

Evaluation of Diyarbakır Urban Parks within the Framework of Biodiversity-Friendly Criteria in the Context of Resilient and Sustainable Cities

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Abstract

Objective: This study evaluates six urban parks in the city center of Diyarbakır within the framework of resilient and sustainable urban development using Biodiversity-Friendly criteria. Species richness, distribution evenness, proportions of native and fruit-bearing species, and ecosystem components were analyzed to determine biodiversity levels and Biodiversity-Friendly performance.

Materials and Methods: The study covered 15 Temmuz Şehitler Parkı (July 15 Martyrs Park, KP1), Park 75 (Park 75, KP2), Kardeşlik Parkı (Brotherhood Park, KP3), Kent Meydanı (City Square, KP4), Sümer Parkı (Sumer Park, KP5), and Tema Parkı (Tema Park, KP6). Plant species were identified through field surveys, individual counts were conducted, and naturalness status was determined. Species diversity was calculated using the Shannon–Wiener (H') and Simpson ($1-\lambda$) indices via BİÇEB software. Parks were also evaluated using the Biodiversity-Friendly Index, consisting of 10 main and 65 sub-criteria, and comparatively assessed.

Results: A total of 173,343 plant individuals were recorded. The highest diversity values were found in KP6 ($H' = 2.93$; $1-\lambda = 0.939$) and the lowest in KP3 ($H' = 1.87$; $1-\lambda = 0.796$), while evenness was highest in KP5. Biodiversity-Friendly Index scores classified KP6 (85) and KP4 (83) as high-level, KP1 (77) as good, and KP2 (72), KP3 (69), and KP5 (71) as insufficient in mandatory criteria. Native species exceeded 10% in all parks.

Conclusion: Biodiversity-friendly suitability depends not only on species richness but also on species evenness, the proportion of native and fruit-bearing species, permeable surfaces, ecological connectivity, and sustainable management approaches. Considering Diyarbakır's semi-arid climatic conditions, high summer temperatures, and rapid urbanization pressure, the use of native and drought-tolerant species together with the development of permeable and ecologically connected green infrastructure systems is of critical importance. The findings provide a scientific basis for ecosystem-based and climate-sensitive urban park planning in Diyarbakır.

Keywords: Biodiversity-friendly park, urban biodiversity, Shannon–Wiener index, Simpson index, sustainable urbanization, ecosystem services, Diyarbakır.

Dirençli ve Sürdürülebilir Kentler Bağlamında Diyarbakır Kent Parklarının Biyoçeşitliliğe Dost Kriterleri Kapsamında Değerlendirilmesi

Öz

Amaç: Bu araştırmanın amacı, Diyarbakır kent merkezinde yer alan altı kentsel park alanını dirençli ve sürdürülebilir kent yaklaşımı doğrultusunda biyodostluk kriterleri çerçevesinde değerlendirmektir. Çalışmada parkların tür zenginliği, türlerin dağılım dengesi, doğal ve meyveli tür kullanım oranları ile ekosistem bileşenleri analiz edilerek biyolojik çeşitlilik düzeylerinin ortaya konulması ve biyodost park niteliğinin belirlenmesi hedeflenmiştir.

Materyal ve Yöntem: Araştırma materyalini 15 Temmuz Şehitler Parkı (July 15 Martyrs Park, KP1), Park 75 (Park 75, KP2), Kardeşlik Parkı (Brotherhood Park, KP3), Kent Meydanı (City Square, KP4), Sümer Parkı (Sumer Park, KP5), and Tema Parkı (Tema Park, KP6) oluşturmaktadır. Parklarda yer alan bitki türleri yerinde tespit edilmiş, birey sayımları yapılmış ve doğallık durumları belirlenmiştir. Tür çeşitliliğinin nicel analizinde Shannon–Wiener (H') ve Simpson ($1-\lambda$) indeksleri kullanılmış, hesaplamalar BİÇEB yazılımı ile gerçekleştirilmiştir. Ayrıca parklar, 10 ana kriter ve 65 alt ölçüt içeren Biyodost İndeksi kapsamında değerlendirilmiş ve veriler karşılaştırmalı olarak analiz edilmiştir.

Araştırma Bulguları: Çalışma alanlarında toplam 173.343 bitki türü tespit edilmiştir. En yüksek çeşitlilik KP6'da ($H'=2,93$; $1-\lambda=0,939$), en düşük değer KP3'te ($H'=1,87$; $1-\lambda=0,796$) saptanmıştır. Tür dağılım eşitliği en yüksek KP5'te belirlenmiştir. Biyodost İndeksi sonuçlarına göre KP6 (85) ve KP4 (83) yüksek; KP1 (77) iyi; KP2 (72), KP3 (69) ve KP5 (71) ise zorunlu şartları yetersiz düzeydedir. Doğal tür oranı tüm alanlarda %10'un üzerindedir.

Sonuç: Biyoçeşitliliğe dost uygunluğu, yalnızca tür zenginliğine değil; türlerin dengeli dağılımına, yerel ve meyve veren tür oranlarına, geçirgen yüzeylere, ekolojik bağlantılılığa ve sürdürülebilir yönetim yaklaşımlarına da bağlıdır. Diyarbakır'ın yarı kurak iklim koşulları, yüksek yaz sıcaklıkları ve hızlı kentleşme baskısı dikkate alındığında, yerel ve kuraklığa dayanıklı türlerin kullanımı ile geçirgen ve ekolojik bağlantılı yeşil altyapı sistemlerinin geliştirilmesi önem taşımaktadır. Elde edilen bulgular, Diyarbakır'da ekosistem temelli ve iklim duyarlı kentsel park planlaması için bilimsel bir temel sunmaktadır.

Anahtar Kelimeler: Biyoçeşitliliğe dost park, kentsel biyoçeşitlilik, Shannon–Wiener indeksi, Simpson indeksi, sürdürülebilir kentleşme, ekosistem hizmetleri, Diyarbakır.

Introduction

Global social and environmental transformations together with changing lifestyles, cultural diversification, rapid population growth, environmental complexity, and ineffective resource management have made sustainability imperative. Accelerating urbanization increases pressure on natural systems, necessitating integrated approaches that address environmental, social, and economic

dimensions. A key objective of sustainable urbanization is the conservation and enhancement of biodiversity, defined as the variability among living organisms across terrestrial and aquatic ecosystems and their ecological complexes (Toprak, 2013). Biodiversity encompasses genetic, species, and ecosystem diversity, including interactions among biotic and abiotic components over space and time (Selim et al., 2015; Yılmaz Gökdoğan and Kaya, 2017; Frantzeskaki et al., 2019; Jalkanen et al., 2020). Since the 1992 United Nations Conference on Environment and Development, biodiversity has become central to international environmental policy, extending beyond conservation to inform development and planning frameworks.

