International Journal for Research in Environment
Published by: **Green Publications**
Article Type: **Research**
DOI: **10.53555/env.v1i2.2580**
Volume 01 Issue 02 June 2026

CHARACTERIZING URBAN GREEN INFRASTRUCTURE THROUGH BIODIVERSITY AND ECOSYSTEM SERVICE DIMENSIONS

Preeti Dogra

[1]*Research Scholar,Government of Jammu and Kashmir, ORCiD ID: 0009-0000-0722-139X, preeti_dogra1979@yahoo.com*

***Corresponding Author:** *Hemant Kumar Mishra, mishrahemant89@gmail.com*

Received:- 12/05/2026, Revised:-16/06/2026, Accepted:-23/06/2026, Published:- 30/06/2026

ABSTRACT

Urban green infrastructure (UGI) is increasingly recognised as a crucial element in sustainable urban development, delivering a range of ecosystem services that enhance environmental quality and human health and wellbeing. Although its significance is increasing, categorizations and terminology have not been uniformly consistent and research results are not easily comparable, which has hindered the establishment of standardized assessment approaches. The aim of this study was to characterize the UGI by combining the dimensions of biodiversity and ecosystem services into one analytical framework. Descriptive and comparative statistical analyses were used to investigate the spatial distribution of classes of urban green infrastructure, terminology used for the classification of urban green infrastructure and the research objectives. The results indicated that more biodiversity-related studies were conducted than ecosystem service oriented studies: biodiversity research was mainly based on the study of plants and birds; the studies on urban heat island mitigation, air quality improvement and water related services were the major ecosystem service themes. The study demonstrates that biodiversity conservation and ecosystem service provision can go together and underlines the value of having a common classification system for the consistent assessment of UGI. The results of these analyses are useful for an informed approach to urban planning, biodiversity protection and environmental sustainability.

Keywords: Urban green infrastructure; Biodiversity; Ecosystem services; Classification; Sustainable urban planning

1. Introduction

Natural landscapes have been modified by urbanisation, which has resulted in the fragmentation of natural habitats, loss of biodiversity and degradation of ecological functions. With urbanisation on the rise, ecological integrity and the need to satisfy social and environmental requirements are a challenge for urban planners and environmental researchers alike (Behm et al., 2022). In the era of climate change, urban green infrastructure (UGI), which is characterized by its network of interconnected natural and semi-natural green spaces including forests, street trees, wetlands, gardens and green roofs has become a viable tool for advancing the environmental sustainability and urban resilience agenda. UGI is an irreplaceable part of sustainable urban development (SD), as it offers a range of benefits beyond its aesthetic appeal, such as contributing to biodiversity conservation, climate regulation, water management, air quality improvement, and human well-being (Grilo et al., 2022; Guillen-Cruz et al., 2021). If vegetation is present, the ecological value of the urban green infrastructure is also reflected in its ability to provide a wide range of ecosystem services and biological communities (Cheng et al., 2021). Ecosystem services directly impact environmental quality and public health, and urban biodiversity helps to support ecosystem stability, nutrient cycling, pollination, carbon sequestration and habitat provision (de Manuel et al., 2021). Recent studies have shown that urban green spaces are beneficial for biodiversity, as well as ecosystem functions that are advantageous for urban residents, which should be taken into account in integrated approaches that include both ecological and societal effects (Kowarik et al., 2025). Therefore, the scope for the assessment of urban green infrastructure has become more comprehensive, with biodiversity conservation and assessment of ecosystem services complementing each other.

Although the importance of multifunctionality in UGI is becoming increasingly evident, there is still a high degree of incongruity in the definition, classification and evaluation of UGI. The terms, classification systems, and assessment criteria used in various studies depend on the goals of the research, the geographical boundaries, or the discipline of the study (Evans et al., 2022). The same components occurring in the urban landscape can have various names, and the same name can encompass a variety of forms of green infrastructure, depending on the study. These inconsistencies make it difficult for comparison between investigations, for data integration and for the transferability of research results to various regions and planning contexts. Lack of standard classification system also hinders the formulation of comprehensive approaches to urban biodiversity conservation and ecosystem service management (ESM) (Grilo et al., 2022; Zhang & MacKenzie, 2024).

Biodiversity conservation and ecosystem service provision have been the focus of previous investigations, both as separate research domains, but they are also inextricably linked in urban ecosystems. Biodiversity can shape the ability of green infrastructure to provide ecosystem services, and ecosystem services can offer indicators of ecological function and society benefits (Fan et al., 2023). The combined approach helps to gain a complete picture of the environmental function of UGIs and enables evidence-based planning decisions. Additionally, recent research has shown that vegetation composition, habitat diversity and landscape configuration play a role in shaping ecological processes and in turn affect regulating, provisioning, supporting and cultural ecosystem services in both urban and non-urban settings (Felappi et al., 2024; Guillen-Cruz et al., 2021).

