

## **BIODIVERSITY AND QUALITY OF PUBLIC SPACES**

### **Preliminary Study for a Common Set of Indicators**

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#### **ABSTRACT**

This paper is part of a PhD study in Urbanism at the Universidade de Lisboa (ULisboa). Cities are rich in biodiversity, regardless of geographical location or altitude. Some are even located within or near biodiversity hotspots, while others are important stopover sites for migratory species. Urban biodiversity is responsible for benefits ecosystems provides, essential for human well-being. Public spaces are places where nature may connect to people and their dynamics. In the last decade, cities have been growing faster, increasing urban pressure on the natural environment, and the impact on quality of life. This paper identifies a set of indicators to understand the relationship between biodiversity and quality of public spaces, from the analysis of indicators sets already tested, assuming the importance of biodiversity and the quality of public spaces for better cities.

**Keywords:** urban biodiversity, quality of public spaces, indicators.

**Thematic clusters:** 2. City and Environment **Topic:** Environment, landscape and climate change

## 1. Introduction

In the last decades, cities are rapidly growing in population, increasing the pressure over the natural environment (Maes, 2019). According to Elmqvist (2013) urbanization is responsible for environmental degradation and has a significant implication for biodiversity loss.

It is commonly assumed that cities, being urban areas, are devoid of flora and fauna – the reality is that many cities have rich biodiversity, regardless of geographical location and climate. Some are even located within or near biodiversity hotspots, while others are important stopover sites for migratory species (Chan, 2014).

Aware that a healthy environment improves the quality of life of the citizens and taking into account the importance of the balance between the natural and the built environment, it is fundamental to understand that a city must be conceived as a system that provides human interrelationships with other living beings and the environment in which they live (Mora, 2009). The capacity of a city to provide ecosystem services that are essential for human well-being depends on the configuration of its ecosystems (Eraydin, 2013), which in turn, support the sustainability and resilience of modern cities (Langemeyer, 2013).

Ecosystem services such as food, clean water and flood protection to cultural heritage and a sense of place, are some of the many different benefits that ecosystems provide to the quality of human life underpinned by biodiversity (MEA, 2005; SEP, 2015).

Therefore, the issue of biodiversity loss in an urban environment becomes a theme of social, environmental, and political relevance (Santos, 2012).

### Urban biodiversity

Biological diversity, or biodiversity, is the term given to the variety of life on Earth. It is the combination of life forms and their interactions with one another, and with the physical environment that has made earth habitable for humans (CBD, 2006; Savard, 2000, Wilson, 1988). According to Ricklefs (2016), three main reasons justify the concern with the conservation of biological diversity: (1) biodiversity is a fundamental property of nature, responsible for the balance and stability of ecosystems; (2) there is a great potential for the economic use of biological diversity; (3) Its valuation is based on social, economic and ecological considerations (Araújo, 2014).

Urban biodiversity is defined as “the variety of species richness and abundance of living organisms (including genetic variation) and habitats found in and on the edge of human settlements”. Species range from the rural fringe to the urban core (Elmqvist, 2013).

### Public spaces

Traditionally, public spaces are conceived as open, free urban space, suitable for the development of collective needs for public life. Public spaces – especially the typology parks and plazas, must allow the integration of the citizens and their activities, the fruition, the cultural expression, the experience of Nature, the combination of the natural with the built as tools of urban planning (Mora, 2009). Public spaces are the engine of new perspectives in the city, the scenario for the development of collective needs and public life, the generator of the identity of the place and high determinant of its landscape, where nature is profoundly connected to the people and its dynamics (Mora, 2009).

It can be considered that the set of places in an urban environment, where there are open spaces for public use (parks, gardens, streets, plazas, waterfronts) constitutes the basis network of public spaces. These public

spaces are linked together, belong to a context, and are the basis of what defines the city as a system (Brandão, A. et al., 2018). According to Project of Public Spaces (PPS) when these spaces work well, they serve as the stage for our public lives. And to be successful, they usually have four qualities: they are accessible, engage people in activities, are comfortable, and sociable places (PPS, 2020).

This paper aims to understand the relationship between biodiversity and the quality of public spaces and therefore, to measure this relationship, it presents a preliminary study on existing sets of indicators.

