



Ecological and environmental assessment of Erzincan Districts within the scope of the biodiversity-friendly city approach

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Abstract This study was conducted between 2022 and 2024 to develop strategies for the inventory, conservation, and sustainable management of biological diversity in urban areas of Erzincan province, encompassing six districts and one town. It also seeks to promote the use of natural plant species to create climate-resilient urban ecosystems. Field surveys, drone imaging, and plant species identification were conducted across 70 open green spaces. The Shannon–Wiener diversity index and Simpson diversity index, together with the Biodiversity-Friendly City Criteria, were applied to the Erzincan case. A total of 105 plant taxa, including 36,799 individuals, were identified, with 56% being natural and 44% exotic. Kemaliye had the highest species diversity index and while Çayirli had the lowest. The plants consisted of 54% edible-leaf broadleaf trees, 19% conifers, and the remaining being edible shrubs, small trees, and vines. Biodiversity assessments revealed that Kemaliye had the highest diversity index, and Çayirli the lowest. Districts were analyzed using the

“Bio-friendly Settlement” criteria, with all districts, including Çağlayan, Çayirli, Kemah, Kemaliye, Refahiye, Tercan, and Üzümlü, showing high biodiversity characteristics. The average Bio-friendly score for the districts was 90.7 points. The Shannon–Wiener diversity index indicated that Kemaliye exhibited the highest biodiversity with a high evenness value ($E=0.896$), whereas Çayirli showed the lowest diversity; this pattern was consistently supported by the Simpson diversity index results. In conclusion, the study stresses the importance of implementing conservation measures to enhance ecological sustainability in Erzincan, which also holds significant potential for agricultural landscapes and tourism. The high Bio-friendly scores of these districts underscore the need for strategies supporting ecological balance and biodiversity preservation.

Keywords Urban biodiversity · Biodiversity-friendly city · Edible fruits · Erzincan · Climate change · Conservation strategies

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Introduction

Population growth, urbanization, industrialization, and unsustainable production–consumption patterns are driving the depletion of natural resources, environmental pollution, climate change, and a dramatic decline in biodiversity, thereby intensifying

anthropogenic pressures on ecosystems (Geng et al., 2025; Zhang et al., 2022). Vegetation studies conducted in Türkiye indicate that important knowledge gaps still exist regarding the characterization of biodiversity and ecological structures. For instance, a study carried out in the Esenli Forest and Vegamaoneta-tion Unit identified four new plant communities and highlighted the importance of local-scale ecological inventory studies (Karaköse, 2019). These findings underscore the necessity of evaluating areas with diverse ecological characteristics, such as the districts of Erzincan, within the framework of the biodiversity-friendly city approach.

In this process, humans are simultaneously the agents of environmental degradation and the ultimate victims of its consequences (Otto & Pensini, 2017). Among these pressures, urbanization stands out as one of the most significant drivers of habitat loss and biodiversity decline within cities (Woodward et al., 2003). Yet urban biodiversity sustains ecosystem services the benefits that ecosystems provide to society, including the regulating, provisioning, and cultural functions that directly enhance human quality of life and societal well-being (Gordon et al., 2009).

Trees and other vegetation in gardens, parks, university campuses, and streets are central to these services: they constitute a crucial component of urban floristic diversity, reconnect people with nature, and support a wider range of wildlife (Hartig & Kahn, 2016; Le Roux et al., 2014; Liu et al., 2021). Conversely, the loss of plant diversity can weaken ecosystem stability (Demir, 2009) and, through associated effects such as urban temperature fluctuations, adversely affect pollinator populations (Fukase & Simons, 2016). Enhancing biodiversity within urban green spaces is therefore increasingly recognized as a key strategy for building resilient, sustainable, and climate-adapted cities (Kowarik et al., 2020).

Building on this recognition, a growing body of research has examined how urban biodiversity can be conserved and enhanced. Studies emphasize ecosystem resilience through planning approaches that promote green infrastructure and natural species (Kowarik et al., 2020), and highlight the role of forest and tree-dominated ecosystems in maintaining ecosystem functions and regulating services (Karaköse & Terzioğlu, 2021).

Recent work has broadened the focus beyond species counts: functional diversity, defined by species' ecological roles and traits, is now understood to be critical for ecosystem functioning and resilience (Petchey & Gaston, 2006), while non-natural species are recognized as integral components of urban ecosystems whose effects range from neutral to highly disruptive when invasive behavior emerges (Pyšek et al., 2020). Wild edible plants have likewise been shown to deliver services spanning nutrition, food security, environmental stressors adaptation, and the sustainable urban management goals (Karaköse, 2026), and a range of analytical software tools (e.g., Biodiv, PAST, EstimateS, PAUP, BİÇEB) now support the measurement of these diversity components (Özkan et al., 2020).

Despite this progress, integrative studies that jointly address floristic diversity and planning approaches in medium-sized cities remain scarce. The Biodiversity-Friendly City concept offers a promising framework for advancing climate-resilient urban ecosystems through biodiversity-oriented planning and for assessing biodiversity patterns across urbanization gradients (McKinney, 2006), yet its application to medium-sized urban settings and its potential to translate ecological knowledge into local planning practice (Askan & Yılmaz, 2025) has rarely been tested empirically.

Erzincan provides an ideal setting to address this gap. As a medium-sized Anatolian city set within a topographically and climatically distinctive valley, it combines an ecologically rich surrounding landscape with a range of urban open–green spaces across its center and affiliated districts, offering a clear urbanization gradient against which biodiversity-friendly city criteria can be evaluated. Within this context, the present study assesses terrestrial plant (floristic) biodiversity in the urban open–green spaces of Erzincan and its districts using biodiversity indices and biodiversity-friendly city criteria, in order to develop conservation-oriented strategies that support climate resilience and sustainable urban planning and to provide a comprehensive reference for landscape architects, urban decision-makers, city planners, and researchers (Askan et al., 2024). The specific objectives are to:

- Assess and map current biodiversity levels in the open–green spaces of Erzincan city center and its affiliated districts;

- Propose short-, medium-, and long-term strategic recommendations and a conceptual framework for ensuring the continuity of biodiversity;
- Encourage the use of natural species in landscape applications to build resilience against environmental stressors, while highlighting the associated ecological and economic benefits;
- Promote the sustainable and efficient use of natural and cultural resources;
- Compare different urban open–green spaces in terms of their biodiversity and ecosystem services; and
- Raise public awareness of biodiversity and ecosystem services at local and broader scales.

Accordingly, the study tests the following hypotheses:

H1: Erzincan has the potential to meet biodiversity-friendly city criteria on the basis of its ecological and environmental characteristics.

H2: Public open–green spaces exhibit higher biodiversity-friendly characteristics than other urban areas.

H3: Biodiversity-friendly characteristics differ among the districts of Erzincan.

Material and method

Material

The main material of this study consists of seven different areas, including six districts (Çayirli, Kemah, Kemaliye, Refahiye, Tercan, Üzümlü) and one town (Çağlayan) within the province of Erzincan, located in the Eastern Anatolia Region. Erzincan is situated in the Upper Euphrates Section of the Eastern Anatolia Region, between 39°02'–40°05' North latitude and 38°16'–40°45' East longitude.

The province is characterized by a geography often described as “surrounded by mountains, with vineyards in the center.” It is generally covered by mountains and plateaus, with mountain ranges extending in various directions within specific boundaries. The locations and images of the study areas are presented in Fig. 1.

Erzincan, located in the Eastern Anatolia Region, has a more temperate climate compared to other

provinces in the region, except for Elâzığ and Malatya, due to its continental climate characteristics. The topography of the region varies between 850 and 3550 m, and local climatic differences, along with geological diversity, further enhance this richness. Erzincan, located in the Iran Turanian Region and close to the European-Siberian Flora Region, serves as a convergence zone for various plant species. Additionally, its position on the Anatolian Diagonal influences species distribution and isolation, hosting approximately 60 local endemic species (Kandemir et al., 2022).

According to long-term meteorological data, the mean annual temperature is approximately 10.6 °C, and the total annual precipitation ranges between 380 and 400 mm. The warmest period generally occurs during July–August, with average temperatures ranging from 22 to 24 °C, while the coldest month is January, with an average temperature of around –5 °C. Precipitation is predominantly concentrated in the spring months, whereas a pronounced dry period is observed during the summer season (MGM, 2023).

The total population of the province is 241,239. The distance and population figures for the eight districts of Erzincan Province from the city center are provided in Table 1.

The population distributions of the districts of Erzincan are presented. This figure quantitatively reveals differences in population among the districts, clearly illustrating where the population is concentrated and which districts have relatively lower population levels. The obtained data allow for the evaluation of the spatial distribution of the population in Erzincan and the analysis of demographic differences among the districts, as shown in Fig. 2.