The ecological and human benefits provided by urban green infrastructure are variable, depending on the type of vegetation and habitat (how complex it is), how connected it is to other habitats, and the way that it is managed. Structurally diverse green spaces have been proven to improve the invertebrate diversity, quality of habitat, and resilience of urban landscapes (Hagemann et al., 2020). Likewise, healthier parks and natural green spaces have been linked to better mental health, more places to relax and enjoy the outdoors, and greater community commitment to conserving wildlife. The results highlight that the ecological contribution of urban green infrastructure is not limited to biodiversity conservation alone, but also covers various other environmental and social benefits contributing to sustainable urban development (Felappi et al., 2024; Sharmin et al., 2024). The growing attention on NbS and climate resilient cities has strengthened the need to systematically characterize UGI.

Accurate classification also allows for ecological characteristics to be compared between urban landscapes, the impact of planning interventions to be assessed and opportunities to increase the delivery of ecosystem services and biodiversity benefits (Hanna et al., 2024). Comprehensive classification systems can also help to communicate between researchers, planners, and policy makers by providing common terminology and consistent assessment criteria. These practices enable better urban planning processes to better consider biodiversity conservation, ecosystem function, and human welfare together, serving long-term environmental sustainability (Kowarik et al., 2025; Zhang & MacKenzie, 2024).

In this context, the present study seeks to define the urban green infrastructure through the consolidation of a classification dataset that integrates both biodiversity and ecosystem services dimensions, with a single analysis (Hansen et al., 2023). The study reviews the distribution of classes of urban green infrastructures, classification terminology and research objectives as reflected in published studies and offers a systematic evaluation of the existing classification patterns and their associations with biodiversity and ecosystem service perspectives. The results will help deepen the understanding of urban green infrastructure characterization and help develop more consistent approaches to the classification in environmental studies and sustainable urban planning in the future. The objectives of this study are as follows:

1. To characterize urban green infrastructure classifications by integrating biodiversity and ecosystem service dimensions within a consolidated analytical framework

2. To compare the distribution of urban green infrastructure classes, terminology, and research objectives across biodiversity- and ecosystem service-oriented studies

3. To identify dominant classification patterns that support consistent urban green infrastructure assessment for sustainable environmental planning and biodiversity conservation

2. Materials and Methods

2.1 Dataset Description

The Consolidated Urban Green Infrastructure Classification for Assessing Ecosystem Services and Biodiversity was used in this study and was created by consolidating urban green infrastructure (UGI) classifications found in published scientific literature. The data set contains 1084 data records, covering two key dimensions of research (biodiversity 589 data records; ecosystem services 495 data records) (Morpurgo et al., 2023). It contains details of study field, research goals, UGI classes, classification terminology, classification definitions, supporting arguments and digital object identifiers (DOIs). The combination of various classification methods in one dataset can offer a wholesome foundation for describing urban green infrastructure and exploring biodiversity and ecosystem service-oriented viewpoints.

2.2 Data Preparation

Data were entered into the analytical environment and pre-screened for fullness, consistency and structural soundness prior to analysis. The variables that were relevant to the research objectives were chosen and duplicate records and inconsistencies in the categorical labels were reviewed and corrected where appropriate. Empty cells were evaluated to see whether they would affect the analytical results and categorical variables such as discipline, UGI classes, and research goals were coded uniformly. The cleaned data set was then categorized and structured to support descriptive, comparative and visualization analysis of urban green infrastructure classification.

2.3 Variables Used

The conceptual and classification characteristics of urban green infrastructure were only analyzed by the variables. Studies on biodiversity or ecosystem services were distinguished from studies on other UGIs through the use of the discipline variable, while the classes and class variables were used for the main and detailed UGI classifications, respectively. The commonName variable was analyzed to find out the common terms that are used in the literature and the goal variable was analysed to assess the main goals of the studies included. Further variables (such as definitions of classes, supporting arguments and chronology of studies) were also added for contextual interpretation and to enhance the understanding of the patterns of classification.

2.4 Statistical Analysis

Descriptive statistical methods were used to compress data of the dataset and analyze the distribution of urban green infrastructure classifications. The prevalence of biodiversity and ecosystem service related studies, the most prevalent UGI classes, predominant classification terminology and objectives of the studies were determined through frequencies and percentages. The differences between the different dimensions of biodiversity and ecosystem services within different classification categories were analyzed through cross-tabulations. Key patterns were explored using graphical visualisations such as bar charts, pie charts, stacked bar charts and frequency plots, to facilitate interpretation of findings. All statistical analyses were done in the R programming language, and conducted in a reproducible manner.

2.5 Analytical Framework

In order to characterize urban green infrastructure, an integrated analytical framework was developed, examining the dimensions of biodiversity and ecosystem services together in a single framework. Records were classified by study discipline, UGI classes, research objectives and also by commonly-used terminology and then subjected to descriptive and comparative analyses of their distributions. Correlations between the two types of classifications (biodiversity and ecosystem service) were evaluated to determine the main trends, overlaps, and discrepancies in the dataset. The framework facilitated a systematic understanding of the classification of urban green infrastructure and offered a structured approach to assessment of their contribution to the biodiversity conservation and ecosystem service assessment in urban environments.