## Indicators

“An indicator is a measure, generally quantitative, that can be used to illustrate and communicate complex phenomena simply, including trends and progress over time” (EEA, 2005). According to Atkins (2014, p.16), this definition sums up the main functions of quantification, communication, simplification, and monitoring progress over time, generally attributed to indicators. They allow us to recall why indicators are so often used in reporting documents and how they contribute to their objectives (Atkins, J., Gräbsch, C., & Jones, M. J. 2014).

As key statistical series they can provide information on the status of and trends, on responses to interventions measures, to monitoring what is happening according to pre-established models, and especially interest for this research, can relate different subjects such as the relationship of biodiversity and quality of public spaces (Reid, 1993; Santos, 2012).

## 2. Methodology

This preliminary study on biodiversity and quality of public spaces consists of three parts.

In the first part, a literature review was undertaken to identify sets of indicators about biodiversity and quality of public spaces and to understand how and why these sets are being used. The criteria for the literature selection was the importance, and the presence of suitable indicators according to the established research objectives. Usually biodiversity indicators are thought to measure and monitor biodiversity loss. Considering that this research area is meant for cities, to understand how happens the relationship between biodiversity and the quality of public spaces, namely parks and plazas, the selection of indicators has the urban perspective. On the other hand, the selection of indicators of quality of public spaces has also the perspective of the natural environment as a need to the human well-being. Quality of public spaces indicators are mostly focused on urban furniture, on urban equipment and functionality – as places of sociability, culture, comfort and aesthetic and psychological well-being. The natural environment reflects the individual’s feeling of physical, psychological, or emotional and environmental well-being due to thermal comfort, but on the other hand it may also be related to crime (Mora, 2009).

In the second part, from the literature, six sets of biodiversity indicators and four sets of quality of public spaces were selected. Namely, the six sets of biodiversity are from the European Environment Agency Index (EEA), the Singapore Index, the Lisbon Index, Reid’s Index (1993), the Landscape Biodiversity Index (LBI), and the RiProCity Project. The four sets of quality of public spaces indicators are from the Project for Public Spaces (PPS), Mora (2009), the PSSS (Brandão, 2018) and the PSQI (Praliya, 2019).

In the third part, from the ten selected indicator sets, there were selected 75 indicators. The selection was based on the feasibility to assess the relationship between biodiversity and the quality of public spaces. The analysis of the resulting indicators, and the grouping by affinities, led to the creation of eight categories, resulting in a new indicator set consisted of thirteen indicators.



### 3. Results

On the following sections are the selected sets of indicators. For each of the indicators sets, there is an explanation of what is it, the list of selected indicators and the explanation of why these sets of indicators have been chosen.

#### 3.1 Sets of urban biodiversity indicators

The sets of indicators listed below, are thought to be used worldwide, not specifically to be used in urban areas.

##### 3.1.1 European Environment Agency (EEA) Index

Aiming to measure progress towards the target of halting biodiversity loss and restoring ecosystem services, the European Environment Agency started in 2005, a streamlined set of biodiversity indicators for Europe, under the Streamlining European Biodiversity Indicators (SEBI) process. This activity was underpinned by the following policies: the Strategic Plan for Biodiversity 2011–2020 together with the Aichi 2020 targets at the global level, the EU 2020 Biodiversity Strategy and the Pan-European 2020 Biodiversity Strategy (EEA, 2012, 2014). The SEBI developed 26 indicators, of which eight have been selected for this research (Table 1).

RN	SN	Indicator set SEBI	Research adaptation
1	1	Abundance and distribution of selected species	Presence of umbrella species
2	2	Red List Index for European species	Red List Index
3	3	Species of European interest	Species of special interest
4	4	Ecosystem coverage	Percentage of vegetation x total area of public space
5	5	Habitats of European interest	Habitats of ecological interest
6	13	Fragmentation of natural and semi-natural areas	Connectivity of the natural area with other "green" areas
7	14	Fragmentation of river systems	Connectivity of the river system
8	26	Public awareness	Public awareness of the importance of "green" public spaces

Table 1: SEBI - Streamlining European Biodiversity Indicators (adapted); RN - Research Number; SN - Set Number. (Source: EEA, 2014).

