea saman*, *Swietenia macrophylla*, and *Pometia pinnata* were identified as key species supporting environmental quality improvement.

**Novelty/Originality of this study:** This study integrates vegetation inventory, stand structure analysis, ecological importance assessment, and GIS-based spatial distribution mapping within a single framework, providing comprehensive scientific evidence to support sustainable urban forest management, biodiversity conservation, and environmental planning.



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## 1. INTRODUCTION

Urbanization has accelerated rapidly worldwide and has become one of the major drivers of environmental degradation in urban areas [1], [2]. The expansion of residential, industrial, and transportation infrastructures has increased air pollution, urban heat island effects, and ecological disturbances that threaten environmental sustainability [3], [4]. Rapid urban development often reduces green open spaces and alters natural ecosystems, resulting in declining environmental quality and increasing pressure on urban ecological systems [5], [6]. Consequently, sustainable urban planning has become a critical strategy for maintaining ecological balance and improving the quality of life in cities.

Urban forests are recognized as one of the most effective nature-based solutions for mitigating environmental problems in urban landscapes [7], [8]. As an integral component of urban green infrastructure, urban forests provide multiple ecological functions, including carbon sequestration, air pollutant removal, temperature regulation, stormwater management, and biodiversity conservation [9], [10]. The presence of trees and other vegetation within urban forests contributes significantly to reducing atmospheric pollutants while enhancing microclimatic conditions and ecological resilience [11], [12]. Therefore, urban forests play a crucial role in supporting sustainable urban development and achieving several Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 15 (Life on Land).

The ecological contributions of urban forests are strongly influenced by vegetation composition, stand structure, and species diversity. Tree species differ considerably in their ability to absorb carbon dioxide, trap particulate matter, regulate temperature, and provide habitat for wildlife [13], [14]. Vegetation characteristics such as tree density, canopy cover, basal area, and species dominance determine the effectiveness of urban forests in delivering ecosystem services [15], [16]. Consequently, understanding vegetation structure and composition is essential for evaluating the ecological performance of urban forests and supporting evidence-based management strategies [7], [17].

In addition to vegetation composition, the spatial distribution of trees is an important aspect of urban forest ecology [18], [19]. Spatial distribution patterns influence ecosystem functioning, habitat connectivity, and environmental service provision across urban landscapes [20], [21]. Geographic Information Systems have increasingly been used to assess vegetation distribution and support urban forest planning by identifying areas with high ecological value as well as locations requiring restoration and conservation efforts. Spatial analysis can therefore provide important information for improving urban forest management and enhancing environmental quality [22], [23].

Previous studies have demonstrated the importance of urban vegetation in improving environmental conditions [24], [25]. Research on urban forests has highlighted their role in carbon storage, air pollution mitigation, and climate regulation. Several studies have also utilized spatial approaches to assess vegetation distribution and land-use changes in urban ecosystems [26], [27]. However, most previous studies have focused primarily on carbon sequestration, air quality improvement, or land-cover dynamics, while limited attention has been given to integrating vegetation inventory, stand structure assessment, and spatial distribution analysis to comprehensively evaluate ecosystem services provided by urban forests, particularly in tropical urban environments [28], [29].

In Indonesia, studies concerning urban forest vegetation have predominantly emphasized species inventories and biodiversity assessments. Although such studies provide valuable baseline information, they often lack detailed evaluations of vegetation structure and spatial distribution patterns that are necessary for supporting sustainable urban forest management [30], [31]. Furthermore, information regarding the ecological contributions of dominant tree species in urban forests remains limited, particularly in medium-sized cities where urban expansion continues to increase environmental pressures [32], [33].

Malvinas Urban Forest in Padang City represents an important urban green space that contributes to environmental protection and ecological sustainability. The area contains diverse tree species with potential ecological functions in carbon sequestration, pollution mitigation, and microclimate regulation [34], [35]. Despite its ecological significance, comprehensive information regarding vegetation composition, stand structure, species dominance, and spatial distribution within the urban forest remains insufficient [36], [37]. Such information is essential for understanding the ecological condition of the forest and developing effective management strategies to maximize ecosystem services [38], [39].

The novelty of this study lies in the integration of vegetation inventory, stand structure analysis, and GIS-based spatial distribution mapping to evaluate the ecological contributions of urban forest vegetation. Unlike previous studies that mainly focus on species identification or carbon-related assessments, this study combines vegetation composition, species dominance, spatial distribution patterns, and ecological functions within a single analytical framework. This integrated approach provides a more comprehensive understanding of how urban forest vegetation contributes to environmental quality improvement and sustainable urban ecosystem management [40], [41].

Therefore, this study aims to (1) identify the composition of tree and pole species in Malvinas Urban Forest, Padang City; (2) analyze vegetation structure and species dominance; (3) evaluate spatial distribution patterns of urban forest vegetation using GIS; and (4) assess the ecological contributions of dominant species toward environmental quality improvement and pollution mitigation. The findings are expected to provide scientific evidence for urban forest management and support sustainable urban planning initiatives in Padang City.

## 2. RESEARCH METHOD

### 2.1. Study Area

This study was conducted in Malvinas Urban Forest, Padang City, West Sumatra, Indonesia. Malvinas Urban Forest is one of the urban green spaces that functions as an ecological buffer zone within the rapidly developing urban environment of Padang City. The area is characterized by a diverse assemblage of tree species that contribute to environmental protection through carbon sequestration, air pollution reduction, temperature regulation, and biodiversity conservation [10], [42]. Due to its strategic location within the urban landscape, Malvinas Urban Forest plays an important role in maintaining ecological balance and supporting ecosystem services for surrounding communities. Geographic coordinates of all observed trees and poles were recorded using a Global Positioning System device to facilitate spatial analysis and vegetation mapping [43].

### 2.2. Research Design

This study employed a field survey approach using descriptive quantitative and spatial analysis methods. A complete census method was applied to inventory all tree and pole individuals within the study area. The census approach was selected to obtain comprehensive information regarding vegetation composition, stand structure, species dominance, and spatial distribution patterns [44], [45]. Tree vegetation was defined as woody plants with a diameter at breast height of $\geq 20$ cm, whereas pole vegetation was defined as woody plants with a diameter at breast height ranging from 10 to $< 20$ cm, following standard forest inventory classifications.

### 2.3. Data Collection

Data were collected through a complete vegetation census conducted within Malvinas Urban Forest. Prior to the field survey, a preliminary observation was carried out to determine the boundaries of the study area and identify the general condition of the vegetation. The census method ensured that all tree and pole individuals within the urban forest were recorded comprehensively, thereby providing accurate information regarding species composition, stand structure, and spatial distribution patterns [46], [47].