Cities are increasingly recognized as dynamic socio-ecological systems supporting distinctive flora and fauna (Müller et al., 2013). The sustainability of urban ecosystem services largely depends on water, vegetation, and soil systems, which are frequently undervalued in dense urban contexts. Strengthening biodiversity and urban sustainability requires the identification, protection, and integration of these areas within green infrastructure networks (Gülpınar Sekban and Acar, 2024a; 2024b; Sekban and Akyol, 2023). Effective conservation demands systematic documentation and scientific assessment of species and habitats (Yılmaz, 2007). Accordingly, biodiversity-oriented planning should apply multi-criteria spatial analyses and incorporate ecological processes into decision-making through interdisciplinary collaboration (Liu and Slik, 2022; Farinha-Marques et al., 2015).

Ecosystem based green space planning should address organisms' habitat, feeding, and life cycle requirements alongside human needs (Askan and Yılmaz, 2025). Urban design must integrate biotic-abiotic interactions to sustain ecological processes. Trees play a central role in ecological continuity (Hartig and Kahn, 2016), and species diversity enhances resilience; thus, no single species should dominate urban tree populations (Kendal et al., 2014).

Increasing native and fruit-bearing species supports urban fauna, ecosystem functioning, and biodiversity oriented afforestation (Hooper et al., 2005; Cardinale et al., 2011; Liu and Slik, 2022; Çorbacı and Ekren, 2022). The variations in the number of species identified within biodiversity-supporting residential areas, according to their native and exotic status, are presented in Figure 1.

Urban areas are dynamic systems shaped by demographic pressure and spatial heterogeneity. However, uncontrolled expansion reduces natural habitats, fragments green infrastructure, degrades agricultural land, and weakens ecosystem services, accelerating biodiversity loss and exacerbating climate change, drought, and habitat degradation. Therefore, planning strategies that protect and reinforce urban ecological balance are essential.

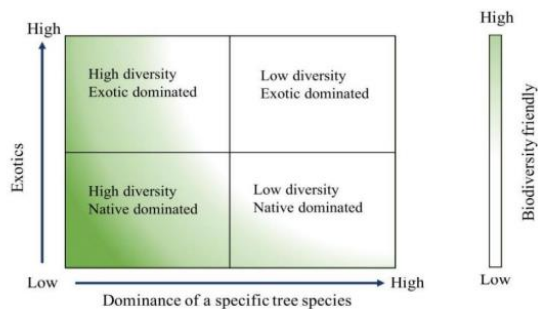


Figure 1. Biodiversity-supporting residential areas (Liu and Slik, 2022).

This study evaluates the urban parks of Diyarbakır using biodiversity-friendly criteria grounded in resilience and sustainability principles. It examines ecological characteristics, species diversity, habitat continuity, ecosystem service contributions, and spatial integration within the urban green network. Beyond recreational functions, parks are assessed for their capacity to support biodiversity, enhance ecosystem resilience, and foster human-nature interaction. The findings inform practical recommendations for ecologically based park planning and design. By framing “Biodiversity-Friendly Park Areas” within resilient and sustainable city models, the study proposes an adaptable approach for cities in Türkiye and comparable contexts.

Material and Methods

Material

The principal material of this study comprises six urban parks located in the city center of Diyarbakır: 15 Temmuz Şehitler Parkı (KP1), Park 75 (KP2), Kardeşlik Parkı (KP3), Kent Meydanı (KP4), Sumer Parkı (KP5) and Tema Parkı (KP6) (Figure 2). Their distribution across different urban zones and varied usage characteristics enables a comparative evaluation of Biodiversity-Friendly park criteria.

Diyarbakır Province is situated in the Southeastern Anatolia Region of Türkiye, approximately between 37°–40° N and 40°–41° E. The city lies in the Tigris Valley at an elevation of about 650 m and is characterized by a continental climate, with hot, dry summers and relatively mild winters. Long-term data indicate an average annual precipitation of approximately 500 mm (Anonim 2025a). These climatic conditions represent key environmental parameters shaping the planning and design of urban open and green spaces.

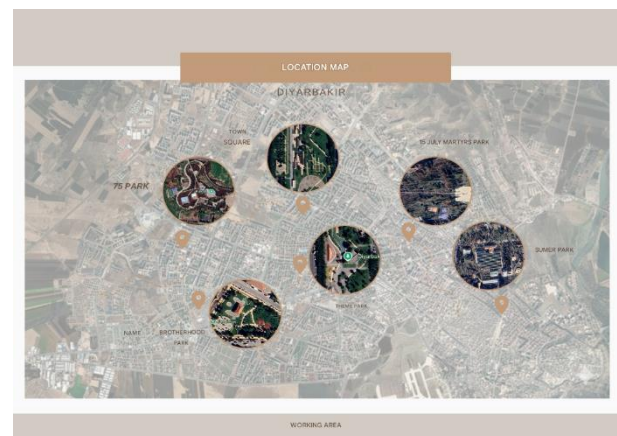


Figure 2. Location map of the study area.

Within the study, the spatial composition of selected parks was evaluated according to land-use distribution, particularly the proportions of green and impervious surfaces. These indicators constituted the primary parameters for assessing ecological performance and Biodiversity-Friendly characteristics.

KP1–15 July Martyrs Park (88,200 m²), located in Kayapınar along the western–northwestern axis, comprises 84% vegetated and 16% hard surfaces, demonstrating high ecological potential in terms of permeability, microclimate regulation, and habitat provision. KP2–Park 75 (75,000 m²), also in Kayapınar, contains 63.3% green space and 36.7% impervious surface, reflecting a more recreation-oriented design. KP3–Brotherhood Park (40,000 m²), situated in the dense urban fabric of Bağlar, includes 62.5% green and 37.5% hard surfaces; despite its compact context, it retains ecological and social significance. KP4–City Square Park (67,000 m²) in central/northwestern Kayapınar consists of 53% green and 47% hard surfaces, functioning as a square–park hybrid that balances public use with

ecological roles. KP5-Sumer Park (80,000 m²), located in the eastern city center, comprises 65% green and 35% impervious areas, indicating a moderate ecological-recreational balance. KP6-Tema Park (34,000 m²), along the western-northwestern development corridor, contains 78% vegetated and 22% hard surfaces, emphasizing ecological sensitivity.

Differences in green-hard surface ratios, urban context, and scale provide a comparative framework for evaluating Biodiversity-Friendly park criteria (Figure 3), influencing ecological resilience, climate adaptation capacity, and overall sustainability performance..