Methodology

In alignment with the research objectives and scope, the following analyses, measurements, findings, and graphical representations aim to provide components for proposed solutions. After conducting a literature review on the topic, the research methodology consists of the following phases:

Determination of research areas

- The typological characteristics of open green spaces located in six districts and one town affiliated with

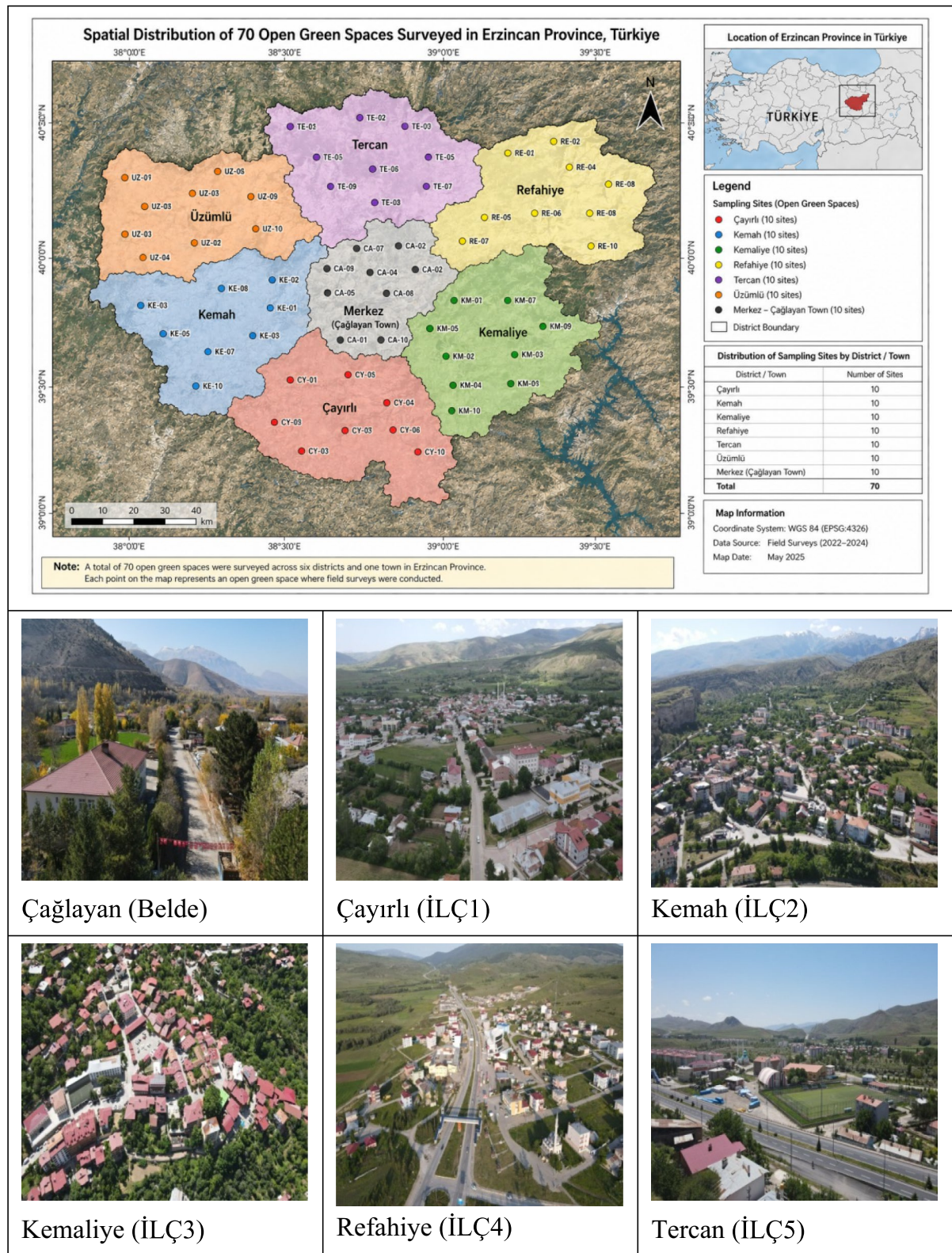
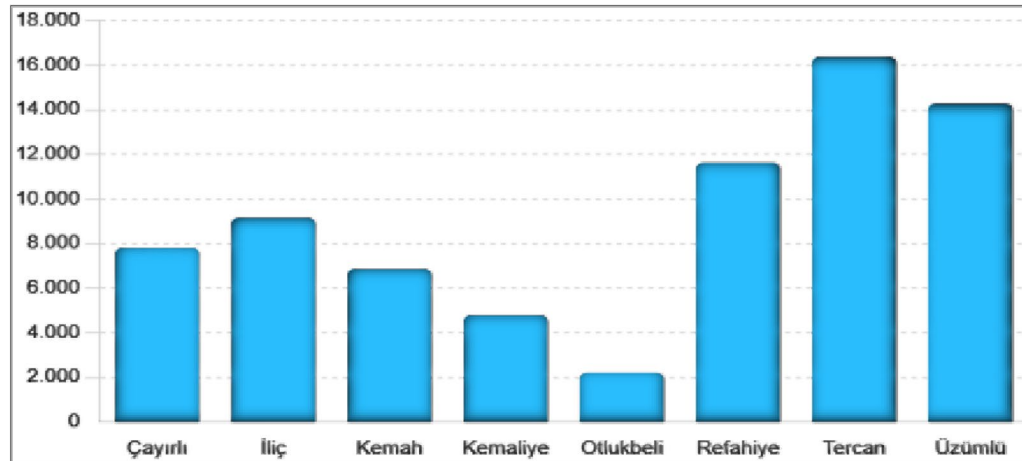


Fig. 1 Location and appearance of 6 districts and 1 town within Erzincan city center

Table 1 Distances of districts from the Erzincan City Center and population figures (TÜİK, 2025)

District Name	Çayırılı	İliç	Kemah	Kemaliye	Otlukbeli	Refahiye	Tercan	Üzümlü
Km	79	114	51	151	142	76	100	24

**Fig. 2** Population distribution of Erzincan districts

Erzincan city center were investigated through field surveys and drone-based imaging techniques. The high-resolution aerial data obtained from drone surveys were utilized for spatial analyses of the study areas and served as a supporting tool for measuring and validating specific assessment criteria included in the applied index.

- To ensure the continuation of field studies and enable drone imagery, necessary permissions were obtained from the Ministry of Agriculture and Forestry/Directorate General of Nature Conservation and National Parks.
- The research on plant species in Erzincan Province was conducted across a total of 70 different green spaces located in the city center and six districts. In the selection of study sites, particular attention was given to evaluating ten green spaces with diverse characteristics representing each district, and only areas that had been established for at least five years were included in the study. Within each sampling site, plant species were identified, the number of individuals was recorded, and the status of natural plant populations was assessed. Species identification was supported by field surveys and observations conducted during different

vegetation periods throughout the year to ensure a more accurate determination of the plants' phenological characteristics.

- The plant species identified were classified into the following groups: broadleaf species with edible fruits, broadleaf species with non-edible fruits, coniferous species, shrub-like plants with edible fruits, climbing plants with edible fruits, and shrub-like or climbing plants with non-edible fruits.
- In determining the areas to be included in the study, criteria such as the land area of the gardens, their establishment at least five years ago, their location in different parts of the city, plant diversity, density levels, and their general recognition across the city were considered.

Studies conducted in the research areas

All study areas located within the city center of Erzincan and six district centers were evaluated based on the Shannon–Wiener Diversity Index (H'), Simpson Diversity Index ($1/D$), and the Biodiversity Index criteria. The biodiversity levels were analyzed in light of the data obtained.

The Shannon–Wiener Diversity Index (H') measures species diversity in an ecosystem and the evenness of individual distribution among species. Higher values indicate greater diversity and more even distribution. The values range from 0 to 5, where values below 1.5 indicate low diversity, values between 1.5 and 2.5 indicate medium diversity, and values above 2.5 indicate high diversity. The Evenness (E) value indicates the homogeneity of species distribution, with values close to 0 indicating inequality and values close to 1 indicating equality.

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

Here,

p_i The ratio of the i th species to the others
 $\ln$ represents the base of the natural logarithm (Magurran, 1988, 2004).

The Simpson index ($1/D$) Lower values (beginning from 1) indicate a greater dominance of particular species and, consequently, lower biodiversity. In contrast, higher values reflect increased biodiversity, indicating a more even distribution of individuals among species within the ecosystem.

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

Here,

i Number of species
 n_i Number of individuals of a species
 N It shows the total number of individuals of a species in a region (Magurran, 1988, 2004).

The Bio-friendly Index assesses the biological diversity of ecosystems by evaluating them against ten primary criteria. Scores ranging from 50 to 60 indicate a low level of biodiversity, while scores between 61 and 80 suggest a moderate level, and scores from 81 to 100 represent high biodiversity levels. This index is particularly used to measure the sustainability of urban green spaces. It provides valuable insights into the ecological health and biodiversity status of these areas, which is crucial for planning and

maintaining sustainable urban environments (Yılmaz, 2024).

Office-based analyses

In this study, the identification of natural species present in the study areas was based on their floristic characteristics and natural distribution ranges within Türkiye. The taxonomic identification of plant species was performed using expert assessments and verified with standard botanical references, including Flora of Turkey and the East Aegean Islands (Davis, 1965–1985), Yücel (2005) and Plants of the World Online (POWO, 2025).

The biological diversity of the six districts and one town in the central area of Erzincan was evaluated using the Shannon–Wiener, Simpson Indices, and the Bio-friendly Index developed by Prof. Dr. Hasan Yılmaz (Magurran, 1988, 2004; Yılmaz, 2024). In addition, urban open-green spaces and ecosystem components were identified, and a logo and QR code system were developed for bio-friendly areas. These tools are intended to enhance public awareness by providing accessible information on the ecological characteristics, biodiversity values, and sustainability attributes of these areas, thereby supporting environmental education and promoting the widespread adoption of bio-friendly practices. As a result, the biological diversity level of Erzincan's six districts and one town was analyzed, with an emphasis on raising awareness.