Field observations involved identifying and recording all tree and pole species encountered within the study area. For each individual, information on species name, diameter at breast height, and geographic coordinates was collected [48], [49]. Species identification was conducted directly in the field using morphological characteristics and supported by relevant botanical references to ensure taxonomic accuracy. Diameter measurements were taken at 1.3 m above ground level using a measuring tape following standard forest inventory procedures. In addition, the geographic position of each individual was recorded using a handheld Global Positioning System receiver to facilitate spatial mapping and distribution analysis [50], [51]. The collected coordinate data were subsequently transferred to a computer and converted into digital spatial formats for Geographic Information System processing. Field documentation, including photographs of vegetation species and site conditions, was also conducted to support species verification and provide additional information regarding vegetation characteristics and ecological conditions within the study area.

### 2.4. Vegetation Analysis

Vegetation data collected during the field survey were analyzed to determine species composition, vegetation structure, species diversity, and the ecological importance of tree and pole species within Malvinas Urban Forest. The analysis included calculations of density, relative density, dominance, relative dominance, and the Importance Value Index (IVI) for each recorded species [52], [53]. These parameters were used to identify dominant species and evaluate their contribution to the overall structure and ecological functioning of the urban forest ecosystem. Species density was calculated using:

$$D = ni / A \ldots (1)$$

where D is species density (individuals $ha^{-1}$), ni is the number of individuals of species i, and A is the total study area (ha). Relative density was calculated as:

$$RD = (ni / N) \times 100 \ldots (2)$$

where RD is relative density (%), ni is the number of individuals of species i, and N is the total number of individuals recorded. Species dominance was determined based on basal area (BA), calculated using:

$$BA = \pi d^2 / 4 \ldots (3)$$

where BA is basal area (m²) and d is diameter at breast height (m). Relative dominance was calculated as:

$$RDo = (Doi / \Sigma Do) \times 100 \; \ldots \; (3)$$

where RDo is relative dominance (%), Doi is the dominance value of species i, and ΣDo is the total dominance value of all species. The ecological importance of each species was assessed using the Importance Value Index:

$$IVI = RD + RDo \; \ldots \; (4)$$

Species with higher IVI values were considered dominant and were assumed to contribute more significantly to ecosystem functioning and environmental quality improvement.

### 2.5. Spatial Analysis

Spatial analysis was conducted to evaluate the distribution patterns of tree and pole vegetation within the study area. Geographic coordinates collected during the field survey were transferred from the Global Positioning System device to a computer using MapSource software [54], [55]. The coordinate data were subsequently converted into General Purpose Exchange Format files and processed using ArcGIS 10.1 software. Vegetation distribution maps were generated to visualize the spatial locations of trees and poles throughout Malvinas Urban Forest. Spatial analysis was further employed to identify vegetation concentration zones, dominant species clusters, and areas requiring management attention or ecological restoration [56], [57]. The resulting maps were used to support the interpretation of vegetation distribution patterns and their ecological implications.

### 2.6. Ecological Function Assessment

The ecological functions of dominant tree species were evaluated based on their documented capacity for carbon dioxide absorption and environmental pollution mitigation. Information regarding carbon sequestration potential was compiled from previous studies and relevant scientific literature on urban forestry and ecosystem services [58], [59]. Species identified as dominant through vegetation analysis were subsequently assessed to determine their potential contributions to improving environmental quality, reducing atmospheric carbon concentrations, and supporting sustainable urban ecosystem management.

### 2.7. Data Analysis

All collected data were analyzed using descriptive statistics and ecological indices. Species richness, abundance, density, dominance, diversity, and ecological importance values were summarized and presented in tables and figures [44], [60]. Spatial data were analyzed and visualized using ArcGIS 10.1 to produce thematic maps of vegetation distribution. The results were subsequently interpreted to evaluate the ecological condition of Malvinas Urban Forest and its contribution to environmental quality improvement, air pollution mitigation, and sustainable urban forest management in Padang City.

## 3. RESULTS AND DISCUSSION

### 3.1. Species Composition of Urban Forest Vegetation

The vegetation inventory conducted in Malvinas Urban Forest recorded a total of 35 plant species consisting of tree and pole growth stages. A total of 1,389 individuals were identified, comprising 1,250 tree individuals and 139 pole individuals. The recorded vegetation represents an important ecological component of the urban landscape and contributes to environmental quality improvement through carbon sequestration, microclimate regulation, biodiversity conservation, and air pollution mitigation [61], [62]. Data on the total number of individual tree and pole categories found in the Malvinas Padang City Forest using the census method can be found in Table 1 and Figure 1 below.

Table 1. Vegetation Types and Number of Individuals in the Malvinas Padang City Forest

| No | Scientific Name | Local Name | Individu |
|---|---|---|---|
| 1 | *Swietenia macrophylla* King | Mahogany | 537 |
| 2 | *Samanea saman* (Jacq.) Merr. | Trembesi | 246 |
| 3 | *Terminalia catappa* L. | Ketaping | 142 |
| 4 | *Albizia falcataria* (L.) Fosberg | Sengon | 73 |
| 5 | *Hibiscus tiliaceus* L. | Waru | 53 |

| | | | |
|---|---|---|---|
| 6 | *Tectona grandis* L.f. | Teak | 43 |
| 7 | *Theobroma cacao* L. | Chocolate | 32 |
| 8 | *Pterocarpus indicus* Willd. | Angsana | 28 |
| 9 | *Spathodea campanulata* P.Beauv. | Kiacret | 26 |
| 10 | *Ficus racemosa* L. | Galapuang | 22 |
| 11 | *Hura crepitans* L. | Dadok Roda | 20 |
| 12 | *Psidium guajava* L. | Guava | 16 |
| 13 | *Pometia pinnata* J.R.Forst. & G.Forst. | Matoa | 15 |
| 14 | *Eugenia aperculata* Roxb. | Salam | 14 |
| 15 | *Artocarpus heterophyllus* Lam. | Jackfruit | 12 |
| 16 | *Spondias mombin* L. | Ambarella | 12 |
| 17 | *Syzygium oleina* (Blume) DC. | Red Tip | 10 |
| 18 | *Syzygium aqueum* (Burm.f.) Alston | Water Apple | 9 |
| 19 | *Macaranga tanarius* (L.) Müll.Arg. | Mara | 8 |
| 20 | *Averrhoa carambola* L. | Starfruit | 8 |
| 21 | *Pinus merkusii* Jungh. & de Vriese | Pine | 7 |
| 22 | *Ficus exasperata* Vahl | Ampas | 7 |
| 23 | *Mangifera indica* L. | Mango | 6 |
| 24 | *Annona muricata* L. | Soursop | 6 |
| 25 | *Pithecellobium jiringa* (Jack) Prain | Bayur | 6 |
| 26 | *Artocarpus communis* J.R.Forst. & G.Forst. | Breadfruit | 5 |
| 27 | *Durio zibethinus* Murray | Durian | 5 |
| 28 | *Toona sureni* (Blume) Merr. | Surian | 5 |
| 29 | *Ceiba pentandra* (L.) Gaertn. | Kapok Randu | 4 |
| 30 | *Averrhoa bilimbi* L. | Starfruit | 3 |
| 31 | *Nephelium lappaceum* L. | Rambutan | 2 |
| 32 | *Garcinia mangostana* L. | Mangosteen | 2 |
| 33 | *Leucaena leucocephala* (Lam.) de Wit | Chinese Stink Bean | 2 |
| 34 | *Muntingia calabura* L. | Seri | 2 |
| 35 | *Ficus benjamina* L. | Banyan | 1 |