According to EEA (2012) the SEBI process was set up to streamline national, regional, and global indicators and, crucially, to develop a simple and workable set of indicators to measure progress and help reach the Aichi target. The process involved around 140 researchers with different expertise and geographical coverage to help ensure the scope of work at all scales: territorial, feasibility and simplification of processes, as much as possible. The SEBI initiative helped European countries to support the development of indicators by helping to convince national authorities of the interest in establishing an indicator system, to develop specific indicators or to benchmark their own system, and helped to improve coherence between European and national sets (EEA, 2012).

##### 3.1.2 Singapore Index (SI)

The Conference of Parties (COP) is the governing body of the Convention on Biological Diversity (CBD). The CBD is a global agreement addressing all aspects of biodiversity: genes, species, and ecosystems. According to Chan (2014), in 2008, the COP-9 marked a watershed in efforts to recognise the role of cities and local authorities in stemming global biodiversity loss. This recognition encourages national governments to engage

cities in the implementation of the CBD. And so, the Singapore Government proposed a set of indicators tailored for application by urban settlements and to be used as a reporting framework at the local level.

This set of indicators is called either “City Biodiversity Index” (CBI), “Singapore Index on Cities’ Biodiversity” or “Singapore Index” (SI) and is a self-assessment tool for cities to evaluate and monitor the progress of their biodiversity conservation efforts against their baselines.

The Singapore Index (SI) is a pioneering self-assessment tool designed to help cities better understand how they can improve their biodiversity conservation efforts over time. The Singapore Index encourages cities to complete a baseline assessment of their biodiversity, to identify policy priorities based on their measurements and then monitor at periodic intervals (Chan, 2014; AECOM, 2013). The SI is based upon the profile of the city and 23 indicators related to biodiversity<sup>1</sup> (Chan, 2014) of which six have been selected for this research (Table 2).

RN	SN	Indicator set SI	Research adaptation
9	1	Proportion of Natural Areas in the city	Proportion of Natural Areas in the intervened area
10	2	Connectivity Measures	Connectivity of the natural area with other “green” areas
11	11	Regulation of quantity of water	Regulation of quantity of water (overflow)
12	13	Recreation and education: area of parks with natural areas	Recreation and education: area of parks with natural areas
13	16	Number of biodiversity projects implemented by the city annually	Number of biodiversity projects implemented by the city annually
14	17	Existence of local biodiversity strategy and action plan	Existence of local biodiversity strategy and action plan

Table 2: SI - Singapore Index (adapted); RN - Research Number; SN - Set Number. (Source: Chan et al., 2014).

The Singapore index focuses on existing ecological conditions as a basis for biodiversity performance targets, as well as on recreational and educational aspects, focused on the scale of cities and towns.

### 3.1.3 Lisbon Index

In 2012 the city of Lisbon, aware of the environmental weaknesses of urban ecosystems, took on an ambitious and pioneering challenge: to increase urban biodiversity by 20% until 2020. With this aim, the Lisbon City Council commissioned a study of characterization of the biodiversity of the city, having amongst its results a “Matrix of Urban Biodiversity Indicators”. This matrix is an adaptation of the “Singapore Index on Cities’ Biodiversity”. The adaptation considers Lisbon particularities and includes other groups of the fauna in addition to those already proposed (Santos, 2012). For this research three indicators have been selected (Table 3).

<sup>1</sup> <https://www.nparks.gov.sg/biodiversity/urban-biodiversity/the-singapore-index-on-cities-biodiversity>

RN	SN	Indicator set Lisbon	Research adaptation
15	1	Natural areas (Singapore 1) – percentage of seminatural spaces (eg ruderal areas) and naturalized areas (Parque de Monsanto and Tapada da Ajuda)	Proportion of Natural Areas in the intervened area
16	2	Fragmentation - Connectivity measures: both ground and canopy tree level	Connectivity between “green” areas
17	12	Climate and air quality regulation through vegetation - measured by the proportion of the canopy areas of trees and large shrubs (from three meters high) and the total land area of the County.	Thermal comfort based on the shade ratio of the tree canopy and the total area of the public space.

Table 3: Lisbon Index (adapted); RN - Research Number; SN - Set Number. (Source: Santos, 2012).

