Analysis of vegetation biodiversity and urban park connectivity as landscape services provider in Bogor city

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Abstract. The rapid urban development has its own positive and negative impacts, especially on the landscape. One of the attempts to overcome those negative impacts of urban development is to create Green Open Space. The proportion of green open space in an urban area should be at least 30% of the total area. One form of green open space is an urban park, which is also become a green belt infrastructure. Therefore, the object of this research is six urban parks in Bogor City; there are Sempur Park, Kaulinan Park, Peranginan Park, Kresna Field Park, Corat-Coret Park, and Katulampa Fasofasum Park located in the Ciliwung Watershed. The methods used in this study are the Shannon-Wiener Index to analyze the biodiversity of urban parks in Bogor City, which has the results of a Shannon-Wiener index from low to high. While based on the results of the Sorensen Index, connectivity between Urban parks in Bogor City is classified from low to moderate. Furthermore, the correlation between vegetation biodiversity and connectivity was tested through the Spearman Rank Correlation Test, a strong and direct correlation. The outputs from this study are three recommendations for urban park management to improve vegetation biodiversity and connectivity in Bogor City.

1. Introduction
Rapid urban development has both positive and negative impacts, especially for landscapes. The number of land conversion actions has caused the city's comfort to decline. One of the efforts to overcome the negative effect of development and to increase the comfort of the city is to create Green Open Space. City green open space is part of the open spaces of an urban area filled with plants to support the direct or indirect benefits generated by green open space in the city, namely safety, comfort, welfare, and beauty of the urban area [1]. RI Law No. 26 of 2007 concerning Spatial Planning has explained that the proportion of green open space in the city area is at least 30% of the city area.

The city of Bogor, with an area of 11,850 hectares, has less than 30% public green open space, an urban park. Urban parks function to improve the environment’s quality, which has changed a lot due to land conversion. Urban parks are one of the right means of increasing or producing the biodiversity of plants in the park. Besides, parks include green infrastructure, namely natural green paths can be semi-natural, and human-made, space, such as gardens, parks, rations, riverbanks, bicycle paths, forests, tree belts [2] and the presence of parks. The city creates connectivity, especially in the city of Bogor. Connectivity can be seen from the similarity of the vegetation in a landscape. Apart from urban parks, connectivity can be seen in riverbank areas with variations in the size and type of vegetation.

The sustainability of a landscape area can be measured from the landscape services provided or obtained from the structure, functions, and dynamics of the natural resources in it [3]. The purpose of this study is to analyze the biodiversity of urban park vegetation in Bogor City, analyze connectivity
between urban parks in Bogor City, analyze the correlation between biodiversity and urban park connectivity in Bogor City, and formulate recommendations for urban park management in Bogor City based on the level of biodiversity and connectivity.

2. Research objectives
The objectives of the study are to analyze the biodiversity of Bogor urban park vegetation, to analyze the connectivity of Bogor urban park, to analyze the correlation between vegetation biodiversity and park connectivity, and to create urban park management based on vegetation biodiversity and connectivity.

3. Research methods

3.1. Data collecting and processing
First, determine the location using purposive random sampling. This research was conducted in six urban parks in Bogor City, West Java (Table 1). The survey and study took samples of urban parks close to the Ciliwung River. The sample was divided into the upper, middle, and lower areas measured as far as 200 m from the riverbank, then reclassified according to the park manager (Figure 1). Furthermore, in the six parks, an inventory of species names and numbers was carried out. After obtaining the inventory data, the data was processed using the Shannon-Wiener Index and the Sorensen Similarity Index to determine the biodiversity of vegetation and connectivity between parks. Apart from primary data from the six parks, secondary data was collected to support primary data.

Table 1. List of sample urban parks

| No | Territory | No | Urban Park                  |
|----|-----------|----|-----------------------------|
| 1  | Upper     | 1  | Corat Coret Park            |
|    |           | 2  | Lapangan Kresna Park        |
| 2  | Middle    | 3  | Sempur Park                 |
|    |           | 4  | Kaulinan Park               |
|    |           | 5  | Peranginan Park             |
| 3  | Lower     | 6  | Fasosfasum Griya Katulampa Park |

Figure 1. (a) Map of West Java (b) Map of sample six urban parks

3.2. Biodiversity analysis
Vegetation biodiversity analysis is carried out by analyzing the vegetation in urban parks along the Ciliwung River border. Vegetation biodiversity analysis is a way of studying the composition or composition of vegetation types and forms or structures [4]. The stages of vegetation biodiversity analysis are as follows:
- Determine which park to test.
- Record and identify types of plants.
- Calculates the Shannon-Wiener biodiversity index

\[ H' = -\sum pi \ln pi \]  

Information:

- \( H' \) = Shannon-Wiener index
- \( pi = ni / N \)
- \( pi \) = relative abundance
- \( ni \) = number of species \( i \)
- \( N \) = total number of individuals

The result from the calculation of the Shannon-Wiener biodiversity index is then categorized based on the index value criteria. These criteria are listed in Table 2.