3. Results

3.1 Overall Dataset Characteristics

The consolidated dataset contained 1,084 records of urban green infrastructure (UGI) information from published scientific studies, and was representative of the approaches used for classification in urban environmental research. This data covered two main areas of research, or dimensions, biodiversity (589 records) and ecosystem services (495 records), with a slightly higher number of records focused on biodiversity studies. All of the records included 20 types of urban green infrastructure and 391 different classification terms (common names) highlighting the variety of concepts found in the literature. The wide range of the study goals and classification systems demonstrate the multi-disciplinary nature of urban green infrastructure research and provide a solid basis for comparative analyses (Table 1) (Figure 1).

Table 1: Quantitative characteristics of the analyzed UGI dataset

Dataset characteristic	Frequency (n)	Percentage (%)
Total records analyzed	1,084	100.0
Biodiversity records	589	54.3
Ecosystem service records	495	45.7
Unique scientific sources/DOIs	161	100.0
Biodiversity sources	75	46.6
Ecosystem service sources	86	53.4
Consolidated UGI class identifiers	20	100.0
Unique detailed class terms	710	100.0
Unique standardized common names	391	100.0
Research objectives represented	10	100.0
Records containing class definitions	795	73.3
Records without class definitions	289	26.7
Records containing classification arguments	71	6.5
Records without classification arguments	1,013	93.5
Records containing residual information	100	9.2
Records without residual information	984	90.8

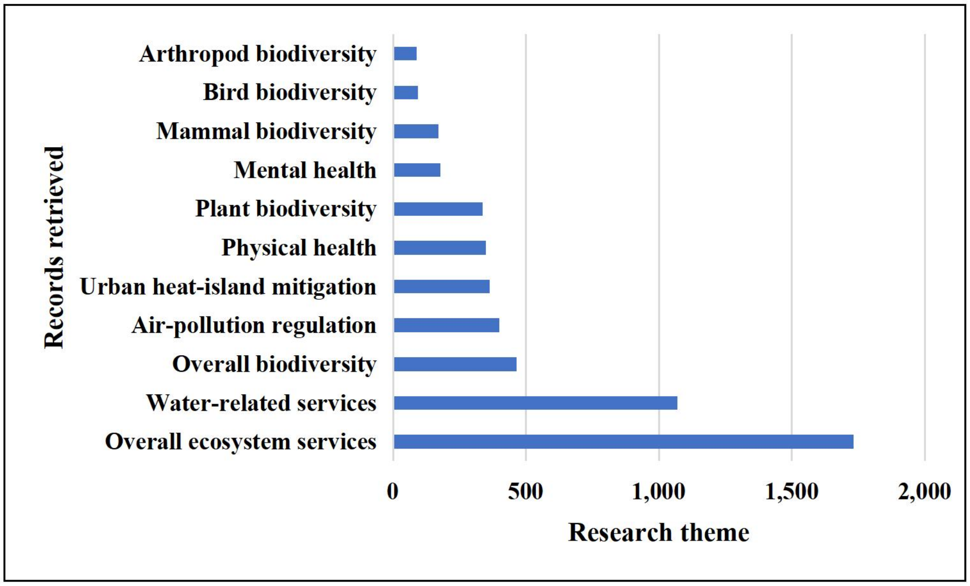

Figure 1: Literature-search records retrieved across research themes

3.2 Distribution of Urban Green Infrastructure Classes

Distribution of urban green infrastructure classes indicated that there was significant variation in the number of occurrences of each class. Several of the classes were found across the literature, reflecting their general use in assessments of biodiversity or ecosystem services, while others were more infrequent, reflecting more specialized and/or context-specific applications. This imbalance reveals the lack of a widely accepted typology for urban green infrastructure. The observed differences also highlight the various research interests, geographical settings and data collection methods used in previous research, resulting in different approaches to defining UGI as a whole (Table 2).

Table 2: Distribution of consolidated UGI class identifiers by research dimension

Class identifier	Biodiversity n (%)	Ecosystem services n (%)	Total n (%)
2	12 (46.2)	14 (53.8)	26 (2.4)
3	42 (42.4)	57 (57.6)	99 (9.1)