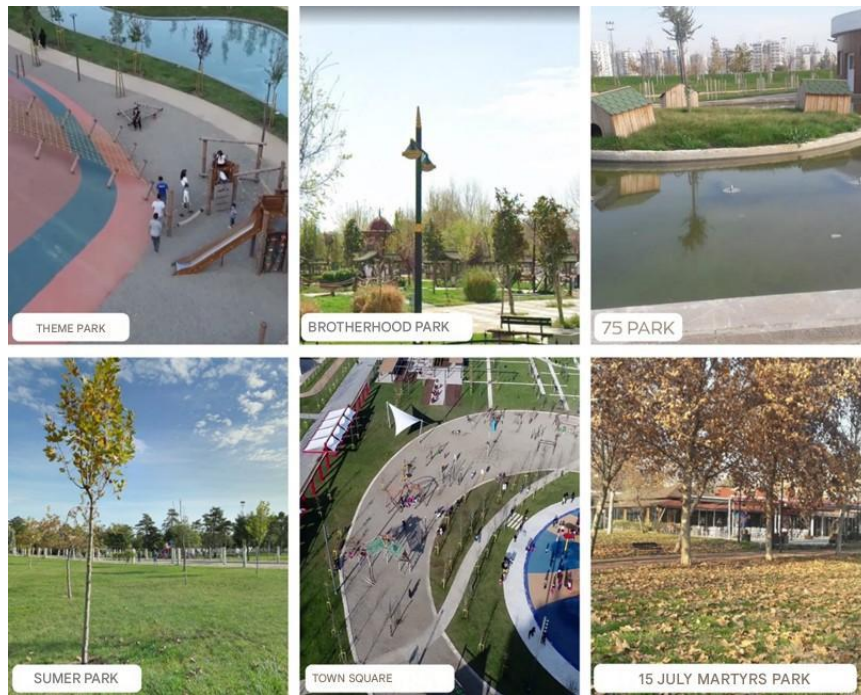


Figure 3. Visuals of the park areas examined within the scope of the study.

Methods

In accordance with the study's aims and scope, analyses, measurements, and field assessments were conducted within the study area. The collected data were evaluated using tables and graphical tools and synthesized to generate solution-oriented recommendations.

First, a comprehensive literature review was undertaken to establish the conceptual framework and define the evaluation criteria. Subsequently, detailed fieldwork was conducted to assess existing conditions. Data were systematically collected and analyzed, and the findings were comparatively interpreted and translated into practical recommendations in the conclusion section. The methodology of the study comprises the following stages:

Determination of the Study Areas

Six parks exhibiting distinct spatial and functional characteristics within the city of Diyarbakır were

selected, and their general landscape attributes were identified. The selection of the study areas was based on specific criteria, including park size, establishment at least five years prior to the study, spatial distribution across different parts of the city, levels of plant diversity and density, and their recognition at the urban scale.

Studies Conducted in the Research Areas

The six park areas located in the city center of Diyarbakır were examined within the framework of the Shannon-Wiener Diversity Index (H'), Simpson Diversity Index ($1/D$), and the Biodiversity-Friendly Index to determine their levels of biological diversity. Based on the calculated index values, species diversity and ecological quality of the parks were comparatively evaluated. In the biodiversity analyses, the Biological Diversity Components (BİÇEB) software was employed, which enables researchers to systematically calculate species diversity indices and offers both online and desktop usage options (Özkan et al., 2020). Through this software, Shannon-Wiener

(H') and Simpson ($1/D$) index values were computed. In addition, the Biodiversity-Friendly Index, developed by Prof. Dr. Hasan Yılmaz (Yılmaz, 2024), was applied to determine the Biodiversity-Friendly level of the park areas, and the results were analyzed within a holistic framework.

Shannon-Wiener Diversity Index (H'): A measure that simultaneously evaluates species richness within an ecosystem and the evenness of the distribution of individuals among species.

$$H' = - \sum p_i \ln(p_i)$$

Where:

- p_i denotes the proportion of the i th species relative to the total number of individuals;
- $\ln$ represents the natural logarithm (Magurran, 1988; Magurran, 2004).

The Shannon-Wiener diversity index (H') increases with greater species richness and a more even distribution of individuals among species. H' generally ranges from 0 to 5: values below 1.5 indicate low diversity, 1.5–2.5 moderate diversity, and above 2.5 high diversity (Odum and Barrett, 1971; Kocataş, 2003). Evenness (E) measures the uniformity of individual distribution, ranging from 0 (uneven) to 1 (homogeneous). Here, $\ln$ denotes the natural logarithm (Magurran, 1988; 2004).

Simpson Diversity Index ($1/D$): An indicator that measures diversity in an ecosystem based on species dominance. As the index value increases, species diversity and the evenness of distribution also increase.

$$1/D = 1 - \sum n_i(n_i - 1) / N(N - 1)$$

Where:

- i denotes the number of species;
- n_i represents the number of individuals belonging to the i th species;
- N indicates the total number of individuals of all species within a given area (Magurran, 1988; Magurran, 2004).

The Simpson Index evaluates diversity by emphasizing the dominance structure within a community. If a single species has a very high number of individuals, the index value decreases, indicating lower biodiversity. As the $(1-\lambda)$ value approaches 1, diversity increases; as it approaches 0, diversity decreases. This metric reveals differences in diversity among areas based on species richness and individual abundance.

Biodiversity-Friendly Index:

The Biodiversity-Friendly Index, developed by Prof. Dr. Hasan Yılmaz (Yılmaz, 2024), is a holistic assessment tool that differs from classical diversity metrics by being applicable to all types of urban areas. In this study, each site was evaluated within the framework of 10 main criteria and 65 sub-criteria. According to the index requirements, plant design must include at least 10% native species, at least 10% fruit-bearing species, and a minimum of 25 taxa. The assessment was conducted on a 100-point scale: scores between 50–60 were classified as low, 61–80 as good, and 81–100 as high-level Biodiversity-Friendly settlements.

- Broad-leaved and coniferous trees, small trees, shrubs, dwarf conifers, and climbing species within the study areas were identified at the taxon level. The number of individuals and their distribution densities were quantified and analyzed.
- Field observations were conducted in different periods, and systematic photographic records were obtained to document spatial and vegetative characteristics.
- The establishment year of each site was determined, and the ratios of green/open spaces to impervious surfaces were calculated. Fauna species (e.g., birds, butterflies, squirrels) observed during one-hour monitoring periods were numerically recorded.
- During species identification, factors affecting ecosystem integrity were assessed. Elements relevant to sustainability and biodiversity were documented through systematic observation and supported by photographic evidence.
- Ecosystem components of each site were analyzed, and features enhancing environmental sustainability, as well as potential risks, were systematically evaluated (Yılmaz, 2024).

Office-Based Analyses:

Within the scope of the research, plant species identified in the field were taxonomically verified, and their native status as well as their potential for producing edible fleshy fruits were determined. The evaluation of native species was based on characteristics specific to the flora of Türkiye and

In addition, the urban open and green space system of Diyarbakır and its associated urban ecosystem components were identified and evaluated.

Evaluation and Conclusion

Results

As a result of the field studies conducted in the park areas of Diyarbakır, plant species belonging to six parks located in different parts of the city's open and green space system were identified. The recorded taxa were classified according to their morphological characteristics into broad-leaved trees, coniferous species, small trees, shrubs, and climbing plants (Table 1).