Based on Table 1, it is known that the vegetation that makes up the Malvinas Padang City Forest consists of 35 plant species with varying numbers of individuals in each species. The species with the highest number of individuals is mahogany (*Swietenia macrophylla* King) with 537 individuals, followed by rain tree (*Samanea saman* (Jacq.) Merr.) with 246 individuals and ketapang (*Terminalia catappa* L.) with 142 individuals. The dominance of these several species indicates that the vegetation that makes up the city forest area is dominated by woody trees that have a high ability to adapt to urban environmental conditions [63], [64]. In addition to functioning as the main constituent of the stand structure, these dominant species also have ecological potential in absorbing carbon, reducing environmental temperatures, and reducing air pollution in urban areas. The diversity of vegetation types found indicates that the Malvinas Padang City Forest has quite diverse vegetation conditions and has the potential to support ecosystem balance and urban environmental services.

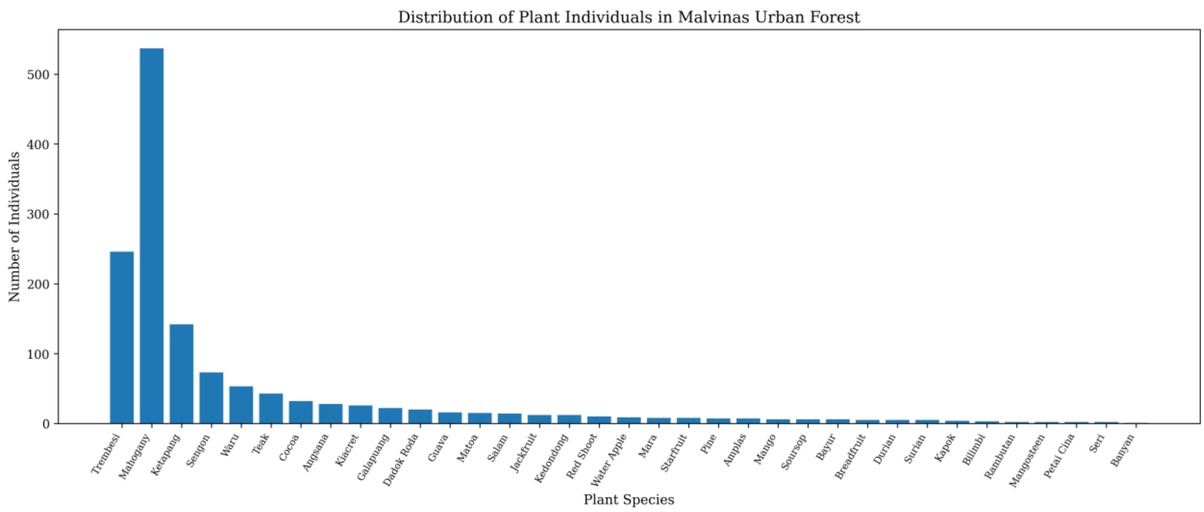


Figure 1. Histogram of the Total Number of Individuals in the Malvinas Padang City Forest

Based on the distribution of vegetation in the Malvinas Padang City Forest, it can be seen that several tree species have a higher level of dominance than others. The mahogany (*Swietenia macrophylla* King) is the vegetation with the highest number of individuals, namely 537 individuals, followed by the rain tree (*Samanea saman* (Jacq.) Merr.) with 246 individuals and the ketapang (*Terminalia catappa* L.) with 142 individuals. The high number of individuals in these several species indicates that the vegetation making up the urban forest area is dominated by large woody tree species that have good adaptation capabilities to urban environmental conditions. The dominance of these types also indicates great ecological potential in supporting carbon dioxide absorption, reducing air pollution, and improving the quality of the urban microclimate [65], [66]. In addition, the presence of various other vegetation types with lower numbers of individuals indicates that the Malvinas Padang City Forest has sufficient vegetation diversity to support ecosystem balance and urban environmental services.

Among the recorded species, mahogany (*Swietenia macrophylla*) was the most abundant species with 537 individuals, followed by rain tree (*Samanea saman*) with 246 individuals and tropical almond (*Terminalia catappa*) with 142 individuals. Together, these three species constituted a substantial proportion of the total vegetation community within the study area. The dominance of these species indicates their strong adaptability to urban environmental conditions and their suitability for urban greening and environmental management programs.

The relatively high species richness observed in Malvinas Urban Forest suggests that the area supports a diverse vegetation community capable of providing multiple ecosystem services. Urban forests with diverse vegetation composition generally exhibit greater ecological stability, enhanced carbon storage capacity, and improved resilience to environmental disturbances [67], [68]. Therefore, the species composition identified in this study highlights the ecological importance of Malvinas Urban Forest in supporting sustainable urban development in Padang City.

### 3.2. Vegetation Structure and Ecological Importance

Vegetation structure was evaluated using density, relative density, dominance, relative dominance, and Importance Value Index (IVI). The analysis revealed substantial variation in ecological importance among the recorded tree species. Mahogany (*Swietenia macrophylla*) exhibited the highest ecological importance, with a density value of 5.57 individuals $ha^{-1}$, relative density of 51.08%, dominance value of 118.92, relative dominance of 9.36%, and an IVI of 60.44. These results indicate that mahogany is the dominant species within Malvinas Urban Forest and serves as the primary structural component of the vegetation community. Its high abundance and dominance suggest strong adaptation to urban environmental conditions and a significant contribution to ecosystem functioning. *Tropical almond (Terminalia catappa)* ranked second in ecological importance with an IVI value of 37.56. Although its abundance was considerably lower than that of mahogany, its large basal area resulted in a relatively high dominance value (312.65) and relative dominance (24.61%). Similarly, *Pometia pinnata* exhibited an IVI value of 20.29, indicating a significant ecological contribution despite its lower abundance. The results of the vegetation analysis are presented in Table 2.