4	36 (40.9)	52 (59.1)	88 (8.1)
5	25 (33.3)	50 (66.7)	75 (6.9)
6	24 (30.8)	54 (69.2)	78 (7.2)
7	35 (31.8)	75 (68.2)	110 (10.1)
8	51 (68.0)	24 (32.0)	75 (6.9)
9	27 (77.1)	8 (22.9)	35 (3.2)
10	40 (40.4)	59 (59.6)	99 (9.1)
11	55 (71.4)	22 (28.6)	77 (7.1)
12	24 (100.0)	0 (0.0)	24 (2.2)
13	78 (66.7)	39 (33.3)	117 (10.8)
14	13 (48.1)	14 (51.9)	27 (2.5)
17	18 (100.0)	0 (0.0)	18 (1.7)
18	18 (100.0)	0 (0.0)	18 (1.7)
20	20 (100.0)	0 (0.0)	20 (1.8)
22	22 (100.0)	0 (0.0)	22 (2.0)
23	23 (100.0)	0 (0.0)	23 (2.1)
26	26 (100.0)	0 (0.0)	26 (2.4)
27	0 (0.0)	27 (100.0)	27 (2.5)
Total	**589 (54.3)**	**495 (45.7)**	**1,084 (100.0)**

3.3 Biodiversity-Oriented Classification Patterns

The main studies by the biodiversity dimension aimed to assess the ecological features and biological diversity related to the urban green infrastructure. The vegetation, bird populations, arthropods, mammals and other biological aspects that help safeguard urban ecosystem integrity are common research objectives. Vegetation-based research was the highest percentage of the biodiversity research, and emphasized the role of vegetation as one of the key parameters for assessing ecological quality in urban areas. In general, the categories of biodiversity highlighted were those that were focused on habitats and species conservation, which highlighted the role of the urban green infrastructure in maintaining ecological processes and supporting urban biodiversity (Table 3).

Table 3: Quantitative distribution of biodiversity-oriented research objectives

Biodiversity research objective	Frequency (n)	Percentage of biodiversity records (%)	Percentage of complete dataset (%)	Rank
Plant	288	48.9	26.6	1
Bird	159	27.0	14.7	2
Multiple biodiversity components	58	9.8	5.4	3
Arthropod	55	9.3	5.1	4
Mammal	29	4.9	2.7	5

3.4 Ecosystem Service-Oriented Classification Patterns

The ecosystem service dimension highlighted the operational benefits of urban green infrastructure to urban population and environment. Urban heat island mitigation, air quality improvement, water regulation, mental health and physical health were among the top research objectives represented. The results have shown that the assessment of ecosystem services is not only related to ecological functions, but also includes ecosystem regulation and human welfare. The wide variety of ecosystem service categories illustrates the multi-functional nature of UGI and its ability to simultaneously deliver environmental sustainability, climate adaptation, public health and urban resilience benefits (Table 4).

Table 4: Quantitative distribution of ecosystem service-oriented research objectives

Ecosystem service research objective	**Frequency (n)**	**Percentage of ESS records (%)**	**Percentage of complete dataset (%)**	**Rank**
Urban heat-island mitigation	107	21.6	9.9	1
Air-pollution regulation	92	18.6	8.5	2
Mental-health benefits	82	16.6	7.6	3
Water-related services	81	16.4	7.5	4
Multiple ecosystem services	68	13.7	6.3	5
Physical-health benefits	65	13.1	6.0	6

3.5 Comparative Assessment of Biodiversity and Ecosystem Service Dimensions

Analytical priorities in the two research dimensions were compared to show that they had significant conceptual overlap but also some different analytical priorities. Biodiversity research mostly focused on ecological composition, habitat quality and species diversity while ecosystem service research focused on the environment and social services provided by urban green infrastructure. Overall, however, several classes of urban green infrastructure were consistently present over both dimensions, reflecting their multifunctional nature in relation to supporting ecological integrity and providing ecosystem services. The complementary nature of the two perspectives emphasizes the need to combine the assessment of ecosystem services with the conservation of biodiversity to better understand urban green infrastructure (Table 5) (Figure 2).

Table 5: Comparative quantitative characteristics of biodiversity and ecosystem-service records

Comparative indicator	Biodiversity	Ecosystem services
Records, n	589	495
Records, %	54.3	45.7
Unique scientific sources, n	75	86
Scientific sources, %	46.6	53.4
Unique standardized common names, n	252	206
Dimension-exclusive common names, n	185	139
Shared common names, n	67	67
Shared common names as a percentage of all names	17.1	17.1
Unique detailed class terms, n	445	323
Dimension-exclusive detailed class terms, n	387	265
Shared detailed class terms, n	58	58
Shared detailed classes as a percentage of all classes	8.2	8.2

Consolidated class identifiers represented, n	19	13
Consolidated class coverage, %	95.0	65.0
Research objectives represented, n	5	6