Table 1. Inventory data on the distribution of broad-leaved trees, herbaceous, coniferous taxa, small trees, shrubs, and climbing plant taxa identified in the study areas, including species distribution, number of individuals, and native/exotic status

	LATIN NAME	FAMILY	TURKISH NAME	NATURAL SPECIES	WORK AREAS						TOTAL
					KP1	KP2	KP3	KP4	KP5	KP6	
BROAD-LEAFED TREES	<i>Acer negundo</i> L.	Aceraceae	Akçaağaç	+	70	150					120
	<i>Acer platanoides</i> L.	Aceraceae	Çınar yapraklı akçaağaç	+				51	420		471
	<i>Acer saccharinum</i> L.	Aceraceae	Şeker akçaağaç	-				114			114
	<i>Acer platanoides</i> 'Crimson king'	Aceraceae	Kırmızı çınar yapraklı akçaağaç	-						35	35
	<i>Acer</i> spp.	Aceraceae	Akçaağaç	-			55				55
	<i>Catalpa bignonioides</i> Walt.	Bignoniaceae	Catalpa	-			45	38			83
	<i>Cercis siliquastrum</i> L.	Fabaceae	Erguvan	+		140	20				160
	<i>Crataegus monogyna</i> Jacq.	Rosaceae	Aliç	+	40			10			50
	<i>Crataegus laevigata</i> 'Paul's Scarlet'	Rosaceae	Pembe çiçekli aliç	+						14	14
	<i>Fraxinus excelsior</i>	Oleaceae	Boylu diş budak	+	130	190			350	60	730
	<i>Fraxinus americana</i> L.	Oleaceae	Beyaz diş budak	-				148			148
	<i>Malus</i> 'Evereste'	Rosaceae	Süs elması	-				2			2
	<i>Malus</i> 'Golden Hornet'	Rosaceae	Sarı meyveli süs elması	-				15			15
	<i>Malus domestica</i> Borkh.	Rosaceae	Elma	-						5	5
	<i>Malus floribunda</i> Siebold ex Van Houtte	Rosaceae	Japon süs elması	+				12		30	42
	<i>Morus alba</i> L.	Moraceae	Dut	+	120			724	250	752	1846
	<i>Melia azedarach</i> L.	Meliaceae	Tespîh ağacı	-	55				120		175
	<i>Olea europaea</i> L.	Oleaceae	Zeytin	+		260					260
	<i>Platanus × acerifolia</i> (Aiton) Willd.	Platanaceae	Londra çınarı	-						135	135
	<i>Platanus orientalis</i> L.	Platanaceae	Çınar	+	180	420	150	119		51	920
	<i>Populus alba</i> L.	Salicaceae	Akkavak	+				3		6	9
	<i>Populus nigra</i> L.	Salicaceae	Karakavak	+	110					43	153
	<i>Prunus armeniaca</i> L.	Rosaceae	Kayısı	-						3	3
	<i>Prunus avium</i> L.	Rosaceae	Kiraz	+	60				220		280
	<i>Prunus cerasifera</i> 'Pissardii Nigra'	Rosaceae	Süs eriği	+				33			33
	<i>Prunus cerasifera</i> Ehrh.	Rosaceae	Can eriği	+	50	120	75			55	300
	<i>Prunus laurocerasus</i> L.	Rosaceae	Karayemiş	+	1100				2800		3900
	<i>Prunus mahaleb</i> L.	Rosaceae	Mahlep	+		3000					3000
<i>Prunus serrulata</i> Lindl.	Rosaceae	Japon kirazı	-				36		25	61	
<i>Pyrus communis</i> L.	Rosaceae	Armut	-						5	5	
<i>Quercus rubra</i> L.	Fagaceae	Amerikan kırmızı meşesi	-	65			27	160	60	312	
<i>Robinia pseudoacacia</i> L.	Fabaceae	Yalancı akasya	+		210	60				270	
<i>Salix babylonica</i> L.	Salicaceae	Ak söğüt	-	55			2		2	59	
<i>Tilia tomentosa</i> Moench.	Tiliaceae	Gümüş ihlamur	+	95	160			300		555	
TOTAL OF BROAD-LEAFED TREES: 14320											
	<i>Cedrus libani</i> A.Rich.	Pinaceae	Toros sediri	+	90			31	180	21	322
	<i>Cupressus arizonica</i> Greene	Cupressaceae	Arizona servisi	-			30				30
	<i>Cupressus macrocarpa</i> 'Goldcrest'	Cupressaceae	Limon servi	-			30				30
	<i>Cupressus sempervirens</i> 'Stricta'	Cupressaceae	Sütun servi	-				72			72
	<i>Cupressus sempervirens</i> L.	Cupressaceae	Akdeniz servisi	+	85				200	4	289
	<i>Juniperus</i> spp.	Cupressaceae	Ardıç	+			1000				1000
	<i>Juniperus chinensis</i> L.	Cupressaceae	Çin ardıcı	-				117		450	567
	<i>Pinus eldarica</i> Medw.	Pinaceae	Eldar çamı	-	100			89	220		409
	<i>Pinus nigra</i> J.F.Arnold	Pinaceae	Karaçam	+		300					300
	<i>Pinus pinea</i> L.	Pinaceae	Fıstık çamı	+		360					360
	<i>Platycladus orientalis</i> 'Compacta'	Cupressaceae	Bodur mızı	-				44			44
TOTAL OF BROAD-LEAFED TREES: 3423											

Table 1 (continued). Inventory data on the distribution of broad-leaved trees, herbaceous, coniferous taxa, small trees, shrubs, and climbing plant taxa identified in the study areas, including species distribution, number of individuals, and native/exotic status