The indicators proposed for a correct assessment and monitoring of biodiversity in Lisbon are particularly interesting in studies of Portuguese cities since it considers the environmental performance of Portugal (Santos, 2012).

#### 3.1.4 Reid's Index (1993)

Right after a new convention on biodiversity has been signed by over 150 countries in 1992, Reid's Index was the result of one of the first works on biodiversity indicators. It lays out a comprehensive plan of action to conserve diversity and presents a set of policy-relevant indicators of biodiversity conservation, better used in provincial, national, regional, or global policymaking. A set of 22 indicators is organized into three categories: wild species and genetic diversity, community diversity and domesticated species (Reid, 1993). From the 22 indicators five have been selected for this research (Table 4).

RN	SN	Indicator set Reid	Research adaptation
18	1	Species richness	Number of species
19	2	Species threatened with extinction	Red List Index
20	4	Endemic species	Endemic species
21	13	Species used by local residents	Percentage of medicinal and unconventional food plants ("UFP" or "PANCs") in comparison of the whole number of spp.
22	14	Percentage of area dominated by non-domesticated species	Percentage of area dominated by non-indigenous species

Table 4: Reid's Index (adapted); RN - Research Number; SN - Set Number. (Source: Reid, 1993).

Reid's Index was developed to identify and monitor biodiversity without, worrying about urban biodiversity. However, this set of indicators was selected because it presents the concern for the preservation of biodiversity, necessary to define some elements in this research.

#### 3.1.5 UB Landscape Biodiversity Index (LBI) (AECOM, 2013)

The LBI was developed from the Singapore Index, in response to the need for a quantitative measurement protocol for biodiversity. This system of landscape-based indicators was also developed to be used in urban areas since urban areas are also the focus of conservation economies and increased biodiversity.

The performance of the indicators is measured through a scoring system and include the structural and pattern characteristics of landscapes such as priority species, habitat quality, connectivity, and total habitat area. The system is calibrated for local ecology and priorities. Therefore, it can be applied anywhere, assess local



performance relative to local biodiversity, and can be used in urban planning (AECOM, 2013; Gomes, 2014). For this research nine indicators have been selected (Table 5).

RN	SN	Indicator set LBI	Research adaptation
23	1	Habitat priorities – target species	Presence of umbrella species
24	1	Habitat priorities – cultural value	Presence of species of cultural value
25	1	Habitat priorities – endemism	Endemic species
26	2	Habitat variety – variety and area of habitat types	Habitat variety – variety and area of habitat types
27	3	Habitat quality – presence of structural layers in habitat types	Habitat quality – presence of structural layers in habitat types
28	6,7	Habitat shape and size – habitat corridor width	Width of the corridor/connection between the parks
29	8,9	Habitat connectivity – network	Connectivity of the natural area with other “green” areas
30	8,9	Consistency (quality of habitat along a network of habitat areas)	Consistency (quality of habitat along a network of habitat areas)
31	10	Ecosystem Type Pattern – habitat type connectivity, adjacent land use, ecotones, off-site connections	Ecosystem Type Pattern – habitat type connectivity, adjacent land use, ecotones, off-site connections

Table 5: LBI Landscape Biodiversity Index (adapted); RN - Research Number; SN - Set Number. (Source: AECOM, 2013).

The system is calibrated for local ecology and priorities. Therefore, it can be applied anywhere, to not very extensive areas, to assess, quantify, compare, and monitor local performance relative to local biodiversity, and can be used in urban planning (AECOM, 2013; Gomes, 2014).

### 3.1.6 RiProCity Project Index

The “Rio e Cidade – Oportunidades para a Sustentabilidade Urbana Project” (RiProCity) explores the contribution of watercourses in urban areas. The RiProCity Project aimed to establish a system of sustainability indicators applicable to river cities, deepening the concepts associated with sustainability, as well as the models and systems already proposed within the scope of various organizations and programmes, in order to support the formulation and application of the indicator system to be built. One of its main objectives is to increase the attachment of Portuguese citizens in a sustainable relationship with their rivers and surrounding areas (Fontoura, 2009).

In this context, eight indicators were developed by the RiProCity Project, from which, seven have been chosen for this research (Table 6).