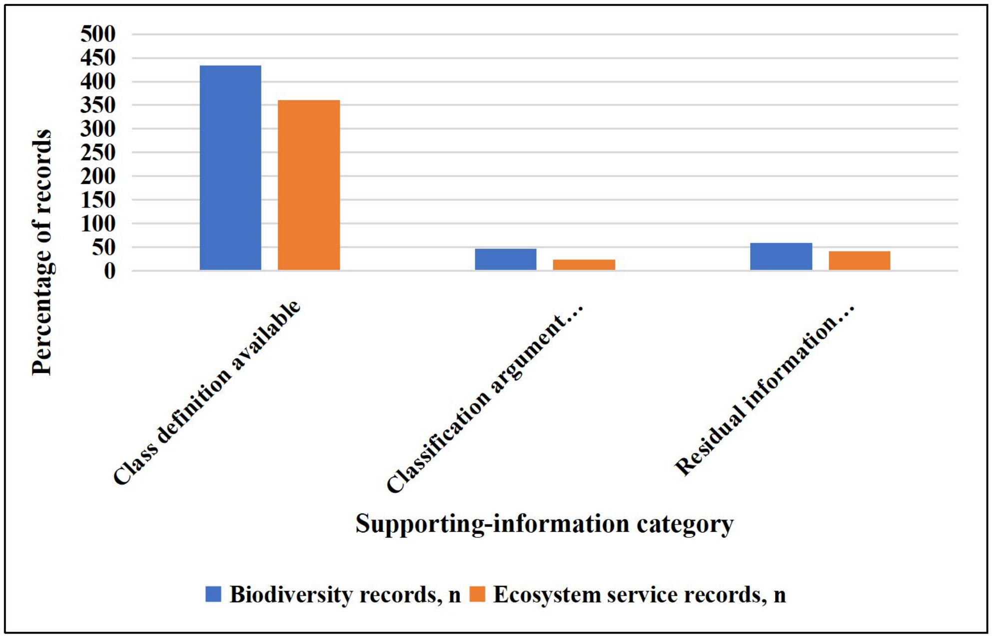

Figure 2: Availability of supporting classification information by research dimension

3.6 Classification Terminology Across Published Studies

The classification terminology was analysed according to its content, and the results showed that the names given to the elements of the urban green infrastructure are very diverse. Many of the studies cited here used comparable terms, but these differences in terminology were related to the differences in the disciplines, regional settings, and research goals. The 391 unique common names that appear in the literature show that there is no consistent terminology used, and that continued inconsistencies exist in the classification of urban green infrastructure. This variability can make it difficult to make direct comparisons between studies and can highlight the need to develop harmonised classification frameworks that enhance the consistency, reproducibility and communication of biodiversity and ecosystem service research (Table 6) (Figure 3).

Table 6: Most frequently recorded standardized UGI common names

Rank	Standardized common name	Frequency (n)	Percentage of total records (%)	Cumulative percentage (%)
1	Forest	41	3.8	3.8
1	Water	41	3.8	7.6
3	Park	38	3.5	11.1
4	Tree	34	3.1	14.2
5	Grassland	25	2.3	16.5
6	Green open space	24	2.2	18.7
7	Urban	23	2.1	20.8
7	Grass	23	2.1	22.9
9	Bare ground	22	2.0	24.9
10	Shrub	20	1.8	26.8
11	Green roof	19	1.8	28.5
11	Garden	19	1.8	30.3
13	Tree canopy	18	1.7	31.9
14	Residential	17	1.6	33.5
15	Agriculture	16	1.5	35.0
16	Buildings	14	1.3	36.3

16	Other	14	1.3	37.5
18	Impervious surface	13	1.x`2	38.7
19	Natural area	11	1.0	39.8
19	Pavement	11	1.0	40.8
20	Remaining terminology	642	59.2	100.0

