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Floristic Composition, Vegetation Structure, and Diversity of Urban Home Gardens in Makassar, Indonesia

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Abstract. *Urban home gardens play an important role in supporting biodiversity conservation within urban landscapes. However, information on the floristic composition and vegetation structure of urban home gardens in Indonesian cities remains limited. This study assessed plant diversity, vegetation structure, and alpha diversity of urban home gardens in Makassar, South Sulawesi, Indonesia. Field surveys were conducted in 24 home gardens selected using purposive sampling. All plant species were identified and classified into lower, middle, and upper vegetation strata. Species richness, family composition, and diversity indices were subsequently analyzed. A total of 190 plant species belonging to 65 families and 2,527 individuals were recorded. Araceae and Asparagaceae were the most species-rich families. The middle stratum contained the highest proportion of species (42.1%), followed by the upper (29.5%) and lower strata (28.4%). Mean species richness was 12.8 ± 3.6 species per garden, while Shannon–Wiener diversity, Simpson diversity, and evenness indices were 2.0 ± 0.49, 0.80 ± 0.13, and 0.60 ± 0.18, respectively. These findings demonstrate that urban home gardens in Makassar maintain considerable plant diversity and a multi-layered vegetation structure despite ongoing urbanization. Urban home gardens therefore represent important components of urban green infrastructure and biodiversity conservation.*

Keywords: *Alpha diversity, Home gardens, Plant diversity, Urban biodiversity, Vegetation structure.*

1. Introduction

Urbanization has accelerated rapidly worldwide, particularly in developing countries, resulting in substantial changes to land use and urban landscapes. The expansion of built-up areas often leads to habitat fragmentation, loss of vegetation cover, and declining biodiversity, thereby reducing the ecological integrity of urban ecosystems (Goddard et al., 2010; Lepczyk et al., 2017). Despite these pressures, urban green spaces have emerged as critical components of sustainable cities because they support biodiversity conservation, maintain ecosystem functions, and enhance environmental quality and human well-being (Lepczyk et al., 2017). Urban green spaces provide important ecological services, including microclimate regulation, carbon sequestration, stormwater management, and habitat provision for diverse organisms (Zhao et al., 2022). While public green spaces such as parks and urban forests are widely recognized for their ecological value, private green spaces, particularly home gardens, also contribute substantially to urban biodiversity conservation (Goddard et al., 2010). Collectively, home gardens constitute an important component of urban green infrastructure and can serve as refuges for plant diversity within highly

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modified urban environments. Consequently, conserving and promoting urban home gardens is increasingly recognized as an important strategy for supporting sustainable cities, biodiversity conservation, and resilient urban ecosystems.Therefore, understanding the role of home gardens in maintaining urban biodiversity has become increasingly important in rapidly growing cities.

Home gardens are widely recognized as multifunctional agroecosystems that provide a range of ecological, economic, and social benefits to urban households. Besides supplying food, medicinal plants, spices, fruits, and ornamental species, home gardens contribute to household well-being and environmental sustainability (Kumar & Nair, 2004; Galluzzi et al., 2010). Despite their relatively small size, home gardens often harbor high levels of plant diversity, making them important reservoirs of biodiversity in both rural and urban landscapes (Caballero-Serrano et al., 2016). By maintaining a mixture of cultivated, semi-cultivated, and occasionally native plant species, home gardens can function as refuges for plant genetic resources and support the conservation of local biodiversity (Galluzzi et al., 2010). Furthermore, the spatial distribution of home gardens across urban areas may enhance habitat connectivity and ecological resilience by providing stepping stones for various organisms within fragmented landscapes (Goddard et al., 2010). The vegetation structure of home gardens is also typically characterized by multiple vertical strata, including ground-cover species, shrubs, and trees, which create diverse ecological niches and contribute to the complexity and stability of urban ecosystems (Kumar & Nair, 2004).