**Table 2. Criteria for the Shannon-Wiener biodiversity index value [5]**

| Shannon Index Value | Category |
|---------------------|----------|
| > 3                 | High diversity, high distribution of individual numbers of each species, and increased community stability |
| 1-3                 | The diversity is medium, the distribution of the number of individuals of each species is moderate, and the strength of the community is moderate |
| <1                  | Low diversity, low distribution of the number of individuals per species, and low community stability |

Apart from Shannon-Wiener diversity, there are horizontal and vertical variations. Horizontal diversity has a classification [6] as follows, plants producing starch, fruit, vegetables, medicines, spices, industrial raw materials, ornamental plants, and other plants, while the classification of vertical diversity [6], namely Strata V (> 10 m), Strata IV (5-10 m), Strata III (2-5 m), Strata II (1-2 m), Strata I (<1m).

### 3.3. Park connectivity analysis

Park connectivity analysis is a way to analyze the relationship between urban parks and the Ciliwung River. Connectivity analysis is done by looking at the level of similarity of species from one park to another and is measured through the Sorensen Similarity Index. The following is a mathematical representation of the Sorensen Similarity Index [7]:

\[ SI = \frac{2C (A + B)^{-1}}{} \times 100\% \]  

Information:

- \( SI \) = Sorensen Similarity Index
- \( A \) = Number of species at site 1
- \( B \) = Number of species at site 2
- \( C \) = Number of species found in locations 1 and 2

**Table 3. Criteria for a similarity index value**

| Similarity Index Value | Category |
|------------------------|----------|
| >91%                   | Very high similarity |
| 61-91%                 | High similarity |
| 31-60%                 | Medium similarity |
| 1-30%                  | Low similarity |

If the SI value is more excellent, the species similarity in the places being compared, the more uniform the vegetation composition will be. The result of the calculation of the Sorensen Similarity Index is multiplied by 100 to get the percentage of each calculated object.
3.4. **Correlation analysis of biodiversity and connectivity**

Correlation analysis is carried out to see the relationship between biodiversity and connectivity. This correlation analysis can be generated from comparing the Shannon-Wiener calculation with Sorensen on two different sites, though the Spearman Rank Correlation Test.

4. **Results and discussion**

4.1. **Site studies**

Bogor City is located between 106° 48’ East Longitude and 6° 26’ South Latitude, Bogor City has an average minimum height of 190 m and a maximum of 330 m above sea level. Climate conditions in Bogor temperature The average monthly temperature is 26 °C, with the lowest temperature being 21 °C with the highest temperature being 34 °C. The average humidity is 80% [8]. The area of Bogor City is flowed by large rivers and branches. The two large rivers are the Ciliwung River and the Cisadane River, and the tributaries are the Cipakancilan River, Cidepit River, Ciparigi River, and Cibalok River [8].

4.2. **Bogor urban parks**

The area of green open space managed by the Bogor City Sanitation and Park Agency is 41,8 hectares. Urban parks are generally governed by the Bogor Urban Park and Sanitation Service, particularly in the park sector. The limitations of this urban park research carried out in six Urban Parks in the City of Bogor are determined through purposive random sampling by determining criteria such as, parks that are crossed by the Ciliwung River and watercourse from the Ciliwung river are 200 m from the right and left side of the river, and are managed by Bogor City Sanitation and Park Agency, further divided into upper, middle and lower areas. The area consists of Tanah Sareal District, West Bogor District, and North Bogor District. The middle area only consists of Central Bogor District and the lower area consists of South Bogor District and East Bogor District.

**Figure 2.** Distribution of six urban parks in Bogor City
4.3. Vegetation biodiversity of urban parks Bogor

4.3.1. Shannon-Wiener Index in Urban Parks Bogor. After identifying the horizontal diversity of plants to determine the function of plants and the diversity to determine the strata in six urban parks in Bogor City through their species and stratum, biodiversity analysis was carried out using the Shannon Wiener Index (H'). The park with the highest biodiversity level is Sempur Park with an H' of 3.14 (Figure 2), which is included in the high diversity class. Corat-coret Park with an H' of 1.71 and is included in the medium diversity class. According to the analysis, it is known that 83% of the parks belong to the medium diversity class, 17% of the parks are included in the high diversity class, and there are no parks with a low Shannon-Wiener Index. So that the six parks in the city of Bogor are parks with moderate and high diversity.