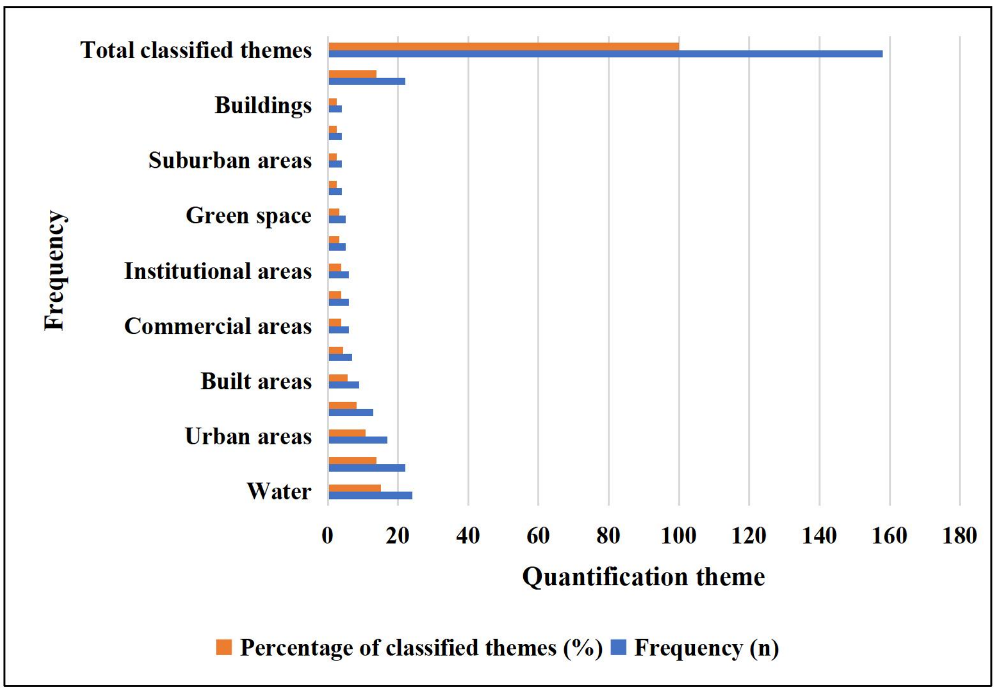

Figure 3: Distribution of quantification themes in defined UGI classes

4. Discussion

Urban green infrastructure (UGI) by introducing the biodiversity and ecosystem service aspects in a unified classification system. The analysis showed that studies related to biodiversity were slightly more than the studies related to ecosystem service, and as such, ecological assessments are still a primary focus of UGI research. The proportion of ecosystem service investigations, however, demonstrates the growing awareness of UGI as a multi-service system that helps maintain environmental quality, climate resilience and human well being. This even-handed presentation reveals a progression from discipline-based investigations to more interdisciplinary ones, which will be able to tackle ecological and societal issues in the context of fast-growing cities (Wang et al., 2024; Herath & Bai, 2024). Results of consolidated UGI classes showed that there is a lot of variation among the frequency of the different categories of UGI classes, meaning there is no single universally accepted classification system.

Some classes occurred regularly within the urban landscape and were frequently included in biodiversity assessments and/or ecosystem services assessments, while others were found only occasionally, and thus had more specific or contextual applications (Jato-Espino et al., 2023). The diversity of these examples reflects the complexity of the urban environments, and the need for harmonized classification systems that increase the uniformity of studies. Inconsistent classification systems have been noted in recent reviews, highlighting their impact on data comparability, lack of interoperability across studies, and challenges to evidence-based urban planning (Zhang & MacKenzie, 2024). The high proportion of plant and bird biodiversity studies in the present analysis is another indication that vegetation continues to be the most important ecological element taken into account for UGI assessments (Julia et al., 2020). Vegetation can create structural habitat, affect microclimate, improve connectivity, and facilitate a variety of ecological interactions that contribute to ecosystem function. Likewise, birds are known to be ecological indicators due to their sensitivity to habitat quality and environmental changes. The increased importance of these biological groups corresponds with recent studies that have focused on the role of vegetation features and species traits in biodiversity conservation and provision of ecosystems services in urban areas (Grilo et al., 2022; Kowarik et al., 2025). Arthropods and mammals, however, are comparatively poorly represented, indicating that some important biological groups are not yet adequately represented in the current studies of UGI classification.

Arthropod studies as a percentage of the total number of investigations conducted in this study was relatively low, suggesting an important research gap as insects make significant contributions to pollination, decomposition, nutrient cycling and food-web stability (Korkou et al., 2023). There is recent evidence that diversified urban vegetation, especially shrub-dominated ones, can greatly boost invertebrate abundance and species richness, and enhance ecosystem resilience (Sharmin et al., 2024). Similarly, extensive syntheses have highlighted the importance of urban green-blue infrastructure to insect communities, although empirical evidence is inconsistent across space and lacks taxonomic breadth (Bowler et al., 2025). Incorporating insect diversity and other underrepresented groups into future classifications would thus enhance the ecological completeness of UGI assessment frameworks.

The ecosystem service dimension illustrated that the most common functional benefits studied were ecosystem service from urban heat island mitigation, air pollution regulation, and water-related services (Liu et al., 2023). The results contribute to the growing need to manage urban ecosystems as a critical part of urban sustainability planning, especially in the face of climate change, urban heat stress, and environmental quality degradation. Meanwhile, significant mental and physical health research is ongoing that has made UGI a well acknowledged factor in human health and quality of life (Prodanovic et al., 2024). Parks and green spaces contribute to the ecological health of the city but also offer opportunities for recreation, support human health and well-being, and promote public acceptance of the value of biodiversity conservation, all while serving as multifunctional urban green infrastructure (Felappi et al., 2024; Herath & Bai, 2024).

There was also significant conceptual overlap between the biodiversity dimensions and ecosystem service dimensions, although the focus of research differed between the two. The primary difference between the two types of studies is that the former look at the composition and habitat quality of the ecosystem (biodiversity) while the latter focus on ecosystem services and benefits to society (Veerkamp et al., 2021). These dimensions are not separate from each other, however, since the biodiversity effects ecosystem functioning, which in turn affects the ability of the urban green infrastructure to provide ecosystem services. Conceptual frameworks in recent years have also shown that the delivery of ecosystem services is shaped by both biodiversity traits and ecological processes, and socio-ecological filters, providing support to the integration of biodiversity conservation and ecosystem service assessment in a single planning framework (Grilo et al., 2022). These complementary viewpoints reinforce the scientific need for a unified classification systems that can assess ecological integrity and functional performance at the same time.