RN	SN	Indicator set RiProCity	Research adaptation
32	1	Citizens' satisfaction with the riverfront	Public awareness of the importance of the riverfront
33	2	River contribution to bioclimatic comfort	River contribution to bioclimatic comfort
34	3	Environmental quality of the river corridor (margin + riverbed)	Environmental quality of the river corridor (margin + riverbed)
35	4	Flood risk	Flood risk
36	5	Sustainable land use	Sustainable land use
37	6	Mobility and accessibility to the river	Accessibility to the river
38	7	Availability of equipment, services, and public spaces	Availability of equipment and services

Table 6: RiProCity Index (adapted); RN - Research Number; SN - Set Number. (Source: Saraiva, 2009).

Urban sustainability indicators, like those from the RiProCity Project, represent a useful tool, as they allow to compare situations among themselves, in the same city over time, or between different cities enabling the evaluation of the management processes developed (Saraiva, 2009 In: Saraiva, 2009).

### 3.2 Sets of quality of public spaces indicators

#### 3.2.1 Project for Public Spaces (PPS)

The Project for Public Spaces, founded in 1975 by Fred Kent, based on William H. Whyte principles, ideas, and techniques, is a non-profit organization dedicated to study public spaces around the world, connecting people to ideas, resources, expertise, and partners who see place as the key to addressing the challenges of creating better places focusing on the community well-being and on what makes successfully or not successfully places. In this sense, the PPS developed "The Place Diagram" as a tool to help people in judging any place, good or bad (PPS, 2020). According to this Project public spaces share four qualities to achieve the success: accessibility, comfort, and image, uses and activities and it is a sociable place.

From the PPS, eight indicators have been selected for this research (Table 7).

RN	SN	Indicator set PPS	Research adaptation
39		Access & Linkages	Readable - easy to get to and get through
40		Comfort & Image - walkable	Walkable, wayfinding
41		Comfort & Image - sittable	Sittable
42		Comfort & Image - clean	Cleanliness
43		Comfort & Image - safe	Safety
44		Comfort & Image - spiritual	Spirituality
45		Uses & Activities - Leisure activities	Leisure activities
46		Sociability	People diversity

Table 7: PPS - Project for Public Spaces' Index (adapted); RN - Research Number; SN - Set Number. (Source: <https://www.pps.org/article/grplacefeat>)

The PPS is a worldwide reference in this area. This this project has a very complete approach, observing several aspects, focusing on the successful use of public spaces. It can be used as a starting point for further studies.

#### 3.2.2 Quality of public spaces' indicators proposed by Mora (2009)

The environmental quality of cities is largely determined by the capacity of their spaces to promote public life for citizens. In this sense, Mora (2009) generate indicators to measure the quality of public spaces to seek urban environmental quality and to achieve citizen dignity. The developed methodology evaluates public spaces and is tested in a medium-size city using a matrix of indicators. The method establishes that the achievement of acceptable objectives of "environmental quality" must be based on a global conception where the multiple factors that influence its determination are considered.

According to Mora (2009) there are three major aspects of a general nature that act as benchmarks for the evaluation of environmental quality:

1. Physical-natural (conditions of the natural environment - climatic-meteorological and relief factors, including, for example, the risk of floods and landslides).
2. Urban-architectural (artificial urban-architectural environment).
3. Socio-cultural (aspects of social order expressed in cultural patterns of individual and social coexistence).



The interaction between the multiplicity of variables linked to these three great categories constitute important references for the evaluation of urban environmental quality (Mora, 2009).

From Mora (2009), five indicators have been selected for this research (Table 8).

RN	SN	Indicator set Mora	Research adaptation
47	2.1	Public space totally in stable areas, without risk areas	Public space totally in stable areas, without risk areas
48	2.2	Presence of air purifying vegetation masses	Presence of trees, shrubs, and undergrowth vegetation
49	2.2	Permanent maintenance of public spaces	Permanent maintenance of public spaces
50	4.2	Possibility of using public space	Possibility of using public space
51	5.1	Waterfront	Presence of waterfront - people awareness of its importance

Table 8: Mora's Index (adapted); RN - Research Number; SN - Set Number. (Source: Mora, 2009).