The biodiversity value of home gardens has been extensively documented in tropical and subtropical regions, where these systems are recognized as important reservoirs of plant diversity and ecosystem services (Kumar & Nair, 2004; Galluzzi et al., 2010). Previous studies have reported that home gardens can support a rich assemblage of cultivated and semi-cultivated plant species while contributing to biodiversity conservation and livelihood sustainability (Caballero-Serrano et al., 2016; Das & Das, 2005). However, much of the existing research has focused on rural home gardens, traditional agroforestry systems, or food-oriented production landscapes. Quantitative baseline information on species composition, vegetation stratification, and alpha diversity of urban home gardens in eastern Indonesian cities remains largely unavailable, limiting evidence-based urban biodiversity planning. Comparatively, studies examining the floristic composition, vegetation structure, and diversity of urban home gardens remain limited, particularly in developing countries. In Indonesia, research on urban biodiversity has primarily concentrated on public green spaces, urban forests, and city parks, whereas information regarding the plant diversity and structural characteristics of urban home gardens is still relatively scarce. This knowledge gap is particularly evident in Makassar, one of the largest and fastest-growing cities in eastern Indonesia, where comprehensive data on plant species composition, diversity patterns, and vertical vegetation stratification in urban home gardens are largely unavailable.

Makassar is one of the largest and fastest-growing cities in eastern Indonesia, serving as a major center of economic activity, trade, education, and urban development. Despite rapid urban expansion, little information is available regarding how residential home gardens contribute to maintaining urban biodiversity in Makassar. Rapid population growth and urban expansion have resulted in substantial land-use transformation and increasing pressure on urban ecosystems (Surya et al., 2020). Such urban development may alter the composition and structure of vegetation within residential landscapes, potentially affecting

the ecological functions and biodiversity value of urban green spaces (Aronson et al., 2017; Lepczyk et al., 2017). Consequently, understanding plant diversity and vegetation stratification in urban home gardens is essential for supporting urban biodiversity conservation and sustainable urban greening initiatives. In addition, comprehensive information on the floristic composition and structural characteristics of home gardens can provide valuable baseline data for future urban ecological planning and biodiversity management (Goddard et al., 2010). Therefore, this study aimed to assess the floristic composition, vegetation structure, and alpha diversity of urban home gardens in Makassar, Indonesia. Unlike previous studies that have primarily focused on rural home gardens, traditional agroforestry systems, or public urban green spaces, this study provides the first comprehensive assessment of floristic composition, vegetation structure, and alpha diversity of urban home gardens in Makassar, Indonesia. The findings establish essential baseline information for understanding the contribution of residential green spaces to urban biodiversity conservation and sustainable urban planning.

2. Methods

2.1. Research Location

The study was conducted in Makassar, South Sulawesi Province, Indonesia (Figure 1). Makassar is located on the southwestern coast of Sulawesi Island and is recognized as one of the largest urban centers in eastern Indonesia. The city covers an area of approximately 175.77 km² and had a population of about 1.46 million inhabitants in 2024, resulting in a relatively high population density compared with other municipalities in South Sulawesi. Rapid urban growth and land-use transformation have contributed to increasing pressure on urban green spaces and residential vegetation. The city experiences a tropical monsoon climate characterized by distinct wet and dry seasons throughout the year (Yafendi et al., 2024).

Rapid urban development in Makassar has altered land-use patterns and reduced the availability of vegetated spaces in several parts of the city. Urban expansion may influence the composition and structure of urban vegetation, making home gardens increasingly important as small-scale green spaces that contribute to biodiversity conservation within residential environments (Surya et al., 2020). Twenty-four urban home gardens were selected using purposive sampling based on accessibility, owner permission, and the presence of cultivated vegetation. The selected gardens were distributed across different residential areas of Makassar to capture variation in plant composition and vegetation structure within the urban landscape. These home gardens were surveyed to document plant species composition, vegetation structure, and diversity. Field surveys and vegetation inventories were conducted at Mei 2026.