Table 2. Density, Relative Density, Relative Dominance, and Importance Value Index (IVI) of Tree Species in Malvinas Urban Forest

| No | Plant Species | Local Name | Individual | KR | FR | DR | INP |
|---|---|---|---|---|---|---|---|
| 1 | *Swietenia macrophylla* | Mahogany | 466 | 96.66 | 37.28 | 1.25684 | 80.08 |
| 2 | *Samanea saman* | Trembesi | 245 | 19.22 | 19.60 | 153538 | 27.01 |
| 3 | *Terminalia catappa* | Ketapang | 124 | 9.71 | 9.22 | 3939 | 18.85 |
| 4 | *Artocarpus heterophyllus* | Jackfruit | 69 | 5.41 | 5.62 | 12188 | 9.98 |
| 5 | *Hibiscus tiliaceus* | Waru | 53 | 4.16 | 4.24 | 16824 | 9.26 |
| 6 | *Tectona grandis* | Teak | 42 | 3.29 | 3.96 | 41220 | 7.25 |
| 7 | *Tamarindus indica* | Tamarind | 29 | 2.27 | 2.32 | 2106 | 3.74 |
| 8 | *Pterocarpus indicus* | Angsana | 25 | 1.96 | 2.00 | 27975 | 4.92 |
| 9 | *Spathodea campanulata* | Kiacret | 23 | 1.80 | 1.84 | 17412 | 3.06 |
| 10 | *Ficus benjamina* | Kalpataru | 21 | 1.65 | 1.68 | 27752 | 4.88 |
| 11 | *Fagraea fragrans* | Dadok Roda | 18 | 1.41 | 1.44 | 10730 | 1.89 |
| 12 | *Eugenia operculata* | Salam | 14 | 1.10 | 1.12 | 3017 | 0.53 |
| 13 | *Pellacalyx saccardianus* | Guava | 13 | 1.02 | 1.04 | 1010 | 0.18 |
| 14 | *Artocarpus heterophyllus* | Jackfruit | 12 | 0.94 | 0.96 | 1986 | 0.34 |
| 15 | *Syzygium aromaticum* | Water Apple | 9 | 0.71 | 0.72 | 4443 | 0.78 |
| 16 | *Mangifera indica* | Mango | 8 | 0.63 | 0.64 | 2101 | 0.37 |
| 17 | *Albizia chinensis* | Sengon | 8 | 0.63 | 0.64 | 331 | 0.05 |
| 18 | *Persea americana* | Avocado | 7 | 0.55 | 0.56 | 2201 | 0.37 |
| 19 | *Psidium guajava* | Guava | 6 | 0.47 | 0.48 | 1509 | 0.25 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | *Musa paradisiaca* | Banana | 6 | 0.47 | 0.48 | 1510 | 0.25 |
| 21 | *Cocos nucifera* | Coconut | 5 | 0.39 | 0.40 | 1302 | 0.21 |
| 22 | *Areca catechu* | Areca Nut | 5 | 0.39 | 0.40 | 987 | 0.16 |
| 23 | *Carica papaya* | Papaya | 4 | 0.31 | 0.32 | 550 | 0.09 |
| 24 | *Durio zibethinus* | Durian | 4 | 0.31 | 0.32 | 720 | 0.12 |
| 25 | *Toona sureni* | Surian | 4 | 0.31 | 0.32 | 885 | 0.16 |
| 26 | *Ficus elastica* | Rubber | 4 | 0.31 | 0.32 | 245 | 0.04 |
| 27 | *Aleurites moluccanus* | Candlenut | 3 | 0.24 | 0.24 | 180 | 0.03 |
| 28 | *Syzygium polyanthum* | Salam | 3 | 0.24 | 0.24 | 190 | 0.03 |
| 29 | *Leucaena leucocephala* | Leucaena | 2 | 0.16 | 0.16 | 120 | 0.02 |
| 30 | *Manilkara zapota* | Sapodilla | 2 | 0.16 | 0.16 | 175 | 0.03 |
| 31 | *Annona muricata* | Soursop | 2 | 0.16 | 0.16 | 150 | 0.02 |
| 32 | *Citrus aurantiifolia* | Lime | 2 | 0.16 | 0.16 | 145 | 0.02 |
| 33 | *Moringa oleifera* | Moringa | 1 | 0.08 | 0.08 | 70 | 0.01 |
| 34 | *Nephelium lappaceum* | Rambutan | 1 | 0.08 | 0.08 | 65 | 0.01 |

The Important Value Index (IVI) analysis showed that *Swietenia macrophylla* (mahogany) was the most dominant plant species in the Padang Lama forest area, with the highest number of individuals (466) and the highest IVI value (80.08). This indicates that the species plays a major ecological role in the vegetation structure of the study area. Other species with relatively high ecological importance were *Samanea saman* (27.01), *Terminalia catappa* (18.85), and *Artocarpus heterophyllus* (9.98), suggesting that these species also contribute substantially to forest composition and canopy structure. In contrast, most other plant species exhibited low IVI values, indicating lower abundance and ecological influence within the community. The dominance of a few species and the relatively low representation of many others suggest uneven vegetation distribution and possible anthropogenic influences on forest composition [69], [70]. Overall, the results demonstrate that the vegetation structure of Padang Lama forest is strongly dominated by several tree species with high adaptability and competitive capacity in the local environment. The vegetation structure of pole species is presented in Table 3.