	LATIN NAME	FAMILY	TURKISH NAME	NATURAL SPECIES	WORK AREAS						TOTAL
					KP1	KP2	KP3	KP4	KP5	KP6	
BROAD-LEAFED TREES	<i>Ajuga reptans</i> L.	Lamiaceae	Sürünücü mayasıl otu	+						600	600
	<i>Buddleja davidii</i> Franch.	Scrophulariaceae	Kelebek çalısı	-	650				1700	550	2900
	<i>Buxus sempervirens</i> L.	Buxaceae	Şimşir	+	800						800
	<i>Cerastium tomentosum</i> L.	Caryophyllaceae	Gümüş halı	-						800	800
	<i>Chaenomeles japonica</i> (Thunb.) Lindl. ex Spach	Rosaceae	Japon ayvası	-				75			75
	<i>Cornus alba</i> 'Sibirica'	Cornaceae	Kırmızı dallı kızılcık	-				57			57
	<i>Cornus mas</i> L.	Cornaceae	Kızılcık	+	48						48
	<i>Cornus</i> spp.	Cornaceae	Kızılcık	-						700	700
	<i>Cotinus coggygria</i> Scop.	Anacardiaceae	Duman ağacı	+				8			8
	<i>Foeniculum vulgare</i> Mill.	Apiaceae	Rezene	+		3000					3000
	<i>Forsythia × intermedia</i> Zabel	Oleaceae	Altın çanı	-						500	500
	<i>Hedera helix</i> L.	Araliaceae	Sarmaşık	+				12		200	212
	<i>Lagerstroemia indica</i> L.	Lythraceae	Oya ağacı	-			15				15
	<i>Laurus nobilis</i> L.	Lauraceae	Defne	+	650				1600		2250
	<i>Lavandula × intermedia</i> Emeric ex Loisel.	Lamiaceae	Melez Lavanta	-		10000					10000
	<i>Lavandula angustifolia</i> Mill.	Lamiaceae	Gerçek lavanta	-	1500	20000	800	1216	5000	700	29216
	<i>Melissa officinalis</i> L.	Lamiaceae	Oğulotu	+		4000					4000
	<i>Mentha</i> spp.	Lamiaceae	Naneler	+		6000					6000
	<i>Nerium oleander</i> L.	Apocynaceae	Zakkum	+	1000				3200		4200
	<i>Ocimum</i> spp.	Lamiaceae	Fesleğen	-						820	820
	<i>Pyracantha coccinea</i> M.Roem.	Rosaceae	Ateş dikeni	+	850		400		1900		3150
	<i>Rhus coriaria</i> L.	Anacardiaceae	Sumak	+	350					35	385
	<i>Rosa</i> (Miniature Group)	Rosaceae	Minyatür gül	-				132			132
	<i>Rosmarinus officinalis</i> L.	Lamiaceae	Biberiye	+		12000		396			12396
	<i>Rosa</i> spp.	Rosaceae	Gül	-	4000	4000			7000		15000
	<i>Salvia officinalis</i> L.	Lamiaceae	Adaçayı	+	900	8000			3800	650	13350
	<i>Salvia rosmarinus</i> Spenn.	Lamiaceae	Biberiye	+	1200				2300		3500
	<i>Sedum acre</i> L.	Crassulaceae	Acı damkoruğu	+				2060			2060
	<i>Sedum</i> spp.	Crassulaceae	Damkoruğu türleri	+						800	800
	<i>Sedum spurium</i> 'Album Superbum'	Crassulaceae	Beyaz sürünücü damkoruğu	-				1830			1830
	<i>Sedum spurium</i> 'Voodoo'	Crassulaceae	Kırmızı yapraklı damkoruğu	-				1650			1650
	<i>Spiraea bumalda</i> Burv.	Rosaceae	Bodur gelin tacı	-				102			102
	<i>Syringa vulgaris</i> L.	Oleaceae	Leylak	-				32		3	35
	<i>Thymus × citriodorus</i> (Pers.) Schreb.	Lamiaceae	Limon kekik	-		6000					6000
	<i>Thymus serpyllum</i> L.	Lamiaceae	Sürünücü kekik	-						600	600
	<i>Thymus</i> spp.	Lamiaceae	Kekik	-		18000				550	18550
	<i>Thymus vulgaris</i> L.	Lamiaceae	Bahçe kekiği	-	1300			2380	4500		8180
	<i>Tulipa</i> spp.	Liliaceae	Lale	+			25				25
	<i>Verbascum calycosum</i> Boiss. & Heldr.	Scrophulariaceae	Siğir kuyruğu	+				408			408
	<i>Verbascum</i> spp.	Scrophulariaceae	Siğirkuyruğu	+						450	450
	<i>Viburnum opulus</i> L.	Adoxaceae	Kartopu	+	700		500		2200		3400
	<i>Viburnum tinus</i> L.	Adoxaceae	Defne yapraklı kartopu	+				106		230	336
TOTAL OF TREES-BUSHES-VINES-HERBS: 155600											
TOTAL OF BROAD-LEAFED TREES: 173343											

15 Temmuz Şehitler Parkı (July 15 Martyrs Park, KP1), Park 75 (Park 75, KP2), Kardeşlik Parkı (Brotherhood Park, KP3), Kent Meydanı (City Square, KP4), Sümer Parkı (Sumer Park, KP5), and Tema Parkı (Tema Park, KP6)

As a result of the inventory and counting studies conducted in the research areas, a total of 173,343 plants were identified, comprising 14,320 broad-leaved trees, 3,423 coniferous trees, and 155,600 small trees–shrubs–climbing–herbaceous plants. The species diversity and the number of individuals recorded in each examined park area are presented in detail in Table 2.

As part of the study, plant species found in park areas were observed on site and photographed to be

evaluated according to Biodiversity-Friendly park criteria (Figure 3).

Table 2. Species diversity and number of individuals in the park areas.

RESULTS	KP1	KP2	KP3	KP4	KP5	KP6
Species Diversity (S)	29	21	14	35	21	35
(N) Total						
Number of Individuals (N)	16353	96310	3205	12151	38420	9972



Figure 3. Images of Plant Species Found in Park Areas.

Plant photographs taken during the field survey were utilized to illustrate the vegetative structure of the parks, the general morphological characteristics of the species, and their relationship with the urban environment.

These images were presented as visual evidence supporting the ecological quality and plant diversity of the parks (Figure 4).



Figure 4. Photographs of Plant Species Identified in the Study Areas

The number of native plant species identified across all study areas and their proportional distribution in terms of naturalness are presented in Figure 5.

In terms of species richness within individual parks, KP3 was determined to have the highest diversity, with 14 different native species. Regarding overall species richness, KP4 and KP6 each recorded the highest total number of species, with 35 taxa identified in both areas.

The prevalence of plant species identified in the study areas (%)

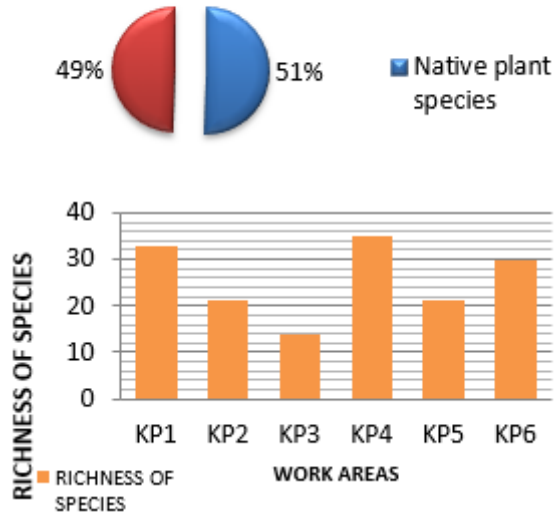
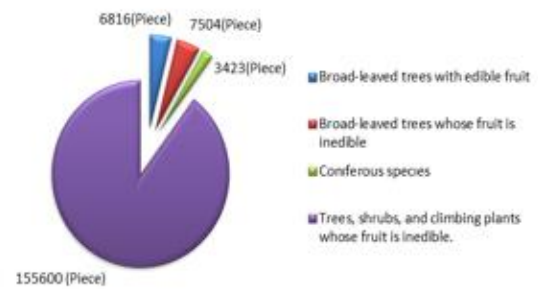


Figure 5. Level of naturalness and species richness of plants used in parks

Considering the total number of plant individuals, the highest density was observed in KP2, with 96,310 individuals, whereas the lowest number of individuals was recorded in KP3, with 3,205 individuals.

Data regarding the number of plant individuals identified in the park areas and the distribution of native species are presented in Figure 6.