In this study, “natural species” are defined as taxa that occur naturally within the biogeographical regions of Türkiye, whereas “non-natural (exotic) species” refer to those introduced intentionally or unintentionally through human activities. This distinction is critical for evaluating ecological functions, species interactions, and potential impacts on ecosystem stability.

Results

In the scope of the research, study areas were determined to analyze the city within the framework of biodiversity-friendly criteria. A total of six districts and one town were examined in detail in terms of land use and plant material.

Analysis of open and green space typologies in the city

As part of the research, the general topographic structure, vegetation density, and existing land uses of the study areas were identified. Fieldwork was carried out continuously, and the typological characteristics of the areas were determined through aerial imaging activities (drone footage) (Fig. 3).

In the urban center of Erzincan and its surrounding districts, field studies were conducted to investigate the seasonal changes in land use, vegetation density, and ecosystem components during the spring and autumn seasons. Drone technology was utilized to capture aerial imagery to provide a comprehensive view of the study areas and to assess the seasonal dynamics of these elements.

The drone imagery proved to be a significant data source, particularly in determining the effects

of seasonal transitions on the natural vegetation, the distribution of green spaces, and landscape integrity. During the spring season, the images revealed the rejuvenation of natural plant species and an increase in the volume of green spaces. In contrast, the autumn imagery highlighted the phenomena of leaf shedding, signs of drought, and maintenance deficiencies in certain areas.

These aerial images enabled a seasonal analysis of the biophysical structure of the study areas, contributing to evaluations on various aspects such as plant species richness, the area's vegetation density, ecosystem continuity, and the ecological impacts of human interventions. Additionally, the drone imagery served as a supplementary tool for field-based plant species identification, enhancing the accuracy and comprehensiveness of the terrestrial analysis. Overall, the aerial footage provided valuable insights into the seasonal fluctuations in urban ecosystems and

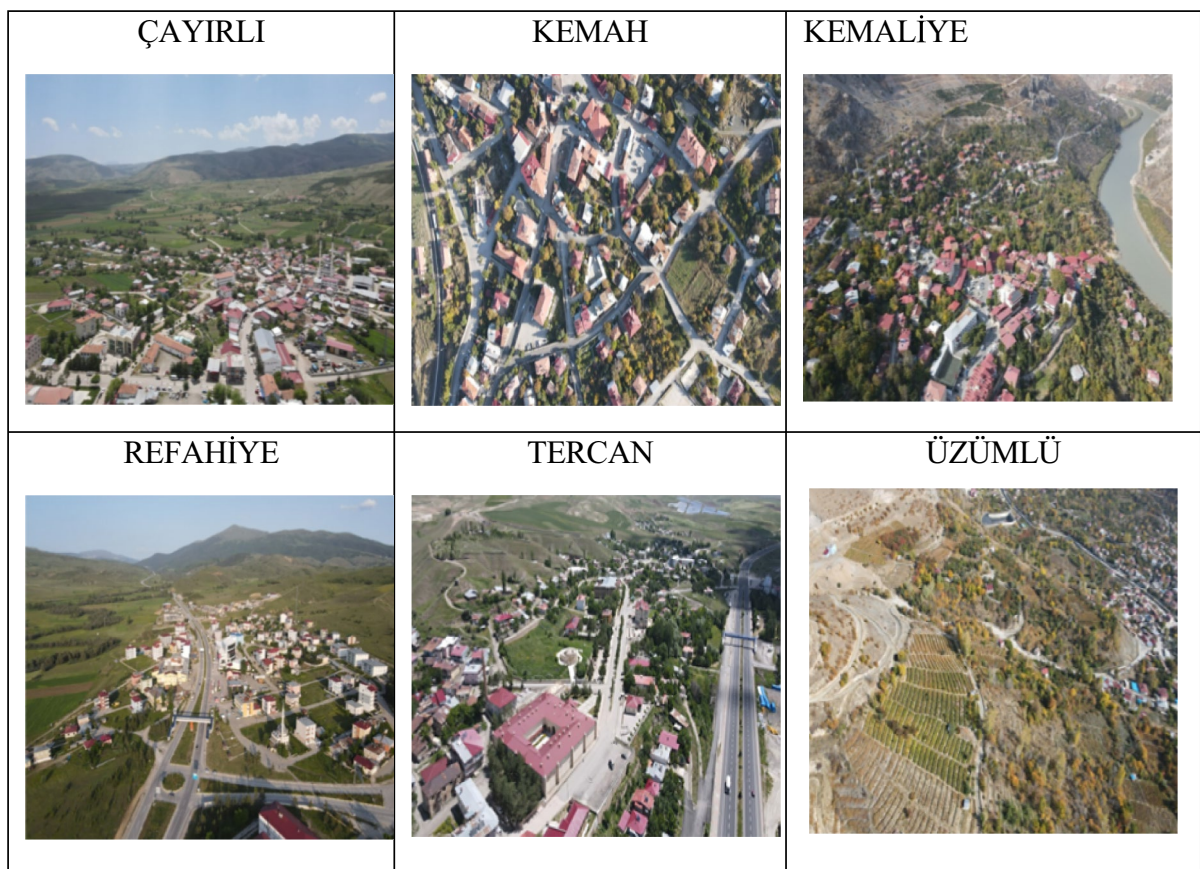


Fig. 3 Typological view of open-green areas in 6 districts and 1 town in the city center

facilitated a deeper understanding of the dynamics between natural and human-influenced ecological systems (Fig. 4).

A total of 105 plant taxa were identified within the scope of this study, comprising 48 natural species and 57 exotic species. Across all study sites, 36,799 individual plants were recorded. Although exotic species accounted for a higher proportion of the total taxa (54.3%) than natural species (45.7%), an evaluation based on the number of individuals revealed an opposite pattern. Natural species represented 56% of all recorded individuals, whereas exotic species constituted 44%. These findings indicate that, despite the greater taxonomic richness of exotic species, natural species were more dominant in terms of population abundance within the investigated green spaces (Table 2).

The distribution of natural plant species and their proportions within the overall species composition across the study areas is presented in Fig. 5. The study revealed that the highest species diversity in terms of natural plant species was observed in Çağlayan Town, with 28 different species, while the lowest diversity was recorded in Refahiye District, with only 17 species. In comparison to other usage areas, the districts were found to have a greater variety of edible fruit-bearing plant species.

Within the scope of the study conducted in seven different regions of the city of Erzincan, the naturalness level and species richness of the plants used in each area were analyzed, and the results are presented in Fig. 5, Table 3.

The number of individuals and the percentage distribution of each group were analyzed and

presented (Fig. 9). In terms of species richness, the highest diversity was found in Çağlayan Township (BLD), with 63 different species, while the lowest diversity was recorded in Refahiye District (ILÇ4), with 40 different species. When evaluating the plant counts, the highest usage, at 54%, was found in broadleaf tree species with edible fruits, while the lowest proportion was observed in shrub-like plants, shrubs, and climbers with non-edible fruits. The numbers and proportions of edible fruit-bearing plants identified in seven different regions of the city of Erzincan are presented in Fig. 6.

Beyond species richness, functional diversity is a key determinant of ecosystem functioning, as species with different ecological traits contribute differently to processes such as nutrient cycling, habitat provision, and resilience to disturbances (Petchey & Gaston, 2006). Therefore, evaluating biodiversity solely based on species counts may overlook important ecological dimensions, and future studies should incorporate trait-based approaches to better understand ecosystem dynamics.

In the study, data on the construction year, the ratio of open-green areas to impervious surfaces, and fauna counts (such as birds, butterflies, squirrels, etc.) for 70 different areas were examined. Construction year data were obtained through municipalities, neighborhood headmen, public institutions, and individual interviews. The ratio of impervious surfaces was determined through on-site land measurements and Google Earth imagery.