Table 3. Data on the Number of Individuals, Relative Density, Relative Dominance, and Importance Value Index of Pole Categories in the Malvinas Padang City Forest

| No. | Scientific Name | Local Name | Individuals | Density (K) | Relative Density (KR) | Dominance (D) | Relative Dominance (DR) | IVI (INP) |
|---|---|---|---|---|---|---|---|---|
| 1 | *Swietenia macrophylla* | Mahogany | 71 | 5.57 | 51.08 | 118.92 | 9.36 | 60.44 |
| 2 | *Terminalia catappa* | Ketapang | 18 | 1.41 | 12.95 | 312.65 | 24.61 | 37.56 |
| 3 | *Syzygium oleina* | Red Shoot (*Pucuk Merah*) | 10 | 0.78 | 7.19 | 166.39 | 13.10 | 20.29 |
| 4 | *Pometia pinnata* | Matoa | 9 | 0.71 | 6.47 | 150.41 | 11.84 | 18.31 |
| 5 | *Laut albizia falcataria* | Sengon | 4 | 0.31 | 2.88 | 82.44 | 6.49 | 9.37 |
| 6 | *Annona muricata* | Soursop | 4 | 0.31 | 2.88 | 69.51 | 5.47 | 8.35 |
| 7 | *Annona muricata* | Soursop | 3 | 0.24 | 2.88 | 69.51 | 5.47 | 8.35 |
| 8 | *Pterocarpus indicus* | Angsana | 3 | 0.24 | 2.16 | 54.53 | 4.37 | 6.53 |
| 9 | *Psidium guajava* | Guava | 3 | 0.24 | 2.16 | 32.32 | 2.54 | 4.70 |
| 10 | *Theobroma cacao* | Cocoa | 3 | 0.24 | 2.16 | 60.97 | 4.80 | 6.96 |
| 11 | *Ficus exasperata* | Ampelas | 3 | 0.24 | 2.16 | 26.72 | 2.10 | 4.26 |
| 12 | *Hura crepitans* | Sandbox Tree | 2 | 0.16 | 1.44 | 44.58 | 3.51 | 4.95 |
| 13 | *Samanea saman* | Rain Tree | 1 | 0.08 | 0.72 | 17.79 | 1.40 | 2.12 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14 | *Ficus racemosa* | Cluster Fig | 1 | 0.08 | 0.72 | 17.79 | 1.40 | 2.12 |
| 15 | *Tectona grandis* | Teak | 1 | 0.08 | 0.72 | 0.25 | 0.02 | 0.74 |
| 16 | *Mangifera indica* | Mango | 1 | 0.08 | 0.72 | 19.95 | 1.57 | 2.29 |
| 17 | *Durio zibethinus* | Durian | 1 | 0.08 | 0.72 | 17.79 | 1.40 | 2.12 |
| 18 | *Toona sureni* | Surian | 1 | 0.08 | 0.72 | 22.23 | 1.75 | 2.47 |

Table 3 shows that the tree community in the study area is dominated by *Swietenia macrophylla* (mahogany), which recorded the highest Importance Value Index (IVI) of 60.44, indicating its strong ecological significance and dominance within the vegetation structure. This species also exhibited the highest density (K = 5.57) and relative density (KR = 51.08%), suggesting that more than half of the trees observed belonged to this species. The second most important species was *Terminalia catappa* (IVI = 37.56), which had the highest dominance value (D = 312.65) and relative dominance (DR = 24.61%), reflecting its relatively large tree size and substantial contribution to stand basal area. Other species such as *Syzygium oleina* and *Pometia pinnata* showed moderate ecological importance, with IVI values of 20.29 and 18.31, respectively. In contrast, species including *Tectona grandis*, *Ficus racemosa*, *Durio zibethinus*, and *Toona sureni* had very low IVI values (< 3), indicating limited abundance and ecological influence within the community. Overall, the vegetation structure appears to be unevenly distributed, with a few dominant species contributing most of the ecological importance, while the majority of species occur at relatively low densities and dominance levels.

The dominance of mahogany and tropical almond demonstrates that ecosystem functions within Malvinas Urban Forest are strongly influenced by a limited number of species. Dominant species generally contribute disproportionately to biomass accumulation, carbon storage, canopy formation, and environmental regulation. Consequently, maintaining the health and sustainability of these species is essential for preserving the ecological integrity of the urban forest [10], [71]. At the pole stage, mahogany remained the most dominant species with 71 individuals, followed by tropical almond with 18 individuals and red shoot (*Syzygium oleina*) with 10 individuals. This dominance pattern indicates ongoing regeneration processes and suggests that the urban forest possesses the capacity to maintain vegetation continuity and long-term ecological stability.

### 3.3. Vegetation Diversity Characteristics

The presence of 35 recorded species indicates a relatively rich vegetation composition. Although biodiversity indices were not calculated in this study, the observed species richness suggests that Malvinas Urban Forest supports a heterogeneous vegetation assemblage capable of providing multiple ecosystem services. The coexistence of numerous species with varying ecological characteristics enhances ecosystem functioning by supporting nutrient cycling, habitat provision, and environmental regulation [72], [73]. Although several species, particularly mahogany and rain tree, exhibited strong dominance, the occurrence of numerous additional species contributed to overall community heterogeneity. Such diversity is beneficial in urban ecosystems because it reduces ecological dependence on a limited number of species and enhances resistance to pests, diseases, and environmental disturbances. The diversity characteristics observed in this study indicate that Malvinas Urban Forest functions not only as urban green infrastructure but also as an important refuge for biodiversity conservation within the urban landscape. These findings support previous studies emphasizing that species-rich urban forests provide broader ecosystem services and contribute significantly to environmental sustainability.

### 3.4. Spatial Distribution Patterns of Vegetation

Spatial analysis using GPS coordinates and ArcGIS mapping revealed heterogeneous vegetation distribution patterns throughout Malvinas Urban Forest. Vegetation was distributed across the study area, although several locations exhibited higher concentrations of tree individuals than others. The generated spatial maps showed that tree vegetation dominated most parts of the urban forest, whereas pole-stage vegetation occurred in smaller clusters associated with regeneration zones. The observed clustering pattern was primarily associated with dominant species such as mahogany and tropical almond, which formed extensive canopy coverage throughout the study area.

Areas characterized by high vegetation density are likely to provide greater ecological benefits, including increased carbon storage, improved air pollutant interception, and enhanced microclimate regulation. Conversely, several areas displayed relatively low vegetation density and may therefore represent suitable locations for enrichment planting and ecological restoration [74], [75]. The integration of GIS technology with vegetation inventory data proved effective for identifying vegetation concentration zones and supporting evidence-based urban forest management. Distribution maps function to determine the distribution of natural resources in a region, so that it is not difficult to see the distribution, you can see it in map form.