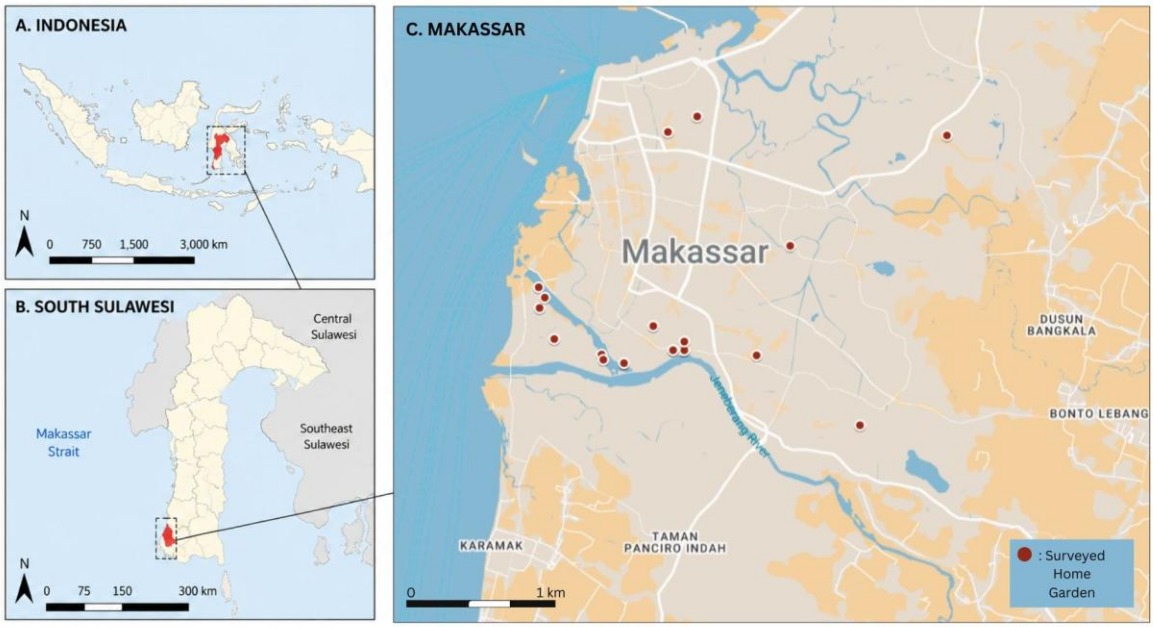

Figure 1. Study area showing the location of Makassar within South Sulawesi and Indonesia, and the spatial distribution of the surveyed home gardens.

2.2. Vegetation Sampling and Plant Identification

A total of 24 urban home gardens distributed across different residential areas of Makassar were selected using purposive sampling based on accessibility, homeowner consent, and the presence of cultivated vegetation. Vegetation surveys were conducted through direct field observation, during which all vascular plant species occurring within each home garden were recorded. For each species, the number of individuals was counted and documented to determine species abundance. Plant species were identified based on their morphological characteristics using regional floras, taxonomic references, and online plant databases. Scientific names and taxonomic classifications were verified and standardized using Plants of the World Online (POWO) https://powo.science.kew.org/ and World Flora Online (WFO) http://www.worldfloraonline.org.

Each recorded species was further classified into one of three vegetation strata according to its predominant growth form and vertical position within the home garden vegetation. The lower stratum consisted of ground-cover and herbaceous species, the middle stratum included shrubs, ornamental plants, and climbing species, whereas the upper stratum comprised trees and tree-like species forming the upper vegetation layer. This classification followed the general concept of vertical stratification commonly observed in tropical home gardens and agroforestry systems (Kumar & Nair, 2004; Caballero-Serrano et al., 2016).

2.3. Analysis Data

Species richness was determined as the total number of plant species recorded in each home garden. Species abundance was calculated as the total number of individual plants observed within each sampling site. Descriptive analyses were used to summarize floristic composition, including the total number of species, families, and individuals recorded across all surveyed home gardens. The relative contribution of vegetation strata

was evaluated by calculating the number and percentage of species occurring in the lower, middle, and upper strata. Plant families were ranked according to the number of species represented within each family to identify the most species-rich families in urban home gardens. Alpha diversity was assessed for each home garden using species richness (S), the Shannon Wiener diversity index (H′), Simpson diversity index (1 − D), and Pielou's evenness index. Mean values and standard deviations were calculated for all diversity indices across the surveyed home gardens. Diversity analyses were performed using PAST version 4.03 (Hammer et al., 2001).

3. Results and Discussion

3.1. Results

3.1.1. Floristic Composition and Structure

A total of 190 plant species belonging to 65 families were recorded from 24 urban home gardens surveyed in Makassar (Table 1). The inventory documented 2.527 individual plants, indicating a considerable diversity of cultivated vegetation within residential landscapes. Species richness averaged 12.8 ± 3.6 species per garden, while the mean abundance reached 105.2 ± 73.3 individuals per garden. The species with the highest species richness in urban home gardens in Makassar are *Cordyline fruticosa* L., *Polygonum aviculare* L., and *Mangifera indica*, which are not only ornamental plants but also fruit-bearing plants. Meanwhile, the plants with the highest abundance were *Cyperus rotundus* dan *Polygonum aviculare L.* which belong to the lower stratum. The relatively high number of recorded species compared with the number of families suggests that urban home gardens in Makassar support a diverse assemblage of ornamental, food, medicinal, and other cultivated plants. On average, each home garden contained approximately 13 plant species, although the number of individuals varied substantially among sampling sites. These findings indicate that urban home gardens constitute important components of residential green spaces and contribute to maintaining plant diversity within the urban environment.