The second major finding of the present study was the wide range of classification terminology that could be found in the published literature. Hundreds of common terms were found that were standardized across the fields, meaning that equivalent features are still referred to by different names, depending on the disciplinary tradition and regional planning practices. These disparities make it difficult to compare investigations and to create a set of common indicators for urban sustainability assessment. The uniformity of terminology and classification criteria would ease knowledge integration, boost the reproducibility and enhance communication among researchers, planners and policymakers for urban environment management (Wang et al., 2024). Practically, the results highlight the need to take into account multiple aspects related to biodiversity, ecosystem services and long-term sustainability goals when designing urban green infrastructure.

Combining ecological monitoring, the use of standardised classifications and multifunctional planning can make urban green infrastructure more effective and adapt it to environmental changes; adaptive management approaches can be developed to achieve this. Furthermore, vegetation composition is a key factor in the delivery of ecosystem services, such as carbon sequestration, air quality improvement, habitat provision, and urban climate regulation, provided by woody vegetation and diverse plant communities (Guillen-Cruz et al., 2021; Strashok et al., 2025). There should therefore be a focus on future planning strategies on implementing green infrastructure networks that are ecologically diverse and structurally interwoven that can provide maximum conservation of biodiversity and delivery of ecosystem services.

This research offers a thorough review of urban green infrastructure typologies, but there are some limitations to note: The analysis was done using a secondary database of published studies, so the priorities are not necessarily based on field observations but rather represent current research priorities. Further, geographical variation, temporal changes and local environmental factors were also not specifically assessed and may restrict the transferability of the individual classification patterns. Future studies should combine spatial analysis, remote sensing, GIS and machine learning with a uniform classification system to enhance the understanding of biodiversity and ecosystem services in urban areas. These holistic solutions will help to ensure more evidence-based planning and enhance the value of urban green infrastructure on the quest of resilient, healthy and sustainable cities (Kowarik et al., 2025; Wang et al., 2024).

5. Conclusion

Urban green infrastructure (UGI) by incorporating the BDI dimension with a merger of the infrastructure classification data set from published research. The results showed that the number of studies on biodiversity was slightly higher than that of studies of ecosystem services, and that both types of studies pointed to the multifunctional role of UGI in relation to ecological integrity and sustainable urban development. There was wide variation in the distribution of UGI classes, the terminology used for the classification and the objective of the research, suggesting that there is not yet universal agreement on how to classify and that existing classification methods are not unified. The most common themes of ecosystem services examined were related to urban heat island mitigation, water-related services and air quality improvement, while plant and bird studies were the most common theme in the biodiversity dimension. The comparative assessment also showed that the fields conservation of biodiversity and provision of ecosystem services are complementary parts of urban greenery, not separate ones of research. Combining these cognitions offers a more holistic view of the ecological roles and societal values that urban green areas bring. The unified classification system used in this study aids in the consistency of UGI characterization and more accurate comparisons with future studies. In summary, the results are relevant to researchers, urban planners and policy makers who aim for the creation of standardised methods to assess urban green infrastructures and for the design of cities which are resilient, biodiversity-rich, and environmentally sustainable to meet modern urban challenges.

References

1. Behm, J. E., Bélouard, N., Gleditsch, J. M., Phillips, P. M., & Swartz, T. M. (2022). Trait-based approaches for understanding how biodiversity generates sustainable benefits in urban vegetated green infrastructure. *Current Opinion in Environmental Sustainability*, *57*, 101204.
2. Bowler, D. E., Callaghan, C. T., Felappi, J. F., Mason, B. M., Hutchinson, R., Kumar, P., & Jones, L. (2025). Evidence-base for urban green-blue infrastructure to support insect diversity. *Urban Ecosystems*, *28*(1), 54.
3. Cheng, X., Van Damme, S., & Uyttenhove, P. (2021). A review of empirical studies of cultural ecosystem services in urban green infrastructure. *Journal of Environmental Management*, *293*, 112895.