Table 4. Tree Types, Number of Individuals, and Leaf Color in the Malvinas Padang City Forest

| No | Scientific Name | Local Name | Individual Tree | Color Description on Leaves |
|---|---|---|---|---|
| 1 | *Swietenia macrophylla* King | Mahogany | 466 | Orange |
| 2 | *Samanea saman* (Jacq.) Merr. | Trembesi | 245 | Dark purple |
| 3 | *Terminalia catappa* L. | Ketaping | 124 | Bottle green |
| 4 | *Albizia falcataria* (L.) Fosberg | Sengon | 69 | Pink |
| 5 | *Hibiscus tiliaceus* L. | Waru | 53 | Frosted yellow |
| 6 | *Tectona grandis* L.f. | Teak | 42 | Purple |
| 7 | *Theobroma cacao* L. | Chocolate | 29 | Green |
| 8 | *Averrhoa bilimbi* L. | Angsana | 25 | Dark turquoise |
| 9 | *Spathodea campanulata* P.Beauv. | Kiacret | 23 | Light turquoise |
| 10 | *Ficus racemosa* L. | Galapuang | 21 | Brown |
| 11 | *Hura crepitans* L. | Dadok Roda | 18 | Yellow |
| 12 | *Eugenia aperculata* Roxb. | Salam | 14 | Black |
| 13 | *Psidium guajava* L. | Guava | 13 | Dark blue |
| 14 | *Artocarpus heterophyllus* Lam. | Jackfruit | 12 | Yellow |
| 15 | *Spondias mombin* L. | Ambarella | 12 | Maroon red |
| 16 | *Syzygium aqueum* (Burm.f.) Alston | Water Apple | 9 | Orange |
| 17 | *Macaranga tanarius* (L.) Müll.Arg. | Mara | 8 | Moss green |
| 18 | *Averrhoa carambola* L. | Starfruit | 8 | Light orange |
| 19 | *Pinus merkusii* Jungh. & de Vriese | Pine | 7 | Dark green |
| 20 | *Pometia pinnata* J.R.Forst. & G.Forst. | Matoa | 6 | Red |
| 21 | *Nephelium lappaceum* L. | Bayur | 6 | Light blue |
| 22 | *Artocarpus communis* J.R.Forst. & G.Forst. | Breadfruit | 5 | Blue |
| 23 | *Mangifera indica* L. | Mango | 5 | Faded green |
| 24 | *Ceiba pentandra* (L.) Gaertn. | Kapok Randu | 4 | Dark purple |
| 25 | *Toona sureni* (Blume) Merr. | Surian | 4 | Blue |
| 26 | *Ficus exasperata* Vahl | Ampaslas | 4 | Pink |
| 27 | *Averrhoa bilimbi* L. | Starfruit | 3 | Tosca purple |
| 28 | *Nephelium lappaceum* L. | Rambutan | 2 | Green |
| 29 | *Annona muricata* L. | Soursop | 2 | Light purple |
| 30 | *Garcinia mangostana* L. | Mangosteen | 2 | Tosca purple |
| 31 | *Leucaena leucocephala* (Lam.) de Wit | Chinese Stink Bean | 2 | Cream |
| 32 | *Muntingia calabura* L. | Seri | 2 | Tosca |
| 33 | *Ficus benjamina* L. | Banyan | 1 | Light turquoise |

Based on Table 4, it is known that the vegetation that makes up the Malvinas Padang City Forest has a variety of individual numbers and leaf color characteristics. The mahogany (*Swietenia macrophylla* King) is the vegetation with the highest number of individuals at 466 individuals, followed by the rain tree (*Samanea saman* (Jacq.) Merr.) with 245 individuals and the ketapang (*Terminalia catappa* L.) with 124 individuals. The variety of leaf colors found, such as dark green, moss green, purple, red, and orange, indicates the high morphological diversity of vegetation in the city forest area. This diversity of leaf colors plays a role in increasing the aesthetic value of the area while supporting ecological functions through the process of photosynthesis, carbon dioxide absorption, and filtering air pollutants. The dominance of large woody tree species with a high number of individuals indicates that the Malvinas Padang City Forest has good potential in supporting environmental quality and the balance of the urban ecosystem.

Table 5. Types of Poles, Number of Individuals, and Leaf Color in the Malvinas Padang City Forest

| No | Scientific Name | Local Name | Pole Individual | Color Description in Legend |
|---|---|---|---|---|
| 1 | *Swietenia macrophylla* King | Mahogany | 71 | Brown |
| 2 | *Terminalia catappa* L. | Ketaping | 18 | Blue |
| 3 | *Syzygium oleina* (Blume) DC. | Red Shoot | 10 | Yellow |
| 4 | *Pometia pinnata* J.R.Forst. & G.Forst. | Matoa | 9 | Dark Green |
| 5 | *Albizia falcataria* (L.) Fosberg | Sengon | 4 | Bottle Green |
| 6 | *Annona muricata* L. | Soursop | 4 | Dark Green |

| | | | | |
|---|---|---|---|---|
| 7 | *Spathodea campanulata* P.Beauv. | Kiacret | 3 | Pink |
| 8 | *Pterocarpus indicus* Willd. | Angsana | 3 | Salmon Pink |
| 9 | *Psidium guajava* L. | Guava | 3 | Green |
| 10 | *Theobroma cacao* L. | Chocolate | 3 | Milo Brown |
| 11 | *Ficus exasperata* Vahl | Sandpaper | 3 | Highlighter Green |
| 12 | *Hura crepitans* L. | Dadok Wheel | 2 | Tosca Blue |
| 13 | *Samanea saman* (Jacq.) Merr. | Trembesi | 1 | Maroon Red |
| 14 | *Ficus racemosa* L. | Galapuang | 1 | Mocha Brown |
| 15 | *Tectona grandis* L.f. | Teak | 1 | Cream |
| 16 | *Mangifera indica* L. | Mango | 1 | Dusty Pink |
| 17 | *Durio zibethinus* Murray | Durian | 1 | Black |
| 18 | *Toona sureni* (Blume) Merr. | Surian | 1 | Brown |

Based on Table 5, it is known that the pole-level vegetation in the Malvinas Padang City Forest consists of 18 species with varying numbers of individuals in each species. The mahogany species (*Swietenia macrophylla* King) has the highest number of individuals at 71 individuals, followed by the ketapang (*Terminalia catappa* L.) with 18 individuals and the red shoot (*Syzygium oleina* (Blume) DC.) with 10 individuals. The dominance of several species indicates that the vegetation regeneration process in the urban forest area is still going well, especially in tree species that have high adaptability to the urban environment [31], [76]. The variation in leaf color in the pole-level vegetation also indicates the diversity of vegetation morphology that can increase the aesthetic value and ecological function of the urban forest area. The existence of this pole-level vegetation plays an important role in maintaining the sustainability of the stand structure and supporting the ecological function of the Malvinas Padang City Forest as an absorber of pollutants and controller of urban environmental quality.

### 3.5. Ecological Functions of Dominant Species

The ecological function assessment demonstrated that several dominant tree species possess substantial potential for environmental quality improvement through carbon sequestration and air pollution mitigation. Previous studies have reported that rain tree (*Samanea saman*) exhibits one of the highest carbon dioxide absorption capacities among urban tree species, reaching approximately 28,488.39 kg $CO_2$ tree$^{-1}$ year$^{-1}$. Other species with considerable carbon sequestration potential include weeping fig (*Ficus benjamina*), matoa (*Pometia pinnata*), mahogany (*Swietenia macrophylla*), teak (*Tectona grandis*), jackfruit (*Artocarpus heterophyllus*), soursop (*Annona muricata*), narra (*Pterocarpus indicus*), and rambutan (*Nephelium lappaceum*). The carbon dioxide absorption capacity of dominant species is presented in Table 6.