Table 1. General characteristics of surveyed urban home gardens in Makassar, Indonesia.

Variable	Value
Number of home gardens	24
Number of plant species	190
Number of families	65
Total individuals	2527
Mean species richness per garden	12.8 ± 3.6
Mean abundance per garden	105.2 ± 73.3

Table 2 presents the ten most species-rich plant families recorded in urban home gardens of Makassar. Among the 65 families documented, Araceae was the most represented family with 16 species, followed by Asparagaceae with 14 species. *Euphorbiaceae* and *Poaceae* each contributed 11 species, whereas *Acanthaceae*, *Araliaceae*, and *Asteraceae* were represented by six species each. *Amaranthaceae*, *Apocynaceae*, and *Bromeliaceae* completed the list of the ten most species-rich families, with five species each.

Table 2. Most species-rich plant families recorded in urban home gardens of Makassar.

No	Family	Number of Species
1	*Araceae*	16
2	*Asparagaceae*	14
3	*Euphorbiaceae*	11
4	*Poaceae*	11
5	*Acanthaceae*	6
6	*Araliaceae*	6
7	*Asteraceae*	6
8	*Amaranthaceae*	5
9	*Apocynaceae*	5
10	*Bromeliaceae*	5

The dominance of *Araceae* and *Asparagaceae* indicates the prominence of ornamental foliage plants in urban home gardens. Several species belonging to these families, including members of Anthurium, Philodendron, Monstera, Aglaonema, Dracaena, and Cordyline, were frequently encountered during the survey. In addition to ornamental plants, the presence of *Poaceae*, *Euphorbiaceae*, and *Asteraceae* reflects the incorporation of food crops, medicinal plants, and multipurpose species within residential gardens, contributing to the overall floristic diversity observed in the study area.

The distribution of plant species among vegetation strata is presented in Table 3. Of the 190 species recorded, the middle stratum contained the highest number of species, comprising 80 species (42.1%). The upper stratum was represented by 56 species (29.5%), while the lower stratum included 54 species (28.4%). These results indicate that species richness was unevenly distributed across the three vegetation layers.

The predominance of species in the middle stratum suggests that shrubs, ornamental plants, and climbing species constitute a major component of urban home garden vegetation in Makassar. In contrast, the lower and upper strata contributed relatively similar proportions of species. The presence of species across all three strata reflects the multilayered vegetation structure commonly observed in tropical home gardens, where herbaceous plants, shrubs, and trees coexist within limited residential spaces.

Table 3. Distribution of plant species among vegetation strata in urban home gardens of Makassar.

Strata	Number of Species	Percentage
Lower	54	28.4
Middle	80	42.1
Upper	56	29.5

3.1.2. Alpha diversity of urban home gardens

The alpha diversity indices of urban home gardens in Makassar are presented in Table 4. The surveyed home gardens exhibited a mean species richness of 12.8 ± 3.6 species per garden. A total of 190 plant species belonging to 65 families were documented across all sampling sites, indicating a diverse assemblage of cultivated vegetation within the urban residential landscape.

Table 4. Alpha diversity indices of urban home gardens in Makassar

Diversity Index	Mean ± SD
Species richness (S)	12.8 ± 3.68
Shannon-Wiener (H')	2 ± 0.49
Simpson (1-D)	0.8 ± 0.13
Evenness (e^H/S)	0.6 ± 0.18

The mean Shannon–Wiener diversity index (H′) was 2.0 ± 0.49, suggesting a moderate level of species diversity among the surveyed home gardens. Similarly, the Simpson diversity index (1 − D) averaged 0.80 ± 0.13, indicating that the plant communities were composed of multiple species rather than being dominated by only a few taxa. These values demonstrate that urban home gardens support relatively diverse plant assemblages despite their limited spatial extent.