In addition to plant diversity, fauna observations contributed to the evaluation of ecosystem functionality. During field surveys, various fauna groups,



Fig. 4 Natural landscape characters of Erzincan districts

Table 2 Plant species identified in 6 districts and 1 town of Erzincan City

Family	Latin name	Natural species	Work areas						Total	
			BLD	İLÇ1	İLÇ2	İLÇ3	İLÇ4	İLÇ5		İLÇ6
Broadleaf trees										
Aceraceae	<i>Acer negundo</i> L	-	20	35			205	60		320
	<i>Acer platanoides</i> L	+	20		70			25		115
Actinidiaceae	<i>Actinidia deliciosa</i> (A.Chev.) C.F.Liang & A.R.Ferguson	-				50			5	55
Amygdaloideae	<i>Mespilus germanica</i> L	-	6	2		30				38
Anacardiaceae	<i>Pistacia vera</i> L	-				20			6	26
Betulaceae	<i>Betula verrucosa</i> Ehrh	+	8	6	2		52	5		73
	<i>Corylus avellana</i> L	+	12			20		30	65	127
Bignoniaceae	<i>Catalpa bignonioides</i> Walt	-	4	10	125			20		159
	<i>Catalpa bignonioides</i> Walter Umbraculifera	-						50		50
Celastraceae	<i>Euonymus europaeus</i> L	+	6							6
Ebenaceae	<i>Diospyros kaki</i> Thunb	-	6			150			2	158
Elaeagnaceae	<i>Elaeagnus angustifolia</i> L	+	28	13	55			20		116
	<i>Elaeagnus umbellata</i> Thunb	-	2							2
Fabaceae	<i>Gleditsia triacanthos</i> L	-			50					50
Fagaceae	<i>Quercus robur</i> L	+				25				25
Hippocastanaceae	<i>Aesculus hippocastanum</i> L	-	11	1	25			5		42
Juglandaceae	<i>Juglans regia</i> L	+	200	18	37	90	10	15	415	785
Leguminosae	<i>Robinia pseudoacacia</i> L. 'Umbraculifera'	-		84	100	25	35	150	10	404
	<i>Robinia hispida</i> L	-	6	4	30	12	80	90		222
Malvaceae	<i>Hibiscus syriacus</i> L	-							10	10
Mimosaceae	<i>Albizia julibrissin</i> Durazz	-				10				10
Moraceae	<i>Ficus carica</i> L	+	6			120			4	130
	<i>Morus alba</i> L	+	36	16	70	300	15	20	1041	1498
	<i>Morus pendula</i> L	-	2	10	12	15			4	43
Oleaceae	<i>Fraxinus exelsior</i> L	+	24	8	85	30	55	90		292
Platanaceae	<i>Platanus orientalis</i> L	+	4		27	20	30	20	10	111
Punicaceae	<i>Punica granatum</i> L	+				8			2	10

Table 2 (continued)

Family	Latin name	Natural species	Work areas						Total	
			BLD	İLÇ1	İLÇ2	İLÇ3	İLÇ4	İLÇ5		İLÇ6
Rosaceae	<i>Cydonia oblonga</i> Mill	-	6	10	10	60	2	10	23	121
	<i>Malus communis</i> Laxm	-	352	95	90	90	34	50	1397	2108
	<i>Malus</i> × <i>purpurea</i> f. <i>eleyi</i> (Bean) Rehder	-	6	25	40	30	110	10	4	225
	<i>Prunus amygdalus</i> Batsch	-	12			290	10		1	313
	<i>Prunus armeniaca</i> L	-	128	62	110	75	20	111	1266	1772
	<i>Prunus avium</i> L	+	21	35	75	45	35	35	1633	1879
	<i>Prunus cerasifera</i> Ehrh. ‘Atropurpurea’	-	4	15			104	33	5	161
	<i>Prunus cerasus</i> L	+	4	8511	50	48	32	35	19	8699
	<i>Prunus divaricata</i> Ledeb	-							5	5
	<i>Prunus domestica</i> L	-	126	12	36	22	60	20	214	490
Salicaceae	<i>Prunus mahaleb</i> L	+	4	6		12	14			36
	<i>Prunus persica</i> L	-	12	2	20	40			347	421
	<i>Pyrus communis</i> L	+	70	12	25	25	10		517	659
	<i>Populus alba</i> L	+	44	100	30	50	50	130		404
	<i>Salix babylonica</i> L	-	220	56	40	18	15	20		369
	<i>Koelreuteria</i> sp.	-			4					4
	<i>Ailanthus altissima</i> (Miller) Swingle	-	6		120			50		176
	<i>Tilia tomentosa</i> Moench	+	12	10	40	30	60	50	2	204
	<i>Ulmus glabra</i> Huds	+	7	8	60		30	100		205
	Total broadleaf trees 23128									
Coniferous trees										
Cupressaceae	<i>Cupressocyparis leylandii</i> (A.B.Jacks. & Dallim.) Dallim	-			10					10
	<i>Cupressocyparis leylandii</i> ‘Gold Rider’	-							6	6
	<i>Cupressus arizonica</i> Greene	-	6	24	250	30		80	18	408
	<i>Juniperus drupacea</i> Labill	+				75				75
	<i>Juniperus sabina</i> L	+	8		60		750	80		898
	<i>Juniperus virginiana</i> L	-							6	6
	<i>Platycladus orientalis</i> (L.) Franco	-	50	140	100	20	150	600	20	1080
	<i>Platycladus orientalis</i> (L.) Franco ‘Pyramidalis Aurea’	-	10	70	120	30	200	270	35	735

Table 2 (continued)

Family	Latin name	Natural species	Work areas						Total		
			BLD	İLÇ1	İLÇ2	İLÇ3	İLÇ4	İLÇ5		İLÇ6	
Pinaceae	<i>Cedrus atlantica</i> (Endl.) Manetti ex Carrière ‘Glaucua’	-					20	62	4	86	
	<i>Cedrus libani</i> A.Rich	+	2	62	15	20	4			103	
	<i>Picea glauca</i> (Moench) Voss ‘Conica’	-							16	16	
	<i>Picea orientalis</i> L	+	4	16	20	25	1		4	70	
	<i>Picea pungens</i> Engelm. ‘Glaucua’	-	22	35	80	30	217	140	14	538	
	<i>Picea pungens</i> Engelm. ‘Glaucua Globosa’	-							6	6	
	<i>Pinus halepensis</i> Mill	+					50			50	
	<i>Pinus nigra</i> Arnold	+			190			30		220	
	<i>Pinus sylvestris</i> L	+		29	210	320	110	720	1310	35	2734
Tamaricaceae	<i>Tamarix tetrandra</i> Pall. ex M.Bieb	+			10					10	7051
Total coniferous trees											
Trees-bushes-vines											
Anacardiaceae	<i>Pistacia terebinthus</i> L	+				45					45
	<i>Rhus coriaria</i> L	+				18					18
Apocynaceae	<i>Nerium oleander</i> L	+	2								2
	<i>Hedera colchica</i> (K. Koch) K. Koch	+				100					100
Araliaceae	<i>Hedera helix</i> L	+				20					20
	<i>Berberis thunbergii</i> DC. ‘Atropurpurea’	-	20	20	50	10	500	180	20	800	6
Berberidaceae	<i>Mahonia aquifolium</i> (Push) Nutt	-		6							6
	<i>Campsis radicans</i> (L.) Bureau	-			5	15			6	36	36
Bignoniaceae	<i>Buxus sempervirens</i> L	+			2				30	32	32
	<i>Lonicera caprifolium</i> L	+	10		20	40		10	10	90	90
Caprifoliaceae	<i>Sambucus nigra</i> L	+				40	20	10		70	70
	<i>Viburnum opulus</i> L	+	18		10					28	28
Celastraceae	<i>Weigela florida</i> (Bunge) A.DC	-			10					10	10
	<i>Euonymus japonicus</i> Thunb	-	20		15			20	20	75	75
Cornaceae	<i>Cornus alba</i> L	-	8	50	6	30			13	107	107
	<i>Arbutus unedo</i> L	+				20				20	20
Ericaceae	<i>Vaccinium angustifolium</i> Aiton	-	6							6	6
	<i>Ribes rubrum</i> L	-	4							4	4
Grossulariaceae											

Table 2 (continued)

Family	Latin name	Natural species	Work areas						Total	
			BLD	İLÇ1	İLÇ2	İLÇ3	İLÇ4	İLÇ5		İLÇ6
Oleaceae	<i>Forsythia x intermedia</i> Zabel	-	10		30			50	26	116
Papilionaceae	<i>Syringa vulgaris</i> L	+	8	2	4		15	55	4	88
	<i>Wisteria sinensis</i> Sims	-				15				15
Rhamnaceae	<i>Paliurus spina-christi</i> Mill	+			50	100				150
	<i>Rhamnus frangula</i> L	+				10				10
Rosaceae	<i>Ziziphus jujuba</i> Mill	-	2							2
	<i>Aronia melanocarpa</i> (Michx.) Elliott	-	2							2
	<i>Crataegus monogyna</i> Jacq	+	80	100		20	20		30	250
	<i>Cydonia japonica</i> Mill	-	4		10		4	20		38
	<i>Pyracantha coccinea</i> M.Roem	+		20	100					120
	<i>Rosa canina</i> L	+	5	156		10	30		30	231
	<i>Rosa hybrida</i> L	-	30	50	370	100	515	150	200	1415
	<i>Rosa</i> sp.	+	6							6
	<i>Rubus idaeus</i> L	+	100			100			12	212
	<i>Sorbus domestica</i> L	+				40	20	10		70
Solanaceae	<i>Spiraea x vanhouttei</i> (Briot) Zabel	+	2			10				10
	<i>Hyoscyamus niger</i> L	+				30				30
	<i>Lycium barbarum</i> L	-				40			4	44
Vitaceae	<i>Ampelopsis veitchii</i> Laurentius	-	16	6	20	50	5	30	10	137
	<i>Vitis vinifera</i> L	+	252		8	25			1960	2245
Total of trees, shrubs and clinging plants										
Total number of plants										

Fields of study:

BLD: Çağlayan Town-DISTRICT 1.; Çayirli District-DISTRICT 2.; Kenah District-DISTRICT 3.; Kemaliye District-DISTRICT 4.; Refahiye District-DISTRICT 5.; Tercan District-DISTRICT 6.; Uzumlu District.

*The symbols (+) and (-) in the table denote, respectively, natural species and exotic species.