Number of plants identified in the study areas



Percentage distribution of plants identified in the study areas

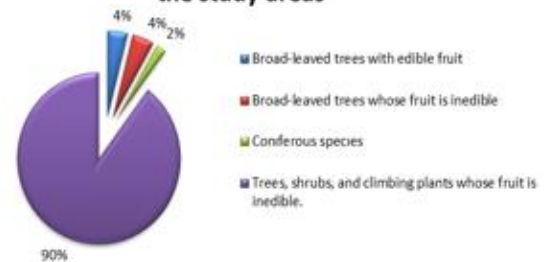


Figure 6. Number of plants identified in park areas and distribution of natural plant species.

Observational Findings on Faunal Elements Contributing to Urban Biodiversity

Within the scope of the study, field surveys were conducted during two different periods, and observations lasting at least one hour were carried out in each study area. In accordance with the criteria required by the Biodiversity-Friendly Index, counts related to fauna presence were performed, and the

average values obtained from the observation periods were used to determine fauna abundance. In addition, the observed faunal diversity was photographed and documented. Observational findings regarding faunal elements contributing to urban biodiversity in the park areas examined within the scope of the research in Diyarbakır are presented in Figure 7.



Figure 7. Field Observations Conducted in the Study Areas During the Spring and Autumn Periods.

Evaluation of Plant Diversity and Biophilic Level in Diyarbakır Parks

The research was conducted across six different urban parks. In order to quantitatively assess species diversity based on the plant taxa identified in the park areas, the Shannon–Wiener Diversity Index (H'), Simpson Diversity Index ($1/D$), and the Biodiversity-Friendly Index were calculated and analyzed.

The Shannon–Wiener (H') values of the examined urban parks

Among the study areas, KP5 exhibited the closest distribution to perfect evenness in terms of species distribution, with an Evenness (E) value of 82.7%. Differences in biodiversity levels were also identified among the parks. According to the statistical evaluation results, the symbol * indicates that the difference in diversity between two communities is statistically significant at the 5% level, whereas ** indicates significance at the 1% level. Based on the Shannon–Wiener diversity index (H') results, the biodiversity levels of the parks were ranked as

follows: KP6 > KP1 > KP5 > KP4 > KP2 > KP3 (Table 3).

Table 3. Shannon–Wiener Diversity Index (H') Values Calculated for the Green Areas of the Urban Parks.

Results	KP1	KP2	KP3	KP4	KP5	KP6
H'	2,67197	2,31017	1,87678	2,41809	2,52013	2,93958
E	0,79351	0,7588	0,71115	0,68013	0,82776	0,8268
Var H'	0,00006	0,00001	0,0003	0,0001	0,00002	0,00005
	1	2	3	4	5	6
1		** $t = 43.24337$ $sd = 22153.76089$ $p = 0.0$	** $t = 41.91019$ $sd = 4579.30039$ $p = 0.0$	** $t = 20.07098$ $sd = 24541.74462$ $p = 0.0$	** $t = 16.97623$ $sd = 27759.18284$ $p = 0.0$	** $t = -$ $sd = 25698.47507$ $p = 0.0$
2			** $t = 24.6149$ $sd = 3422.10124$ $p = 0.0$	** $t = -$ $sd = 14684.18363$ $p = 0.0$	** $t = -$ $sd = 78605.65501$ $p = 0.0$	** $t = -$ $sd = 14300.45287$ $p = 0.0$
3				** $t = -27.0655$ $sd = 5535.54671$ $p = 0.0$	** $t = -$ $sd = 3645.22629$ $p = 0.0$	** $t = -$ $sd = 4323.75956$ $p = 0.0$
4					** $t = -9.31493$ $sd = 17278.8504$ $p = 0.0$	** $t = -$ $sd = 20955.97433$ $p = 0.0$
5						** $t = -$ $sd = 18765.80663$ $p = 0.0$
6						

In terms of species evenness (E), the parks were ranked as follows: KP6 > KP5 > KP1 > KP2 > KP3 > KP4. The statistical analysis revealed that the differences among the study areas coded as KP1, KP2, KP3, KP4, KP5, and KP6 were statistically significant at the 1% significance level. The Shannon-Wiener Diversity Index (H') values calculated for the urban parks and the findings related to species distribution are presented in Figure 8.

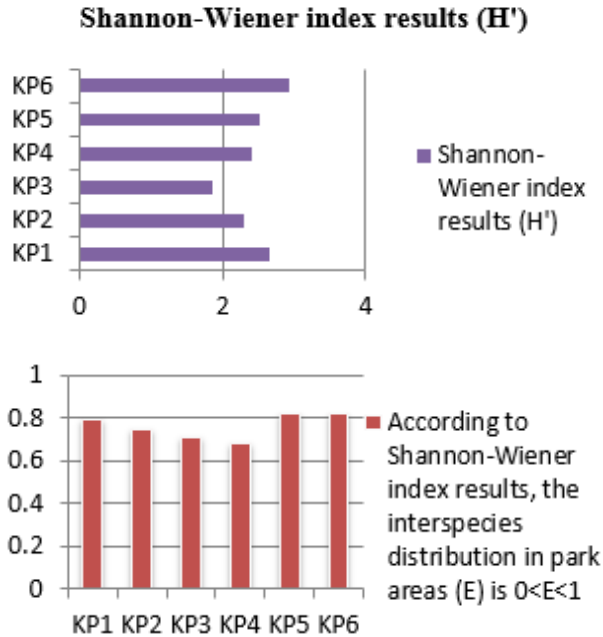


Figure 8. Shannon-Wiener Diversity Index (H') Values Calculated for the Green Areas of the Urban Parks and Findings Related to Species

Based on the evaluation conducted using the Shannon-Wiener Diversity Index (H'), KP6 exhibited the highest species diversity among the urban parks, whereas the lowest diversity level was recorded in KP3. In terms of species evenness, KP5 demonstrated the most balanced composition (highest evenness value), while KP4 displayed a more heterogeneous distribution pattern. The Simpson Diversity Index ($1/D$) results calculated for the urban parks are presented below.

The Simpson diversity index ($1-\lambda$) is a metric that simultaneously considers species richness and individual abundance, allowing comparison of diversity levels across sites. According to the obtained ($1-\lambda$) values, the parks were ranked in terms of biodiversity as follows: KP6 > KP5 > KP1 > KP2 > KP4 > KP3 (Figure 9).

Simpson index biodiversity result ($1-\lambda$)

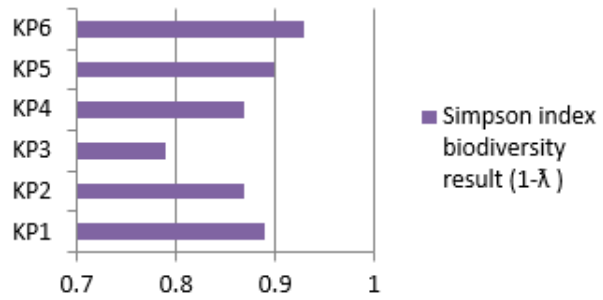


Figure 9. Biodiversity results of the parks according to the obtained ($1-\lambda$) values

In Table 4, the symbol * indicates that the difference in diversity between two parks is statistically significant at the 5% level, while ** indicates significance at the 1% level. The analysis results revealed a statistically significant difference between KP1 and KP2 at the 1% level, and between KP1 and KP5 at the 5% level. In contrast, KP2 and KP4 exhibited similar biodiversity characteristics in terms of Simpson index values (Table 4).