The mean evenness value (e^H/S) was 0.60 ± 0.18, indicating a moderate distribution of individuals among species. The observed variation in species richness, abundance, and diversity indices among home gardens suggests differences in vegetation composition and plant management practices across sampling sites. Overall, the diversity indices reveal that urban home gardens contribute substantially to maintaining plant diversity within the urban environment of Makassar.

3.2. Discussion

3.2.1. Floristic Composition of Urban Home Gardens

The present study documented 190 plant species belonging to 65 families across 24 urban home gardens in Makassar. This finding confirms that home gardens function as important reservoirs of plant biodiversity, even within densely populated urban environments. Similar studies have reported that home gardens commonly harbor a high diversity of cultivated species because they combine ornamental, food, medicinal, and multipurpose plants within relatively small areas (Galluzzi et al., 2010; Korpelainen & Pirttilä, 2023). The high species richness recorded in Makassar suggests that urban residents actively maintain diverse plant assemblages, thereby contributing to biodiversity conservation at the household level.

The 190 species recorded in Makassar indicate that urban home gardens support substantial plant diversity. The presence of 65 plant families suggests that these gardens fulfill multiple functions, not only ornamental, food but also medicinal, and environmental purposes. Similar observations have been reported from home gardens in Pujon, where plant diversity was closely associated with household needs and multifunctional garden management (Agustina et al., 2024). Such multifunctionality is a characteristic feature of tropical home gardens and contributes significantly to biodiversity conservation at the household scale (Kumar & Nair, 2004; Galluzzi et al., 2010).

Among the recorded families, *Araceae* and *Asparagaceae* were the most species-rich, followed by *Euphorbiaceae* and *Poaceae*. The predominance of *Araceae* and Asparagaceae is likely associated with the increasing popularity of ornamental foliage plants in urban residential landscapes. Species belonging to Anthurium, Philodendron, Monstera, Aglaonema, Dracaena, and Cordyline are widely cultivated because of their aesthetic value, adaptability to limited spaces, and relatively simple maintenance requirements. Similar observations have been reported in urban and peri-urban home gardens where ornamental

plants constitute a substantial proportion of the recorded flora (Marco et al., 2010; Caballero-Serrano et al., 2016).

The occurrence of *Poaceae*, *Euphorbiaceae*, and *Asteraceae* further indicates that urban home gardens in Makassar serve functions beyond ornamental purposes. These families include species utilized for food production, medicinal applications, and household needs, reflecting the multifunctional nature of home gardens as urban agroecosystems. Previous studies have emphasized that home gardens often integrate ecological, economic, and socio-cultural functions, thereby supporting both biodiversity conservation and household well-being (Kumar & Nair, 2004; Santos et al., 2022). The coexistence of ornamental and utilitarian plant species observed in this study highlights the role of urban home gardens as important components of urban green infrastructure and biodiversity conservation in rapidly developing cities.

The high floristic richness observed in Makassar may also be associated with the rapid urban expansion of the city. As one of the major urban centers in eastern Indonesia, Makassar has experienced substantial population growth and land-use transformation over recent decades (Surya et al., 2020). In such rapidly urbanizing environments, home gardens may function as important green spaces that maintain plant diversity within residential areas and partially compensate for the loss of natural vegetation associated with urban development.

3.2.2. Vegetation Structure and Stratification

The vegetation structure of urban home gardens in Makassar was characterized by the presence of lower, middle, and upper strata. The middle stratum contained the highest proportion of species (42.1%), followed by the upper (29.5%) and lower strata (28.4%). This pattern indicates the prominent role of shrubs and small trees in shaping the vertical structure of urban home gardens. A similar multi-layered vegetation structure has been reported in home gardens of Pujon Sub-district, East Java, where vegetation was organized into herbaceous, shrub, and tree strata that collectively formed a complex vertical arrangement (Agustina et al., 2024). Multi-strata vegetation is widely recognized as a defining characteristic of tropical home gardens because it promotes efficient utilization of space, light, and other resources while facilitating the coexistence of diverse plant species (Kumar & Nair, 2004).

The dominance of species in the middle stratum of Makassar home gardens may reflect the widespread cultivation of ornamental shrubs, fruit trees, and small woody species that are well adapted to urban residential environments. This observation is consistent with findings from West Java, where urbanization was associated with an increasing proportion of ornamental plants, particularly within the lower and intermediate vegetation layers, while the abundance of taller vegetation declined in highly urbanized areas (Arifin et al., 1998). The preference for medium-sized vegetation may be related to limited land availability, ease of maintenance, and the aesthetic functions expected from urban home gardens. Furthermore, urban residents often select plant species that provide multiple benefits, including shade, ornamental value, and household use, while remaining compatible with restricted residential spaces.