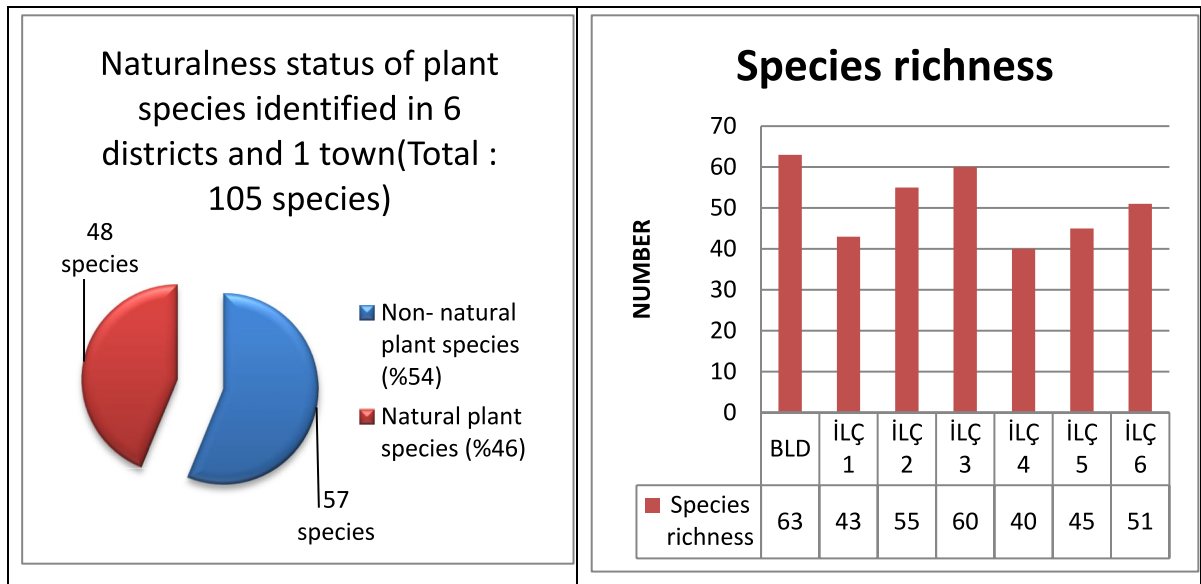


Fig. 5 Naturalness level and species richness of plants used in 7 areas of Erzincan city center

Table 3 Species diversity determined in the 6 districts and 1 town of Erzincan city

Results	BLD1	İLÇ1	İLÇ2	İLÇ3	İLÇ4	İLÇ5	İLÇ6
Species richness	63	43	55	60	40	45	51
Total plant count	2167	10133	3340	2948	4289	4381	9546

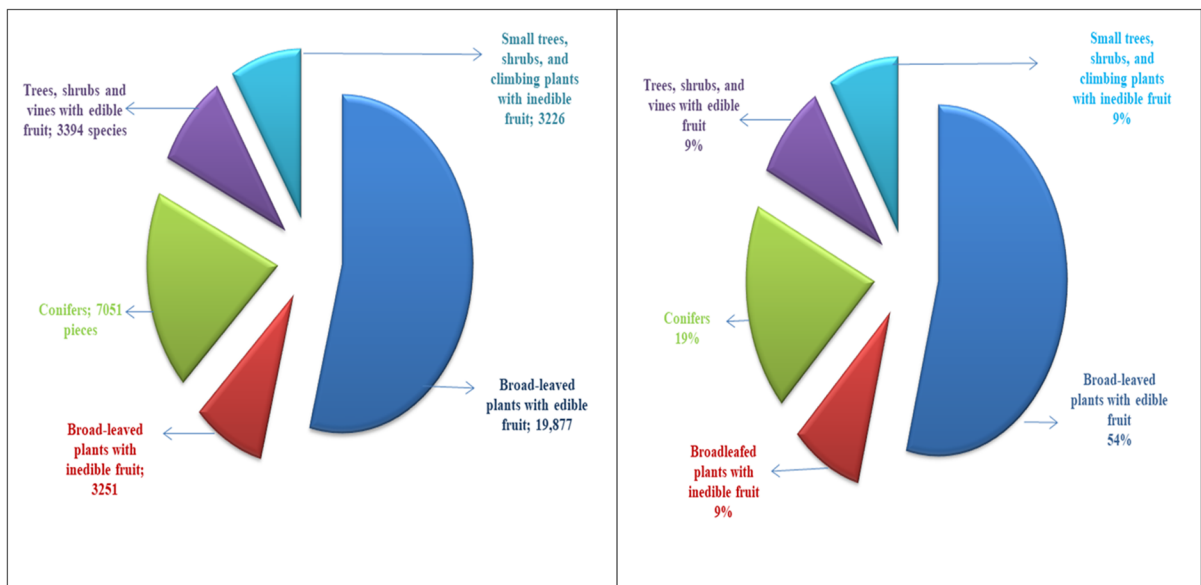


Fig. 6 Number and proportion of plants with edible fruits in 7 areas of Erzincan city center

including birds, bees, lady beetles, butterflies, and small mammals, were recorded. Areas characterized by higher species richness and greater structural complexity of vegetation were associated with increased fauna presence and activity. In particular, green spaces dominated by natural and fruit-bearing plant species were observed to provide essential feeding and shelter opportunities for urban wildlife. These findings indicate a strong relationship between vegetation diversity and fauna distribution, underscoring the ecological significance of plant-based urban biodiversity (Fig. 7).

Biodiversity level of open-green areas in the districts of Erzincan city center

The plant species identified in the districts affiliated with Erzincan City Center were analyzed using the Shannon–Wiener Diversity Index (H'), the Simpson Diversity Index ($1/D$), and the Biodiversity Index.

Shannon–Wiener Diversity Index (H') results for the districts affiliated with Erzincan city center

The statistical significance of the diversity difference between the two communities is indicated by an asterisk (*), representing a significance level of 5%, and the double asterisk (**) represents a significance level of 1%.

The study areas reveal that the ILÇ3 area exhibits a nearly perfect equality characteristic, with a proportion of 89.6%. There is also a distinction in terms of biodiversity. In the results, the * symbol indicates a

significant diversity difference between the two communities at the 5% level, while the ** symbol indicates significance at the 1% level.

The Shannon–Wiener index results are as follows: $ILÇ3 > ILÇ2 > BLD > ILÇ5 > ILÇ4 > ILÇ6 > ILÇ1$ (Table 4). The distribution balance of species (E) is ranked as: $ILÇ3 > ILÇ2 > BLD > ILÇ5 > ILÇ4 > ILÇ6 > ILÇ1$. A statistically significant difference at the 1% level is found between the ILÇ1 and ILÇ3 areas. The Shannon–Wiener index results (HI) and the interspecies distribution are presented in Fig. 8.

Based on the Shannon–Wiener index results applied in the central district of Erzincan and its associated districts, Kemaliye district (ILÇ3) is characterized by high biodiversity, while Çayırılı district (ILÇ1) is identified as an area with low biodiversity. In terms of species distribution, the best species distribution is observed in Kemaliye (ILÇ3), whereas Çayırılı (ILÇ1) exhibits the lowest level of species homogeneity.

The results of the Simpson Diversity Index ($1/D$) for the districts of Erzincan city center and its surrounding districts show the significance of biodiversity differences between the communities. This index is based on the number of species and individuals present in the areas. According to Simpson index values ($1-\lambda$), the biodiversity ranking from highest to lowest is as follows: $ILÇ3 > ILÇ2 > BLD > ILÇ4 > ILÇ5 > ILÇ6 > ILÇ1$ (Table 5). Additionally, the biodiversity characteristics of ILÇ5 and ILÇ6 are similar, as indicated by the data (Table 5). The Simpson diversity index values obtained from analyses conducted in the green