Table 4. Simpson Diversity Index ($1-\lambda$) Values Determined for the Green Areas of the Urban Parks.

RESULTS	KP1	KP2	KP3	KP4	KP5	KP6
$1-\lambda$	0,89771	0,87552	0,79655	0,8751	0,90067	0,93934
Var D	1,72E-06	1,8E-07	1,3E-05	1,32E-06	2,7E-07	1,7E-07
1		**	**	**	*	**
2			**	**	**	**
3				**	**	**
4					**	**
5						**
6						

An examination of the Simpson Diversity Index ($1-\lambda$) values calculated for the urban parks indicates that the highest level of biological diversity was recorded in KP6, whereas the lowest diversity level was observed in KP3. The Biodiversity-Friendly levels of the park areas evaluated across the city and the corresponding index results are presented in Table 5.

Table 5. Biodiversity-Friendly Index Values Calculated for the Urban Parks

Criterion No.	Evaluation Criteria	Criteria Requirement	Area characteristics	Score Obtained	Total points	KP1	KP2	KP3	KP4	KP5	KP6
1	Number of plant species in the area*	It must contain at least 25 plant taxa.	25 types 26-30 types 31-35 types More than 35 types	7 8 9 10	10 points	X			X		X
					Total	8	0	0	9	0	9
2	Percentage of native plant species used*	It must be at least 10% of the total number of species.	%10 %10-15 %16-20 More than 20%	14 16 18 20	20 points	X	X	X	X	X	X
					Total	20	20	20	20	20	20
3	Percentage of succulent fruit plant species usage*	It must be at least 10% of the total number of species.	%10 %10-15 %16-20 More than 20%	12 13 14 15	15points	X	X	X	X		X
					Total	13	12	12	12	12	14
4	The ratio of the number of plant species to the total number of plants.	At least two plant species must be dominant in the total plant population.	2 plant species being dominant 3 plant species being dominant 4 plant species being dominant 5 plant species being dominant Dominance of more than 5 plant species	2 4 6 8 10	10 points			X			
					Total	10	10	6	10	10	10
5	Year the green area was built		Less than 5 years 6-10 years 11-15 years 16-20 years More than 20 years	1 2 3 4 5	5 points		X	X	X		X
					Total	4	2	2	2	4	2
6	Number of fauna observed in the area within 1 hour (Birds, butterflies, squirrels, etc.)		< 5 Between 6-10 Between 11-15 Between 16-20 >20	1 2 3 4 5	5 points	X	X		X	X	X
					Total	3	2	1	2	2	2
7	Area size		Smaller than 500 m2 500 m2 - 2 acres 2-6 acres 6-10 acres More than 10 acres	1 2 3 4 5	5 points						
					Total	5	5	5	5	5	5
8	The ratio of open green spaces to hard, impermeable surfaces.		Less than 10% If 10-30% If 31-50% If 51-75% If more than 75%	1 2 3 4 5	5 points		X	X	X		X
					Total	5	4	4	4	5	5
		More than 100 m from the main transportation axis Green corridor connection		2 2			X	X	X	X	X
		Presence of endemic plant species in the area (10 points × number of species)		10							
		Presence of existing tree stands during site development		6	25 points			X			
		Presence of wetlands		5							
		Presence of existing shrubs during site development		4							
		Presence of natural grasslands and pastures in the area		3							
9	Positive ecosystem components	No fertilizers or pesticides used in the area		2		X	X	X	X	X	X
		Natural stream or pond in the area		8							
		artificial pond		6			X	X	X	X	X
		Small pool		3			X	X	X	X	X
		Fountain, water basin		2		X	X			X	
		The percentage of tree and shrub canopy cover in the entire garden.	Fully closed (100%) Partially closed (50%) Quarter closed (25%)	5 4 2					X		
		Plants being named/ Identification cards		2		X	X	X		X	X
		Having someone involved in the area/Being under control		4							
		The area is well-maintained.		2		X	X	X	X	X	X
		Avoid severe pruning of plants.		2		X	X	X	X	X	X
		Clean air quality		3		X		X	X	X	X
		Renewable energy resources		5							
		Rainwater harvesting garden		5							
					Total	15	23	25	25	19	24

Table 5 (continued).. Biodiversity-Friendly Index Values Calculated for the Urban Parks

10	Negative ecosystem components	Air and soil pollution	-3						
		High noise levels	-3		X		X		X
		Intensive use of agricultural pesticides and fertilizers	-5						
		Excessive exposure to nighttime light	-3	-6 points	X	X	X	X	X
		Lack of a clean water source in or near the area	-6		X		X		X
		Neglect and lack of control	-2				X		
		High-voltage power lines passing through the area	-5						
		Total		-6	-6	-6	-6	-6	-6
TOTAL SCORE		100	77	72	69	83	71	85	
15 Temmuz Şehitler Parkı (July 15 Martyrs Park, KP1), Park 75 (Park 75, KP2), Kardeşlik Parkı (Brotherhood Park, KP3), Kent Meydanı (City Square, KP4), Sümer Parkı (Sumer Park, KP5), and Tema Parkı (Tema Park, KP6)									

Based on the evaluation conducted according to the criteria defined within the scope of the Biodiversity-Friendly Index, the park areas coded as KP2, KP3, and KP5 were classified as non-Biodiversity-Friendly areas, as they failed to meet the first three mandatory criteria. In contrast, the parks coded as KP4 and KP6, which fully satisfied the fundamental criteria, were identified as areas with a high level of Biodiversity-Friendly quality, while KP1 was classified as a good-level Biodiversity-Friendly area (Figure 10).

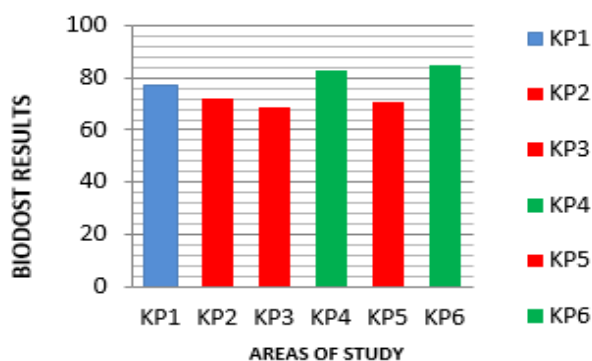


Figure 10. Biodiversity-Friendly results of green areas in city parks (15 Temmuz Şehitler Parkı (July 15 Martyrs Park, KP1), Park 75 (Park 75, KP2), Kardeşlik Parkı (Brotherhood Park, KP3), Kent Meydanı (City Square, KP4), Sümer Parkı (Sumer Park, KP5), and Tema Parkı (Tema Park, KP6)). The evaluation was done out of 100 points; 50-60 points were classified as low, 61-80 points as good, and 81-100 points as high level of Biodiversity-Friendly campus. The Biodiversity-Friendly Index score is below 50, and the first three mand

Discussion

In this study, six park areas located in the city center of Diyarbakır were evaluated according to the criteria of species richness (S), Shannon–Wiener (H'), Simpson (1-λ) and Biofriendliness Index. The findings reveal that the levels of biological diversity and biofriendliness performance of the parks differ significantly from each other.