4. de Manuel, B. F., Méndez-Fernández, L., Peña, L., & Ametzaga-Arregi, I. (2021). A new indicator of the effectiveness of urban green infrastructure based on ecosystem services assessment. *Basic and Applied Ecology*, *53*, 12-25.
5. Evans, D. L., Falagán, N., Hardman, C. A., Kourmpetli, S., Liu, L., Mead, B. R., & Davies, J. A. C. (2022). Ecosystem service delivery by urban agriculture and green infrastructure–a systematic review. *Ecosystem services*, *54*, 101405.
6. Fan, K., Chu, H., Eldridge, D. J., Gaitan, J. J., Liu, Y. R., Sokoya, B., ... & Delgado-Baquerizo, M. (2023). Soil biodiversity supports the delivery of multiple ecosystem functions in urban greenspaces. *Nature Ecology & Evolution*, *7*(1), 113-126.
7. Felappi, J. F., Sommer, J. H., Falkenberg, T., Terlau, W., & Kötter, T. (2024). Urban park qualities driving visitors mental well-being and wildlife conservation in a Neotropical megacity. *Scientific reports*, *14*(1), 4856.
8. Grilo, F., McPhearson, T., Santos-Reis, M., & Branquinho, C. (2022). A trait-based conceptual framework to examine urban biodiversity, socio-ecological filters, and ecosystem services linkages. *Npj Urban Sustainability*, *2*(1), 32.
9. Guillen-Cruz, G., Rodríguez-Sánchez, A. L., Fernández-Luqueño, F., & Flores-Rentería, D. (2021). Influence of vegetation type on the ecosystem services provided by urban green areas in an arid zone of northern Mexico. *Urban Forestry & Urban Greening*, *62*, 127135.
10. Hagemann, F. A., Randrup, T. B., & Sang, Å. O. (2020). Challenges to implementing the urban ecosystem service concept in green infrastructure planning: a view from practitioners in Swedish municipalities. *Socio-Ecological Practice Research*, *2*(3), 283-296.
11. Hanna, E., Bruno, D., & Comín, F. A. (2024). The ecosystem services supplied by urban green infrastructure depend on their naturalness, functionality and imperviousness. *Urban Ecosystems*, *27*(1), 187-202.
12. Hansen, R., Mattes, A., Meier, M., & Kurths, A. (2023). Reorienting urban green infrastructure planning towards biodiversity–Perspectives and ongoing debates from Germany. *Urban Forestry & Urban Greening*, *90*, 128155.
13. Herath, P., & Bai, X. (2024). Benefits and co-benefits of urban green infrastructure for sustainable cities: six current and emerging themes. *Sustainability Science*, *19*(3), 1039-1063.

14. Jato-Espino, D., Capra-Ribeiro, F., Moscardó, V., del Pino, L. E. B., Mayor-Vitoria, F., Gallardo, L. O., ... & Dietrich, K. (2023). A systematic review on the ecosystem services provided by green infrastructure. *Urban Forestry & Urban Greening*, *86*, 127998.
15. Jones, L., Anderson, S., Læssøe, J., Banzhaf, E., Jensen, A., Bird, D. N., ... & Zandersen, M. (2022). A typology for urban Green Infrastructure to guide multifunctional planning of nature-based solutions. Nature-Based Solutions, 2, 100041.
16. Julia, P., Banzhaf, E., & Priess, J. A. (2020). How do the green components of urban green infrastructure influence the use of ecosystem services? Examples from Leipzig, Germany. *Landscape Ecology*, *35*(5), 1127-1142.
17. Korkou, M., Tarigan, A. K., & Hanslin, H. M. (2023). The multifunctionality concept in urban green infrastructure planning: A systematic literature review. *Urban Forestry & Urban Greening*, *85*, 127975.
18. Kowarik, I., Fischer, L. K., Haase, D., Kabisch, N., Kleinschroth, F., Konijnendijk, C., ... & von Haaren, C. (2025). Promoting urban biodiversity for the benefit of people and nature. *Nature Reviews Biodiversity*, *1*(4), 214-232.
19. Liu, X., Zhao, Y., Zeng, D., Yang, Y., Li, W., Kang, Y., ... & Si, X. (2023). Characterizing bird species for achieving the win-wins of conserving biodiversity and enhancing regulating ecosystem services in urban green spaces. *Urban Forestry & Urban Greening*, *87*, 128064.
20. Morpurgo, J., Remme, R., & van Bodegom, P. (2023). *Dataset: CUGIC: The consolidated urban green infrastructure classification for assessing ecosystem services and biodiversity* (Version 1) [Data set]. Leiden University. https://doi.org/10.17632/cmzkcxvykt.1
21. Prodanovic, V., Bach, P. M., & Stojkovic, M. (2024). Urban nature-based solutions planning for biodiversity outcomes: human, ecological, and artificial intelligence perspectives. *Urban Ecosystems*, *27*(5), 1795-1806.
22. Sharmin, M., Tjoelker, M. G., Esperon-Rodriguez, M., Katlav, A., Gilpin, A. M., Rymer, P. D., & Power, S. A. (2024). Urban greening with shrubs can supercharge invertebrate abundance and diversity. *Scientific Reports*, *14*(1), 8735.
23. Strashok, O., Bidolakh, D., & Ziemiańska, M. (2025). Ecosystem benefits of urban woody plants for sustainable green space planning: a case study from Wroclaw. *Scientific Reports*, *15*(1), 10999.

24. Veerkamp, C. J., Schipper, A. M., Hedlund, K., Lazarova, T., Nordin, A., & Hanson, H. I. (2021). A review of studies assessing ecosystem services provided by urban green and blue infrastructure. *Ecosystem Services*, *52*, 101367.
25. Wang, D., Xu, P. Y., An, B. W., & Guo, Q. P. (2024). Urban green infrastructure: Bridging biodiversity conservation and sustainable urban development through adaptive management approach. *Frontiers in Ecology and Evolution*, *12*, 1440477.