The development of a stratified vegetation structure contributes not only to plant diversity but also to the ecological functions of urban home gardens. Home gardens have been described as agroecosystems that mimic natural ecosystems through the integration of

diverse plant species arranged in multiple layers (Abdoellah et al., 2020). Such vegetation complexity can enhance ecosystem services by creating a variety of ecological niches, supporting biodiversity conservation, regulating microclimatic conditions, and improving environmental quality within urban landscapes. In addition, studies in Yogyakarta demonstrated that urban home gardens provide multiple ecosystem services, including biodiversity conservation, food provision, aesthetic value, social interaction, and environmental benefits, even under conditions of limited space and high settlement density (Irwan & Sarwadi, 2017). Therefore, the multi-strata vegetation observed in Makassar home gardens highlights their potential contribution to sustaining urban biodiversity and supporting ecosystem functioning in rapidly urbanizing environments.

3.2.3. Plant Diversity and Ecological Significance

The diversity indices obtained in this study indicate that urban home gardens in Makassar support relatively diverse plant communities. The mean Shannon–Wiener diversity index (H′) was 2.0 ± 0.49, while the Simpson diversity index (1 − D) reached 0.80 ± 0.13. These values suggest a moderate level of plant diversity and indicate that the vegetation assemblages were not dominated by only a few species. The mean evenness value (0.60 ± 0.18) further demonstrates that individuals were relatively distributed among species, although some species occurred more frequently than others. Similar observations have been reported in tropical home gardens, where diverse plant assemblages are maintained through the cultivation of ornamental, food, medicinal, and multipurpose species (Galluzzi et al., 2010; Korpelainen & Pirttilä, 2023).

The relatively high diversity recorded in Makassar may be attributed to the multifunctional role of urban home gardens. Unlike conventional urban green spaces, home gardens are actively managed by household owners who often cultivate a wide variety of plant species to satisfy aesthetic, cultural, nutritional, and economic needs. Such management practices increase species richness and contribute to the maintenance of plant diversity within urban landscapes. Similar patterns have been documented in Indonesian home gardens, where plant diversity is strongly associated with household preferences and the multiple functions performed by home gardens (Abdoellah et al., 2020; Agustina et al., 2024).

Beyond their contribution to plant conservation, diverse home gardens provide important ecological benefits for urban environments. Previous studies have highlighted that home gardens serve as habitats for various organisms, enhance habitat connectivity, and contribute to ecosystem services such as microclimate regulation, carbon sequestration, and environmental quality improvement (Goddard et al., 2010; Irwan & Sarwadi, 2017). Therefore, the diversity observed in urban home gardens of Makassar demonstrates their ecological significance as small-scale green infrastructures capable of supporting urban biodiversity within a rapidly growing tropical city.

Conclusions

Urban home gardens in Makassar support substantial plant diversity and contribute significantly to the ecological value of residential landscapes. A total of 190 plant species belonging to 65 families were recorded from 24 surveyed home gardens, demonstrating the important role of these small-scale green spaces in conserving urban biodiversity. Araceae and Asparagaceae were the most species-rich families, reflecting the prominence of

ornamental plants in urban home gardens. The vegetation exhibited a multi-layered structure, with the middle stratum containing the highest proportion of species, indicating the important role of shrubs and small trees in shaping vegetation composition. The diversity indices revealed a moderate level of plant diversity, suggesting that urban home gardens maintain relatively balanced plant communities despite being located in a rapidly urbanizing environment. Beyond their contribution to plant conservation, home gardens provide ecological functions through vegetation stratification and diverse species assemblages, which may enhance ecosystem services and environmental quality within the city.

These findings highlight the importance of urban home gardens as components of urban green infrastructure and biodiversity conservation strategies in Makassar. Promoting and maintaining urban home gardens should therefore be considered an important strategy for enhancing urban biodiversity and supporting sustainable city development in rapidly growing tropical cities. Future studies should examine the relationships between home garden size, management practices, and biodiversity patterns, as well as evaluate the contribution of home gardens to ecosystem services and urban sustainability.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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