Two fundamental tools were considered for this methodology, namely: fieldwork and literature review. Throughout the development of the study, matrices were developed to assess the quality of the evaluated public spaces.

### 3.2.3 *Common places – public space evaluation and interpretation guide; Public Space's Service System (PSSS) (Brandão, 2018)*

The PSSS proposes a theory and method for interpreting and evaluating the public space service, understanding the dynamics of its use, outlining solutions and defining strategies for its improvement, provoking dialogue between the various actors and interests involved, and supporting planning and the management of public spaces. The PSSS recognizes the importance of the interaction and continuity of several interconnected urban systems that can act for common purposes, highlighting the natural elements such as watercourses and green structures (Brandão, 2018). For this research six indicators have been selected (Table 9).

RN	SN	Indicator set PSSS	Research adaptation
52		Appropriate design and public equipment	Access to natural areas
53		Diversity of urban elements, favouring the multifunctionality of space	Diversity of urban elements, favouring the multifunctionality of space
54		Connectivity within the public space	Connectivity within the public space
55		Connectivity with other parks	Connectivity of the natural area with other "green" areas
56		Wayfinding	Wayfinding
57		Diversity of users (different ages, social classes, inclusion)	Diversity of users (different ages, social classes, inclusion)

Table 9: PSSS - Public Space's Service System (adapted); RN - Research Number; Set Number. (Source: Brandão, 2018).

According to Brandão (2018), the value of a public space stems not only from the qualities inherent to the physical space itself but also from the way it is "read" and perceived. This means that the valorisation of the public space can go through physical intervention in the space, as well as the transformation of the ways of looking. The central object of the PSSS, which makes it extremely interesting, is the notion of a public space system, considering its intrinsic and extrinsic relations (Brandão, 2018).

### 3.2.4 *PSQI (Praliya, 2019)*

Aiming the development of an evaluation framework to improve the management of public spaces and their surroundings to improve the quality of these spaces, Praliya (2019) developed a set of indicators for the evaluation of the quality of public spaces employing the Public Space Quality Index (PSQI).

The proposed framework is easy to understand and to implement, can be utilized by planning, development, and management agencies, either during the initial stages of planning of new public spaces as well as during the evaluation process and improvement of existing public spaces. For this research 18 indicators have been selected (Table 10).

RN	SN	Indicator set Pralyia	Research adaptation
58	1	Accessible & linked - ease of movement in and around; accessibility walking	Wayfinding
59	2	Maintenance - condition of green areas; condition of park infrastructure; conditions for walking, jogging, cycling tracks	Permanent maintenance of public spaces
60	3	Attractiveness and appeal - uncluttered view of the space	Uncluttered view of the space
61	3	Attractiveness and appeal - landscape, condition of grass/verges	Condition of grass/verge
62	3	Attractiveness and appeal - presence and condition of flowered areas	Presence and condition of flowered areas
63	4	Comfort - comfortable sitting areas	Leisure activities
64	4	Comfort - presence and condition of shelter spaces	Leisure activities
65	4	Comfort - presence of Signage's	Uncluttered view of the space
66	4	Comfort - provision of buffer from traffic nuisance	Comfort - provision of buffer from traffic nuisance
67	5	Inclusiveness - Used by all, irrespective of age, race, class, gender, and physical abilities	People diversity
68	6	Activity and uses - walking	Walkable
69	6	Activity and uses - socializing	Socializing
70	6	Activity and uses - family outings	Leisure activities
71	6	Activity and uses - contact with flora and fauna	Contact with flora and fauna
72	7	Purposefulness - suitability of layout and design	Suitability of layout and design
73	7	Purposefulness - ambience	Ambience
74	8	Safety and security - presence of adequate lighting, illumination	Safety
75	8	Safety and security - surveillance measures	Safety

Table 10: Praliya's Index (adapted); RN - Research Number; Set Number. (Source: Praliya, 2019).

The PSQI evaluates the performance of public spaces by calculating an average rating for each of the quality attributes, assigning weightages to the quality attributes, calculating an attribute score, a dimension score and an overall performance score of public space. This indicator set is detailed and may be used to compare public spaces from different cities.

