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\(^1\) (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).

\(^1\) [https://www.nparks.gov.sg/biodiversity/urban-biodiversity/the-singapore-index-on-cities-biodiversity](https://www.nparks.gov.sg/biodiversity/urban-biodiversity/the-singapore-index-on-cities-biodiversity)
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 ("UFF" 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 |

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 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  | Set Number | Praliya Indicator Set | 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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