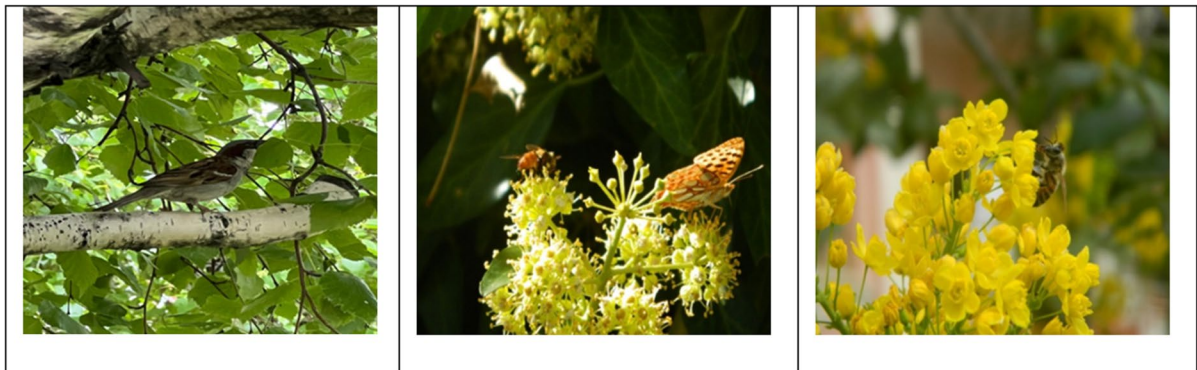
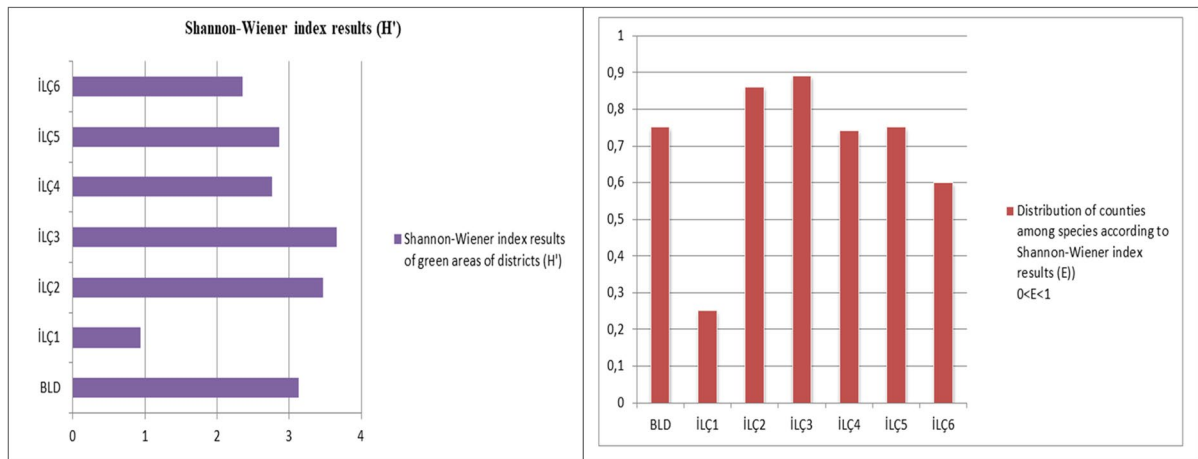


Fig. 7 Observations made in the field, along with fauna density and diversity, contributed to the assessment of ecosystem functionality

Table 4 Shannon–Wiener Index results for green areas in 6 district centers and 1 township

Results	BLD	İLÇ1	İLÇ2	İLÇ3	İLÇ4	İLÇ5	İLÇ6
H'	3.13996	0.94629	3.47928	3.66913	2.76158	2.86335	2.35954
E	0.75787	0.25159	0.86823	0.89615	0.74862	0.75219	0.60011
Var H'	0.00074	0.00032	0.00027	0.0003	0.00032	0.00045	0.00014
	1	2	3	4	5	6	7
1		** $t=67.37804$ $SD=4275.4104$ $p=0.0$	** $t=-10.67699$ $SD=3715.86026$ $p=0.0$	** $t=-16.40887$ $SD=3818.82126$ $p=0.0$	** $t=11.62185$ $SD=4062.55652$ $p=0.0$	** $t=8.01852$ $SD=4737.35769$ $p=0.0$	** $t=26.30795$ $SD=3039.80956$ $p=0.0$
2			** $t=-104.28155$ $SD=10,901.30974$ $p=0.0$	** $t=-109.35189$ $SD=9459.87931$ $p=0.0$	** $t=-71.75564$ $SD=12,053.92789$ $p=0.0$	** $t=-69.08605$ $SD=10,525.86369$ $p=0.0$	** $t=-65.89312$ $SD=17,403.01661$ $p=0.0$
3				** $t=-7.95194$ $SD=6205.64942$ $p=0.0$	** $t=29.54724$ $SD=7616.83842$ $p=0.0$	** $t=22.95436$ $SD=7618.07678$ $p=0.0$	** $t=55.30002$ $SD=7039.49221$ $p=0.0$
4					** $t=36.44809$ $SD=7065.63077$ $p=0.0$	** $t=29.42293$ $SD=7328.84738$ $p=0.0$	** $t=62.43225$ $SD=5941.86031$ $p=0.0$
5						** $t=-3.66754$ $SD=8458.23667$ $p=0.00025$	** $t=18.74521$ $SD=8160.98424$ $p=0.0$
6							** $t=20.74153$ $SD=7210.69101$ $p=0.0$
7							


Fig. 8 Shannon–Wiener index results (H') and inter-type distribution (E) of green areas in districts

spaces of six districts and one town are presented in Fig. 9.

The Bio-friendly index results for the districts affiliated with Erzincan city center are presented in Table 6.

The application of the Biophilic Index criteria to the six district centers and one town has resulted in the identification of high-level biophilic areas, specifically in the BLD, İLÇ1, İLÇ2, İLÇ3, İLÇ4,

Table 5 Simpson diversity index results of green areas of 6 district centers and 1 town

Results	BLD	İLÇ1	İLÇ2	İLÇ3	İLÇ4	İLÇ5	İLÇ6
1—λ	0.92692	0.29303	0.95535	0.96186	0.90187	0.87762	0.87044
Var D	5.53e-06	3,66E-02	1.49e-06	1.51e-06	3.93e-06	1,36E-02	1.66e-06
	1	2	3	4	5	6	7
1		** $t=97.63715$ SD=12,130.89376 $p=0.0$	** $t=-10.73021$ SD=3334.98659 $p=0.0$	** $t=-13.16851$ SD=3329.51529 $p=0.0$	** $t=8.14446$ SD=5052.27203 $p=0.0$	** $t=11.2835$ SD=6498.03891 $p=0.0$	** $t=21.06349$ SD=3589.81851 $p=0.0$
2			** $t=-107.28732$ SD=10,919.51724 $p=0.0$	** $t=-108.31344$ SD=10,922.05204 $p=0.0$	** $t=-95.61098$ SD=12,095.49904 $p=0.0$	** $t=-82.5251$ SD=14,445.46706 $p=0.0$	** $t=-93.32507$ SD=11,048.38929 $p=0.0$
3				** $t=-3.75855$ SD=6258.08241 $p=0.00017$	** $t=22.97163$ SD=6886.57362 $p=0.0$	** $t=20.03643$ SD=5312.54641 $p=0.0$	** $t=47.84137$ SD=10,407.86006 $p=0.0$
4					** $t=25.7205$ SD=6765.04187 $p=0.0$	** $t=21.7001$ SD=5313.12471 $p=0.0$	** $t=51.34659$ SD=9461.30535 $p=0.0$
5						** $t=5.79852$ SD=6712.49539 $p=0.0$	** $t=13.29347$ SD=8033.51998 $p=0.0$
6							$t=1.84042$ SD=5481.58837 $p=0.06576$
7							

İLÇ5, and İLÇ6 zones, based on their spatial characteristics (Fig. 10).

Kemaliye District exhibits higher biodiversity compared to the other study areas primarily due to its

relatively lower elevation, which contributes to more favorable microclimatic conditions. In addition, its historical location along the Silk Road has facilitated cultural and biogeographical interactions that have

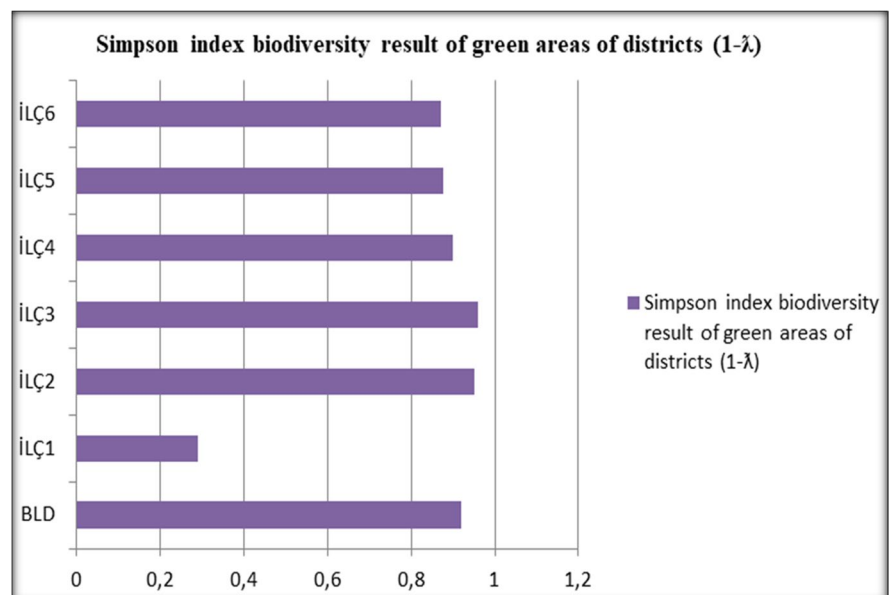
Fig. 9 Simpson diversity index results of green areas of 6 district centers and 1 town

Table 6 Bio-friendly index results of green areas of 6 district centers and 1 town