### 3.3 Grouping the indicators in categories and creating a new set of indicators

From the ten sets of indicators mentioned and described above, 75 indicators were selected, regardless of their origin, being from the sets of indicators of biodiversity or the quality of public spaces. Analysing the selected indicators, it was possible to notice that the indicators are organized into eight different categories, namely:

connection, event, habitat level, planning, proportion, public awareness, species level, and public awareness. Table 11 shows the description from each category.

Category	Description
CONNECTION	connectivity within public spaces, between public spaces and surroundings, and rivers, and riverbanks
EVENT	related to natural phenomena
HABITAT LEVEL	related to habitats; the vegetation as "macro" sense, involving several species and specimens
PLANNING	includes indicators resulting from planning actions
PROPORTION	proportion of areas of different typologies
PUBLIC AWARENESS	public awareness and respect for diversity in all the senses
SPECIES LEVEL	related to species; the vegetation as "micro" sense, involving species as individuals
WELL-BEING	comfort, leisure, happiness

Table 11: description of the categories.

The analysis of the resulting indicators, and the grouping by affinities, led to the creation of eight categories, resulting in a new indicator set consisted of thirteen indicators. Table 12 shows the proposed common indicator set.

RN	Category	Indicator adapted to the research
6, 10, 29, 55, 16, 28, 31	CONNECTION	Connectivity of the natural area with other "green" areas; width of the corridor/connection between the parks; ecosystem type pattern – habitat type connectivity, adjacent land use, ecotones, off-site connections
54	CONNECTION	Connectivity within the public space
7, 34	CONNECTION	Connectivity of the river system; environmental quality of the river corridor (margin + riverbed)
11, 35, 47	EVENT	Risk areas: flood, geologically unstable
5, 26, 27, 30, 48	HABITAT LEVEL	Habitats of ecological interest; habitat variety – variety and area of habitat types; habitat quality – presence of structural layers in habitat types
37, 52	PLANNING	Accessibility to the river and to natural areas
72, 73, 60, 65, 13, 14, 36, 39, 40, 68, 41, 42, 43, 74, 75, 56, 58, 53, 49, 59, 38, 61, 62	PLANNING	Permanent maintenance of public spaces regarding security, suitability of layout and design (diversity of urban elements, favouring the multifunctionality and comfort of space), ambience, sustainability, wayfinding, cleanliness; projects regarding local biodiversity strategy and action plan
4, 9, 15, 22	PROPORTION	Percentage of vegetation x total area of public space; proportion of natural areas in the intervened area; percentage of area dominated by non-indigenous species
17	PROPORTION	Thermal comfort based on the shade ratio of the tree canopy and the total area of the public space.
21	PROPORTION	Percentage of medicinal and unconventional food plants ("UFP" or "PANCs") in comparison of the whole number of spp.
8, 12, 32, 46, 51, 57, 67	PUBLIC AWARENESS	Recreation and education; awareness of the importance of respecting people's diversity (age, social classes, inclusion) and public spaces (waterfront, "green" areas)
1, 2, 3, 18, 19, 20, 23, 24, 25	SPECIES LEVEL	Presence of umbrella species; Red List Index; species of special interest; number of species; endemic species; species of cultural value
33, 44, 45, 50, 63, 64, 66, 69, 70, 71	WELL-BEING	River contribution to bioclimatic comfort; spirituality; socializing; leisure activities; contact with flora and fauna; protection against pollution

Table 12 – proposed common indicator set



#### 4. Considerations

This is a preliminary study to understand the relationship between biodiversity and the quality of public spaces and to group two themes that are usually applied independently. The set of indicators resulting from the analysis of several sets of indicators will be particularly useful to understand the relationship between biodiversity and the improvement of public space, on how they are articulated and how they affect each other.

This initial study allows us to evaluate the possibility of using the proposed set of indicators, in the subsequent analysis of the relationship between bioindicators and quality of public space.

There are certainly more indicators that have not been considered, and, being a preliminary study, this study is not intended to be exhaustive. The set of indicators resulting from this research allows the incorporation and interaction of other indicators to increase the capacity for analysis. With the help of other tools, it will eventually be possible to draw some conclusions about how the relationship between biodiversity and the quality of the ecosystem occurs in public spaces.

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