Species Diversity and Distribution Balance

According to the Shannon–Wiener (H') index, the highest diversity value among the parks was

determined in KP6 (H'=2.93), and the lowest value was in KP3 (H'=1.87).

Similarly, the Simpson (1-λ) index results show that the highest diversity is in KP6 and the lowest diversity is in KP3. This situation indicates that the number of species alone is not sufficient; Studies have shown that the balanced distribution of individuals among species is also a determining factor in terms of ecological quality (Magurran, 2004; Odum and Barrett, 1971).

Biodiversity-Friendly Index Assessment

According to the Biodiversity-Friendly Index results:

- KP4 and KP6 are highly Biodiversity-Friendly,
- KP1 is well-Biodiversity-Friendly,
- KP2, KP3 and KP5 are areas that do not fully meet the Biodiversity-Friendly criteria.

Use of Native Species and Fruit Tree Species

While the proportion of native species was found to be above 10% in all parks, it was observed that in some areas, species diversity was concentrated around a small number of dominant species. The dominance of one or a few species in urban ecosystems can create ecological vulnerability in the long term (Kendal et al., 2014).

Fauna Observations and Ecosystem Components

Faunal observations and ecosystem components were evaluated within the framework of urban biodiversity and ecological sustainability. In order to determine fauna presence within the study areas, field observations were conducted during two different periods, with a minimum observation duration of one hour in each area. As a result of these observations, fauna abundance was identified and the data obtained from different periods were comparatively evaluated. The findings revealed that bird and insect diversity was higher in park areas exhibiting elevated levels of Biodiversity-Friendly characteristics. In this context, plant diversity, habitat continuity, water elements, and green infrastructure

connectivity were found to contribute positively to fauna presence and ecosystem functioning. The positive relationship between plant diversity and ecosystem processes has also been strongly emphasized in the literature (Hooper et al., 2005; Cardinale et al., 2011). Overall, parks characterized by high species richness, balanced species distribution, sufficient proportions of native and fruit-bearing species, low ratios of impervious surfaces, and strong ecological connectivity were determined to demonstrate higher Biodiversity-Friendly performance.

Recommendations for Transforming Non-Biodiversity-Friendly Parks

In order to enhance the Biodiversity-Friendly characteristics of the park areas coded as KP2, KP3, and KP5 which were identified as non-Biodiversity-Friendly areas the following interventions are recommended based on the Biodiversity-Friendly Index evaluation criteria:

1. Increasing Species Diversity and Reducing Dominant Species

- Reducing single-species dominance,
- Increasing the proportion of native and indigenous species,
- Developing afforestation strategies in accordance with the 10/20/30 rule (Kendal et al., 2014),
- Reducing the dominance of widespread exotic species (Liu and Slik, 2022).

This approach would enhance resilience against climate change impacts and pest outbreaks.

2. Promoting Native and Habitat-Providing Species

- Increasing the use of fruit-bearing and flowering native species that support birds and pollinators.

It has been observed that the use of fruit trees in residential gardens within urban areas is becoming increasingly widespread. Such species not only provide direct food resources for households but also enrich landscape aesthetics through their flowering and fruiting phases, while contributing ecologically to urban ecosystems (Askan and Yılmaz, 2016).

- Implementing multi-layered planting designs incorporating shrub layers and groundcovers (Müller et al., 2013),

- Establishing productive species compositions that strengthen ecosystem services (Cardinale et al., 2011).

These interventions would increase faunal diversity and reinforce the ecological functions of the parks. Furthermore, the utilization of native species constitutes one of the most fundamental components in the development of resilient cities and climate-responsive design approaches (Askan et al., 2024).

3. Reducing Impervious Surfaces and Increasing Permeable Areas

Reducing impervious surface coverage, establishing rain gardens and bio-ponds, and strengthening green infrastructure connectivity (Sekban and Akyol, 2023; Gülpınar Sekban and Acar, 2024a) would support the urban water cycle and enhance microclimatic comfort. Considering Diyarbakır's semi-arid climatic conditions and intense summer temperatures, the design of rain gardens and bio-pond systems should additionally incorporate evaporation-mitigation strategies, including the use of drought-tolerant native plant species, multilayered vegetation structures providing partial shading, organic matter-enhanced soil compositions, mulching applications, and deeper retention zones. Furthermore, controlled water circulation systems and interconnected green infrastructure corridors may contribute to reducing surface water loss, improving hydrological performance, and increasing the long-term resilience of urban water-sensitive landscape systems.

4. Adopting an Ecological Management Model

- Limiting the use of chemical fertilizers and pesticides,
- Replacing intensive pruning practices with maintenance approaches that support natural growth patterns,
- Creating habitat patches and natural meadow areas (Yılmaz, 2024).

An ecosystem-based management approach supports long-term sustainability.

5. Ensuring Green Corridors and Spatial Connectivity

- Integrating parks into the urban green infrastructure network,
- Establishing linear green connections that ensure ecological continuity (Jalkanen et al., 2020).

The ecological network approach supports species mobility and genetic continuity. Although

urbanization exerts pressure on biodiversity, urban green spaces and aquatic ecosystems serve as important habitats. Their holistic planning is critical for conserving and enhancing urban biodiversity (Goddard et al., 2009; Pouya and Pouya, 2017; Basnou et al., 2020). Urban resilience is fundamentally associated with a city's capacity to adapt to changing environmental conditions, generate ecologically informed solutions from an urban perspective, and develop strategic initiatives that ensure long-term sustainability (Yılmaz and Askan, 2024).

The research findings indicate that Biodiversity-Friendly quality depends not only on high species richness but also on ecological integrity, balanced species distribution, native species use, habitat continuity, and sustainable management practices. Reconsidering Diyarbakır's urban parks within the framework of a resilient and sustainable city vision would:

- Increase climate change adaptation capacity,
- Reduce the urban heat island effect,
- Strengthen biodiversity,
- Support human-nature interaction (Hartig and Kahn, 2016).

In conclusion, the Biodiversity-Friendly park approach should not be regarded merely as an aesthetic design concept, but rather as an integrated planning model aligned with urban resilience, ecosystem services, and sustainable development goals. The case of Diyarbakır presents an applicable model for other semi-arid cities in Türkiye.

Author Contributions

All authors contributed to the conception and design of the study. G.A designed the study and wrote and edited the article. M.Ç established the field trial and performed laboratory analysis. All authors have read and approved the final version of the manuscript.

Disclosure Statement

No potential conflict of interest was reported by the authors

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