Criterion No	Evaluation criteria	Criterion condition	Field properties	The score included in the index	Total points	BLD	İLÇ1	İLÇ2	İLÇ3	İLÇ4	İLÇ5	İLÇ6	
1	Number of plant species in the area*	Containing at least 25 plant taxa	25 species	7	10 points								
			26–30 species	8									
			31–35 species	9									
			More than 35 species	10		X	X	X	X	X	X	X	
						Total	10	10	10	10	10	10	10
2	Natural plant species usage rate	* Must be at least 10% of the total number of species	%10	14	20 points								
			%10–15	16									
			%16–20	18									
			More than 20%	20		X	X	X	X	X	X	X	
						Total	20	20	20	20	20	20	20
3	Fleshy fruit plant species usage rate*	Must be at least 10% of the total number of species	%10	12	15 points								
			%10–15	13									
			%16–20	14									
			More than 20%	15		X	X	X	X	X	X	X	
						Total	15	15	15	15	15	15	15
4	The ratio representing the number of plant species relative to the total number of plant individuals	At least two types of plants are dominant in the total number of plants	2 plant species are dominant	2	10 points		X				X		
			3 plant species are dominant	4				X	X				
			4 plant species are dominant	6		X				X			
			5 plant species are dominant	8								X	
			More than 5 plant species are dominant	10									
5	Year of construction of the green area		Less than 5 years	1	5 points								
			Between 6 and 10	2									
			Between 11–15	3									
			Between 16–20	4									
			More than 20 years	5		X	X	X	X	X	X	X	
						Total	6	2	4	4	6	2	8
						Total	5	5	5	5	5	5	5

Table 6 (continued)

Criterion No	Evaluation criteria	Criterion condition	Field properties	The score included in the index	Total points	BLD	ILC1	ILC2	ILC3	ILC4	ILC5	ILC6
6	Number of fauna observed in the area within 1 h (Birds, butterflies, squirrels, etc.)		<5	1	5 points							
			Between 6–10	2								
			Between 11–15	3								
			Between 16–20	4								
			>20	5		X	X	X	X	X	X	X
7	Area size		Less than 500 m ²	1	5 points							
			500 m ² –2 acres	2								
			2–6 acres	3								
			6–10 acres	4								
			More than 10 acres	5		X	X	X	X	X	X	X
8	The ratio of open-green areas to hard impermeable surfaces		Less than 10%	1	5 points							
			If it is 10–30%	2								
			If 31–50%	3								
			If 51–75%	4								
			If more than 75%	5		X	X	X	X	X	X	X
9	Positive ecosystem components	More than 100 m away from the main transportation axis Green corridor connection		2	25 points							
						X	X	X	X	X	X	X

Table 6 (continued)

Criterion No	Evaluation criteria	Criterion condition	Field properties	The score included in the index	Total points	BLD	ILC1	ILC2	ILC3	ILC4	ILC5	ILC6
		Presence of natural habitat	Presence of endemic plant species in the area (each species number × 10 points)	10			X	X	X	X		X
			The existing tree grove at the time of construction	6		X	X	X	X	X	X	X
			Wetland presence	5		X	X	X	X	X	X	X
			Existing shrub presence in the area at the time of construction	4		X	X	X	X	X	X	X
			Presence of natural meadows and pastures in the area	3		X	X	X	X	X	X	X
		No fertilizer or pesticide application within the area		2								
		Natural stream or pond within the area		8		X	X			X	X	X
		Artificial pond		6								
		Small pool		3								

Table 6 (continued)

Criterion No	Evaluation criteria	Criterion condition	Field properties	The score included in the index	Total points	BLD	ILC1	ILC2	ILC3	ILC4	ILC5	ILC6
		Fountain, water basin		2		X	X	X	X	X	X	X
		The percentage of canopy cover of trees and shrubs throughout the garden	Fully closed (100%) Half closed (50%) Quarter closed (25%)	5 4 2								
		Plants are named/introductory cards										
		The area is tended to/supervised		4								
		The area is well-maintained		2		X	X	X	X	X	X	X
		Plants are not pruned harshly		2								
		Clean air quality		2								
		Renewable energy availability		3		X	X	X	X	X	X	X
		Rain harvest garden		5								
		Fountain, water basin		5								
Total					25	25	25	25	25	25	25	25

Table 6 (continued)

Criterion No	Evaluation criteria	Criterion condition	Field properties	The score included in the index	Total points	BLD	ILC1	ILC2	ILC3	ILC4	ILC5	ILC6
10	Negative ecosystem components	Air and soil pollution		-3	-6 points					X	X	
		Loud noise		-3				X		X	X	X
		Intensive use of agricultural pesticides and fertilizers		-5			X					X
		Excessive exposure to night light		-3		X						
		Lack of clean water sources within or near the area		-6								
		Poor maintenance and uncontrolled		-2								
		High voltage power lines passing through the area		-5								
Total score					Total	-3	-3	-3	0	-6	-6	-6
Bio-friendly index result average of districts and towns					100	93	89	91	94	90	86	92
						90.7 points						

supported increased species diversity. Furthermore, the district's distinctive topographical and ecological typology provides diverse habitat conditions, thereby

promoting higher levels of biodiversity compared to the other districts.

The biodiversity-friendly scores and the bio-friendly area logo/QR outputs are presented below (Figs. 11 and 12).

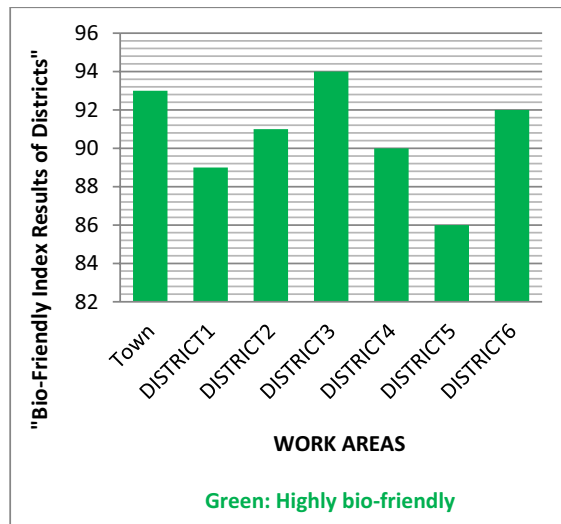


Fig. 10 Bio-friendly index results of green areas of towns and districts (BLD: Çağlayan town, DISTRICT1: Çayirli district, DISTRICT2: Kemah district, DISTRICT3: Kemaliye district, DISTRICT4: Refahiye district, DISTRICT5: Tercan district, DISTRICT6: Üzümlü district)

Discussion

The urbanization process and the resulting land-use changes have led to habitat fragmentation and a deterioration of the structural integrity of ecosystems. This situation particularly facilitates the spread of invasive species, which are highly adaptable to environmental changes, in urban areas. Such species tend to thrive in disturbed habitats created by urban expansion (Gaertner et al., 2017; McKinney, 2006). Furthermore, urbanization introduces significant threats to urban biodiversity, including air, water, and soil pollution, as well as light and noise pollution, the formation of urban heat islands, and the reduction of green spaces (Yılmaz, 2024).

The differences observed among districts can also be interpreted within the framework of urban ecological gradients. Urban ecosystems typically exhibit spatial variation in biodiversity due to differences in