Table 6. Tree Absorption Capacity in Absorbing $CO_2$

| No | Scientific Name | Local Name | $CO_2$ Absorption Capacity (kg/tree/year) |
|---|---|---|---|
| 1 | *Samanea saman* (Jacq.) Merr. | Rain Tree | 28.488,39 |
| 2 | *Ficus benjamina* L. | Banyan Tree | 535,90 |
| 3 | *Pometia pinnata* J.R.Forst. & G.Forst. | Matoa Tree | 329,76 |
| 4 | *Swietenia mahagoni* (L.) Jacq. | Mahogany Tree | 295,73 |
| 5 | *Lagerstroemia speciosa* (L.) Pers. | Bayur Tree | 160,14 |
| 6 | *Tectona grandis* L.f. | Teak Tree | 135,27 |
| 7 | *Artocarpus heterophyllus* Lam. | Jackfruit | 126,51 |
| 8 | *Annona muricata* L. | Soursop Tree | 75,29 |
| 9 | *Pterocarpus indicus* Willd. | Angsana Tree | 11,12 |
| 10 | *Nephelium lappaceum* L. | Rambutan Tree | 2,19 |

Based on Table 6, it is known that several types of vegetation in the Malvinas Padang City Forest have different abilities in absorbing carbon dioxide ($CO_2$). The rain tree (*Samanea saman* (Jacq.) Merr.) shows the highest carbon dioxide absorption capacity compared to other types, which is 28,488.39 kg/tree/year, so it has great potential in supporting carbon emission reduction in urban areas. In addition to rain trees, banyan (*Ficus benjamina* L.), matoa (*Pometia pinnata* J.R.Forst. & G.Forst.), and mahogany (*Swietenia mahagoni* (L.) Jacq.) also have quite high carbon absorption capacity. Differences in carbon absorption capacity in each type of vegetation are influenced by the size of the canopy, trunk diameter, growth rate, and leaf surface area of each tree [77], [78]. The existence of these types of vegetation indicates that the Malvinas Padang City Forest has important ecological potential as a provider of ecosystem services in improving air quality and supporting mitigation of urban environmental pollution.

The dominance of mahogany and rain tree within the study area suggests that Malvinas Urban Forest contributes significantly to carbon storage and atmospheric pollution reduction. Large-canopy species are particularly effective in intercepting airborne particulates, reducing ambient temperatures through shading and evapotranspiration, and improving urban microclimatic conditions. These ecological functions are increasingly important in rapidly urbanizing cities where vegetation serves as a natural mechanism for mitigating environmental degradation. The multifunctional ecological roles of dominant species reinforce the importance of urban forests as green infrastructure that supports climate change mitigation, environmental sustainability, and human well-being.

### 3.6. Implications for Sustainable Urban Forest Management

The findings of this study demonstrate that Malvinas Urban Forest possesses considerable ecological value as a provider of ecosystem services and environmental benefits. Species with high IVI values, particularly mahogany and tropical almond, should be prioritized in conservation and maintenance programs because of their substantial contribution to vegetation structure and ecosystem functioning. At the same time, management strategies should promote greater species diversity to enhance ecosystem resilience and reduce dependence on a limited number of dominant species. Areas identified as having lower vegetation density should be considered for enrichment planting and restoration initiatives to improve ecological connectivity and ecosystem service provision. The integration of vegetation inventory, ecological analysis, and GIS-based spatial assessment provides a comprehensive framework for evidence-based urban forest management. Such an approach can assist local governments in developing sustainable urban greening policies and maximizing the contribution of urban forests to environmental quality improvement, pollution mitigation, and sustainable urban development in Padang City.

The dominance of several tree species within Malvinas Urban Forest reflects the adaptive capacity of particular species to urban environmental conditions. Urban ecosystems are frequently characterized by environmental stressors such as soil compaction, elevated temperatures, air pollution, and limited water availability. Species that become dominant in urban forests generally possess physiological and morphological traits that enable them to tolerate these disturbances more effectively than other species. The prevalence of large-canopy species suggests that urban forest development in the study area has been influenced by both ecological suitability and management practices aimed at maximizing environmental benefits. Similar patterns have been reported in tropical urban forests, where a limited number of well-adapted species often contribute disproportionately to ecosystem functioning and vegetation structure.

The vegetation structure observed in this study highlights the important role of dominant species in maintaining ecosystem processes within urban landscapes. According to urban forest ecology theory, species with high ecological importance values contribute significantly to biomass accumulation, nutrient cycling, microclimate regulation, and habitat provision [11], [61]. Their dominance often determines the overall capacity of urban forests to deliver ecosystem services. However, reliance on a limited number of dominant species may increase ecological vulnerability to pests, diseases, and environmental disturbances. Therefore, while dominant species provide substantial ecological benefits, maintaining species diversity remains essential for ensuring long-term ecosystem stability and resilience.

From a spatial ecology perspective, the distribution of vegetation across the urban forest demonstrates how ecosystem services may be distributed unevenly throughout the landscape. Areas characterized by higher vegetation concentrations are likely to generate greater ecological benefits, including carbon sequestration, temperature moderation, and air pollution interception [13], [79]. Conversely, areas with lower vegetation density may contribute less effectively to environmental regulation and could become priorities for future restoration and enrichment planting programs. The use of GIS-based mapping in this study provides valuable spatial information that can support evidence-based urban forest planning by identifying locations where ecological functions can be enhanced through targeted management interventions.

The ecological significance of urban forests extends beyond biodiversity conservation to include their contribution to climate change mitigation and urban environmental quality [80], [81]. Large-canopy tree species are widely recognized for their ability to absorb atmospheric carbon dioxide, intercept particulate pollutants, and reduce urban heat accumulation through shading and evapotranspiration processes. These functions are increasingly important in rapidly urbanizing cities where environmental degradation and climate-related risks continue to intensify. Consequently, urban forests should be viewed not merely as aesthetic landscape elements but as essential green infrastructure that supports environmental sustainability and public well-being.