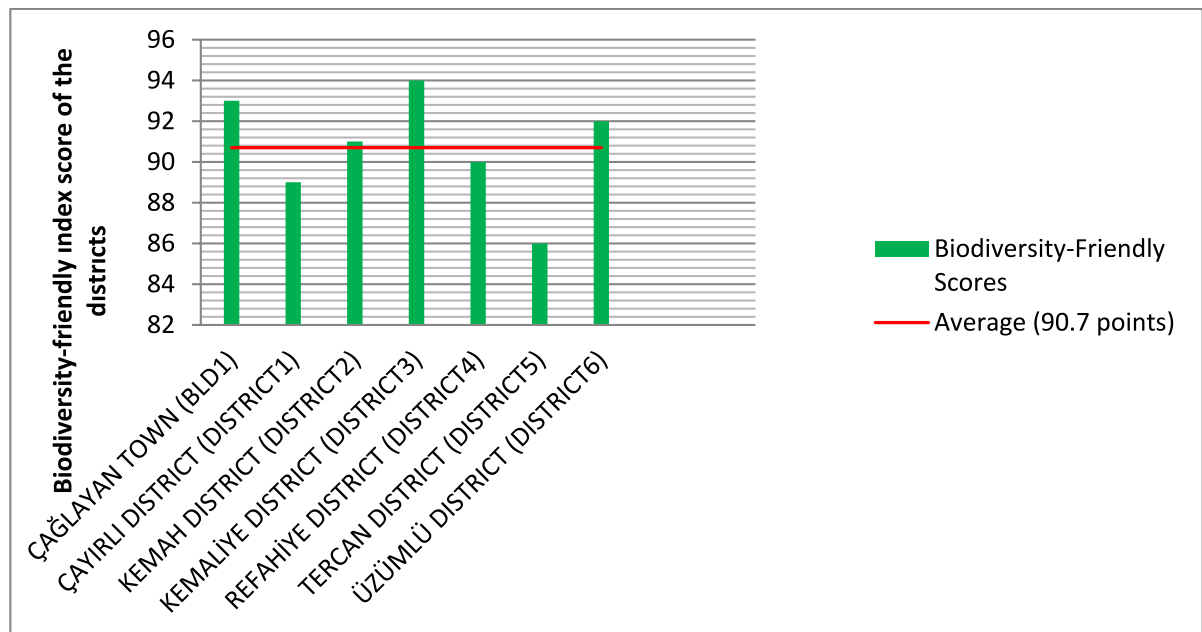


Fig. 11 Biodiversity-friendly scores of green spaces in districts

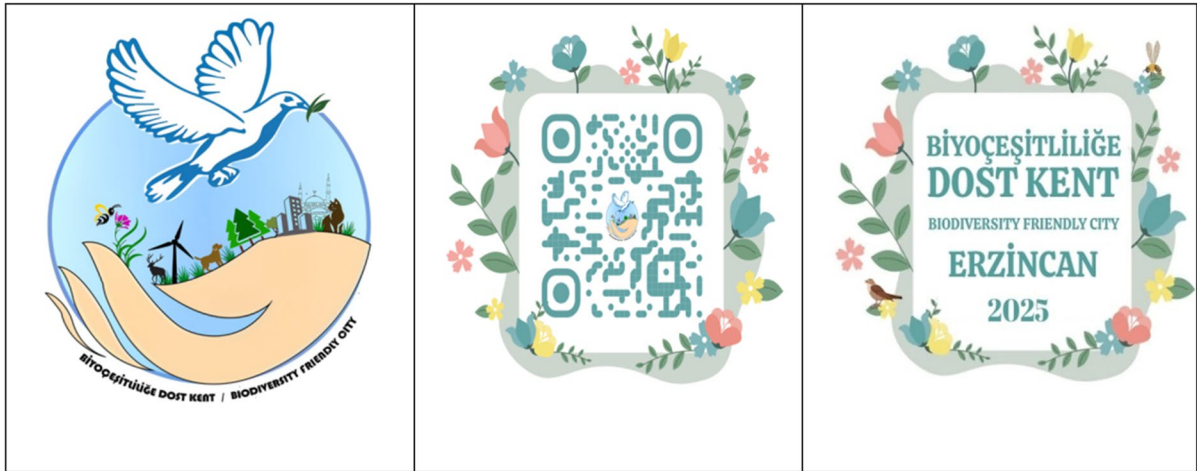


Fig. 12 Logo and QR code work specially designed for spaces that qualify as bio-friendly areas

land-use intensity, habitat fragmentation, and environmental conditions from urban centers to less disturbed peripheral areas (McKinney, 2006). These findings are consistent with previous studies emphasizing that urban biodiversity patterns are strongly shaped by gradients of disturbance and habitat heterogeneity (Aronson et al., 2014; Pickett et al., 2011).

In particular, Urban ecological gradient theory highlights how species richness and composition change along urban–rural continuums, often resulting in biotic homogenization in highly urbanized areas (Aronson et al., 2014; McKinney, 2006). Therefore, the variation in biodiversity indices across Erzincan districts may reflect differences in urbanization intensity, habitat continuity, and landscape structure, in line with global patterns reported in the literature.

The sustainable management of urban settlements is crucially dependent on the continuity of ecosystem components and the services they provide. The conservation of biological diversity is vital for the ecological resilience of cities. However, assessing urban biodiversity presents numerous challenges due to city-specific biotic, abiotic, and socio-economic dynamics (Özgeriş, 2023). Previous research has demonstrated that urban ecosystems function as complex socio-ecological systems where human activities and ecological processes are tightly interconnected (Alberti, 2015; Elmqvist et al., 2013). These studies emphasize that ecosystem resilience in cities cannot be addressed solely through ecological parameters but must also consider planning policies, governance

structures, and human behavior. Therefore, the present study contributes to this integrated perspective by combining ecological data with urban spatial patterns.

This study develops strategies for the conservation of natural tree species and associated wildlife in urban areas. The findings point to the relevance of increased investment in urban green infrastructure at both local and regional levels. The findings of this study align with previous research indicating that natural plant species play a crucial role in supporting urban biodiversity by providing habitat, food resources, and ecological connectivity (Burghardt et al., 2009; Tallamy, 2004). In contrast, exotic species may exhibit different functional roles and, in some cases, contribute to ecological imbalance or invasive dynamics (Pyšek et al., 2020).

In this context, the proportion of natural (46%) and exotic (54%) species identified in this study is particularly significant. Similar ratios have been reported in urban flora studies worldwide, where increasing urbanization is often associated with a higher proportion of non-natural species (Aronson et al., 2014; Pyšek et al., 2020).

While exotic species may contribute to aesthetic and functional diversity, their ecological impacts remain context-dependent and may include competition with natural flora and disruption of trophic interactions. Natural species are known to play a crucial role in supporting habitat continuity, strengthening trophic interactions, and providing

food and shelter for local fauna. In contrast, exotic species may increase interspecific competition and exert pressure on natural species. Since natural plants generally require lower maintenance and exhibit higher rates of establishment and growth, their use is recommended (Askan & Yılmaz, 2016).

Moreover, recent studies highlight that urban green spaces designed with natural vegetation significantly enhance ecosystem services such as pollination, carbon sequestration, and microclimate regulation (Elmqvist et al., 2015; Norton et al., 2015). Therefore, promoting natural species in urban planning can enhance both ecosystem resilience and ecosystem service delivery in cities. The study complements human-centered perspectives in landscape design through a more inclusive framework that considers the requirements of multiple living organisms. This approach is consistent with emerging concepts such as Nature-based solutions and ecological urbanism, which advocate for integrating biodiversity considerations into urban design and planning processes (Eggermont et al., 2015; Kabisch et al., 2017). These frameworks emphasize multifunctional landscapes that simultaneously support biodiversity, human well-being, and climate adaptation.

Erzincan exhibits characteristics that suggest potential for biodiversity-oriented urban planning approaches. In this regard, the study represents one of the early comprehensive urban-scale biodiversity assessments in Turkey and contributes to the growing body of international literature on urban ecology. However, some limitations should be acknowledged. The study is spatially limited to selected districts and does not include long-term monitoring data, which may restrict the generalizability of the findings. Future research should incorporate temporal analyses and broader spatial scales to better understand biodiversity dynamics in urban systems.

Conclusion

This study assessed urban biodiversity across six districts and one town within Erzincan Province, applying well-established diversity indices in conjunction with field-based assessments to establish a replicable baseline for biodiversity-oriented urban planning. Deliberately limiting the scope to six districts and one town enabled a detailed and context-sensitive

examination of urban biodiversity. A total of 36,799 individual plants belonging to 105 species were recorded, of which 56% were natural and 44% exotic, with broad-leaved trees bearing edible fruits dominating the landscape.

Diversity analyses identified Kemaliye as the district with the highest biodiversity and the most balanced species distribution (Shannon–Wiener evenness=89.6%), whereas the lowest diversity was observed in Çayırılı; these patterns were corroborated by the Simpson index. Under the “Biodiversity-Friendly Settlement” criteria, all assessed areas were classified as high-level, with an average score of 90.7 points, although Çayırılı, Refahiye, and Tercan fell below the overall average.

This variation is attributed to factors such as topography, altitude, geographical location, and water availability, which directly shape habitat conditions and the spatial distribution of biodiversity. The region’s historical position along the Silk Road further facilitated cultural and biogeographical interactions that have supported species diversity. Owing to their geographical location and natural resources, the examined districts are notable for their agricultural landscape values and hold considerable potential for agricultural production and rural landscape planning.

A novel “biodiversity-friendly pathway” index was introduced, integrating the combined use of natural and fleshy-fruited species (Liu & Slik, 2022) with the recommendation that no single species exceed 10–15% of the total species used (Kendal et al., 2014). Designed as a flexible framework, the index can be calibrated to local ecological conditions for application across different climatic regions; in this context, parameters such as natural species composition, faunal presence, and plant characteristics, together with threshold values, can be adjusted to reflect regional biodiversity conditions.

For areas scoring below the average, recommended measures include increasing species diversity, prioritizing natural and fleshy-fruited species, enhancing water resources, and diversifying dominant taxa. Conversely, given that invasive-prone species such as *Ailanthus altissima* and *Robinia pseudoacacia* may affect natural biodiversity through competitive exclusion and rapid spread, their ecological roles should be carefully managed.

Threats to biodiversity are associated not only with direct habitat loss but also with indirect factors, such as the establishment of invasive species accompanying

urban expansion. In this regard, the development of biodiversity corridors in areas with high urbanization potential emerges as an effective management strategy requiring coordinated efforts among local and regional administrative bodies. Such corridors become even more significant when considering species migration arising from climate-driven shifts in distribution.

Within the scope of this study, two logo designs and one QR code were developed to promote biodiversity-friendly areas, with logo selection conducted through a survey involving 106 experts. Furthermore, discussions were held with the Governorate of Erzincan regarding the promotion of the city and its districts within a “biodiversity-friendly” urban concept, and administrative procedures were initiated to place signage highlighting this approach at the main entrances of the districts. Representing an early city-scale application in Turkey, this initiative may serve as an informative example for similar efforts elsewhere.

In conclusion, the findings demonstrate that, beyond species richness, urban biodiversity should be evaluated through species composition, functional diversity, and ecological interactions, which are essential for ecosystem resilience and sustainability. By providing a transferable framework for sustainable biodiversity management, the study offers baseline information that may support the ecological sustainability of urban areas, including their touristic and livability values.

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Author contribution Gökhan Askan: conceptualization, methodology, formal analysis, and writing – original draft preparation. Hasan Yılmaz: supervision, writing – review, and editing.

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Data availability All data will be made available upon reasonable demand.

Declarations

Ethical approval All authors have read, understood, and complied as applicable with the statement on “Ethical responsi-

bilities of Authors” as found in the Instructions for Authors and are aware that, with minor exceptions, no changes can be made to authorship once the paper is, submitted.

Consent to participate All authors have agreed to participate in this article.

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