The findings of this study also support the ecosystem services framework, which emphasizes the direct and indirect benefits that natural ecosystems provide to human societies. Urban forest vegetation contributes regulating services through carbon storage, air quality improvement, and microclimate regulation, while simultaneously providing supporting services related to biodiversity conservation and ecological connectivity [61], [82]. Integrating ecosystem service considerations into urban planning can help decision-makers recognize the economic and environmental value of urban forests, thereby encouraging greater investment in conservation, restoration, and sustainable management initiatives.

From a sustainable urban development perspective, the results indicate that effective urban forest management should balance the conservation of ecologically important species with efforts to enhance vegetation diversity. Conservation strategies focusing solely on dominant species may maximize short-term ecosystem service provision but could reduce long-term ecological resilience [83]. Therefore, management programs should encourage species diversification, regeneration monitoring, and habitat enhancement to strengthen ecosystem stability under future environmental change. Such an approach aligns with the principles of sustainable urban planning and contributes to achieving broader environmental objectives, including climate adaptation, biodiversity conservation, and improved urban livability.

The findings of this study are consistent with previous research highlighting the ecological importance of urban forests in improving environmental quality and supporting sustainable urban development. Numerous studies have reported that vegetation composition and species dominance strongly influence the capacity of urban forests to provide ecosystem services, including carbon sequestration, air pollution mitigation, and microclimate regulation [84], [85]. Similar to the present study, dominant tree species in tropical urban forests often contribute disproportionately to ecosystem functioning because of their larger biomass, extensive canopy cover, and greater environmental adaptability. These findings reinforce the view that species composition is a critical determinant of ecosystem service provision in urban green spaces.

Furthermore, previous studies have demonstrated that integrating vegetation inventories with spatial analysis provides valuable information for urban forest management and conservation planning [86], [87]. GIS-based approaches have been widely recognized as effective tools for identifying vegetation distribution patterns, ecological hotspots, and areas requiring restoration interventions. The present study extends these findings by combining vegetation structure assessment with spatial distribution mapping and ecosystem service evaluation within a single analytical framework. This integrated perspective contributes to a more comprehensive understanding of how urban forest vegetation supports environmental sustainability in tropical urban environments.

The results also support the ecosystem services theory, which emphasizes that urban vegetation generates multiple environmental benefits that contribute directly to human well-being. Dominant species identified in this study possess ecological characteristics associated with high carbon sequestration potential and environmental regulation capacity [77], [88]. Similar conclusions have been reported in studies conducted in other tropical cities, where large-canopy species play a significant role in reducing atmospheric carbon concentrations, improving air quality, and mitigating urban heat island effects. Therefore, the ecological functions observed in Malvinas Urban Forest reflect broader patterns of ecosystem service provision commonly reported in urban forestry research.

This study provides important theoretical, practical, and policy contributions to the field of urban forestry and sustainable urban development. Theoretically, the research enriches the understanding of vegetation structure, species dominance, and ecosystem service provision within tropical urban forest ecosystems. The integration of vegetation inventory, ecological importance assessment, and spatial analysis offers a comprehensive framework for evaluating urban forest performance beyond traditional biodiversity inventories. Practically, the findings provide baseline information that can support evidence-based urban forest management in Padang City. Knowledge regarding dominant species, vegetation distribution patterns, and ecological functions can assist urban planners and environmental managers in prioritizing conservation activities, enrichment planting programs, and ecological restoration initiatives. Such information is particularly valuable for maintaining ecosystem services that contribute to air quality improvement, climate regulation, and urban environmental resilience.

From a policy perspective, this study highlights the strategic role of urban forests as green infrastructure supporting sustainable cities. The results suggest that urban forest management should not only focus on preserving existing vegetation but also on enhancing species diversity and ecological connectivity. Strengthening urban forest conservation policies can contribute to climate change mitigation, biodiversity conservation, and the achievement of Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 15 (Life on Land). Several limitations should be considered when interpreting the findings of this study. The assessment of ecological functions was based primarily on documented carbon sequestration and pollution mitigation capacities reported in previous studies rather than direct field measurements of carbon stocks, biomass accumulation, or air quality improvements. Consequently, the ecological contributions identified in this study represent potential ecosystem service values rather than site-specific quantitative estimates.

## 4. CONCLUSION

This study demonstrated that Malvinas Urban Forest plays an important ecological role in supporting environmental quality and urban sustainability in Padang City. The vegetation inventory recorded 35 species comprising 1,389 individuals, consisting of 1,250 trees and 139 poles, indicating a relatively diverse urban forest ecosystem. Vegetation structure analysis revealed that *Swietenia macrophylla* was the dominant species, exhibiting the highest density, relative density, dominance, and Importance Value Index, followed by *Terminalia catappa* and *Pometia pinnata*. These dominant species contribute substantially to stand structure and ecosystem functioning within the urban forest.

Spatial analysis showed that vegetation was distributed throughout the study area, although several zones exhibited higher concentrations of dominant species, particularly mahogany and tropical almond. The distribution patterns identified through GIS mapping provide valuable information for urban forest planning, monitoring, and restoration initiatives. Furthermore, the ecological function assessment indicated that several dominant species possess considerable carbon sequestration potential and contribute to air pollution mitigation, temperature regulation, and environmental improvement. Species such as *Samanea saman*, *Swietenia macrophylla*, and *Pometia pinnata* were identified as important contributors to ecosystem service provision.

Theoretically, this study contributes to the understanding of vegetation structure, species dominance, and ecosystem service provision in tropical urban forests. Practically, the findings provide scientific evidence to support urban forest management and conservation strategies in rapidly developing cities. From a policy perspective, local governments should prioritize the conservation of dominant species with high ecological value while promoting species diversification to enhance ecosystem resilience and long-term sustainability. Future research should incorporate comprehensive biodiversity indices, carbon stock estimation, and long-term monitoring to better evaluate the ecological dynamics and ecosystem service contributions of urban forests in supporting sustainable urban development. Future studies should incorporate direct measurements of carbon stocks, biomass accumulation, air pollutant removal, and microclimatic regulation to provide more accurate estimates of ecosystem service provision by urban forest vegetation.

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## AUTHOR CONTRIBUTIONS

Conceptualization, R.A. and J.A.; Methodology, R.A. and D.T.T.T.; Software, R.A.; Validation, J.A., D.T.T.T., and D.N.; Formal Analysis, R.A. and J.A.; Investigation, R.A.; Resources, J.A. and D.N.; Data Curation, R.A.; Writing – Original Draft Preparation, R.A.; Writing – Review & Editing, J.A., D.T.T.T., and D.N.; Visualization, R.A.; Supervision, J.A. and D.N.; Project Administration, R.A.; Funding Acquisition, J.A.

## CONFLICTS OF INTEREST

The authors declare no conflict of interest.

## USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

Not applicable.

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