![Figure 3. Shannon-Wiener Index of six parks in Bogor City](image1)

![Figure 4. Shannon-Wiener Index of three park areas in Bogor City](image2)
Sempur Park, with an area of 13,631.68 m² is planted with 43 species, such as golden flower (*Ruellia* sp.), striped grass (*Tradescantia pallida*), red purslane (*Portulaca oleracea*). Corat Coret Park has an area of 571 m² planted with ten species, such as golden flowers (*Ruellia* sp.), mini chives (*Ophiopogon jaburan*), and bromeliads (*Bromelia* sp.). Based on the Shannon-Wiener Index chart (Figure 4), the middle region’s diversity is 2.43. The upper region has a Shannon-Wiener Index of 1.98. Furthermore, the lower area is only Katulampa Fasosfusum Park of 1.87. This shows that the central region has a higher diversity of plant species than the upper and lower regions, this is influenced by the location of the central area, which can be used as core green open space or ecotone areas in Bogor City. Ecotone generally has greater diversity than other regions because it is a transitional area. The results from the Shannon-Wiener Index for each of the three regions belong to medium diversity.

### 4.3.2. Horizontal diversity

Based on research that has been conducted in six parks in Bogor City, there are 85 species found in the inventory that fall into 47 families. Asparagaceae is the most common family with plants found with a percentage of 8.33%, it is one of the flowering plant families needed by the park to improve aesthetics. Next, the Fabaceae family of 5.95%, followed by the Apocynaceae, Commelinaceae, and Myrtaceae families which had the same percentage of 4.76%. The function of plants as ornamental or ornamental plants was mostly found with a percentage of 42%. This shows that plants as landscape elements in Bogor City parks have the function of enhancing the beauty and creating an aesthetic impression. Furthermore, the second largest function is as a medicinal plant by 25%. Meanwhile, 13% of the function of plants in Bogor City parks is as fruit producers. Other functions of plants in Bogor City parks are plants with other functions of 11%, the function of producing vegetables and industrial materials is 4%, the function of spices is 1%, and 0% for starch-producing plants.

Plants in the family Asparagaceae is a plant that is dominated by ornamental functions such as roseary flowers (*Canna* sp.), pandan bali (*Dracaena loureiri*), drasena (*Dracaena fragrans*), and the tongue-in-law (*Sansevieria trifasciata*). Family Fabaceae dominated by multi-functional plants such as legumes (*Arachis pintoi*) and flamboyant (*Delonix regia*). Then Ki Hujan (*Samanea saman*) leaves from the ki hujan tree can be used to relieve symptoms of asthma, improve blood flow, treat flu, medicinal plants, namely angsana (*Pterocarpus indicus*). Angsana tree leaves can treat kidney stones using angsana leaf tea therapy another, medicinal, industrial function plant is lamtaro (*Leucaena leucocephala*).

![Figure 5. Percentage of plant function in six parks in Bogor city](image)

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**Figure 5.** Percentage of plant function in six parks in Bogor city

### 4.3.3. Vertical diversity

Based on research in 6 parks in Bogor City, 31% were strata I plants low shrubs or ground cover plants. The second-largest percentage is planting with strata IV of 21%. Plants in strata II, III, and V with the respective percentages of 20%, 11%, and 17%. Several plant species in strata I, namely, bromeliads (*Bromelia* sp.), sri rejeki (*Aglaonema costatum*), tongue-in-law (*Sansevieria trifasciata*) and spider lilies (*Hymenocallis speciose*), onions (*Zephyranthes grandiflora*), red purslane (*Portulaca oleracea*), adam air (*Rhoeo discolae*), blood sambang (*Excoecaria cochinchinensis*) and seruni rampat (*Wedelia trilobata*).
Strata IV, namely moringa (*Moringa oleifera*), there are plants from the Aracaceae family, namely, squirrel tail palm (*Wodyetia bifurcara*), female palm (*Veitchia Merillii*), red palm (*Cyrtostachys lace*), jambang (*Syzygium cumini*), water guava (*Psidium guajava*), sapodilla (*Manikara zapota*), starfruit (*Averrhoa bilimbi*), soursop (*Annona muricate*), coconut (*Cocos nucifera*) and sapodilla (*Manilkara kauki*), papaya (*Carica papaya*), then teak (*Tectona grandis*).

![Figure 6. Percentage of plant stratum in park in Bogor city](image)

4.4. Plant connectivity in urban park Bogor city

4.4.1. Sorensen index. Connectivity has been described as an extension of movement for flora and fauna that is not only linear [9]. For this connectivity to be formed, a corridor is needed to connect between patches. Corridors between these patches can be either a path or a stepping stone. Through the Sorensen index, a park as a stepping stone can be measured the level of similarity to find out how close the relationship between two parks is to one another. Based on Table 5, Peranginan Park and Sempur Park have the greatest similarity and are included in the moderate criteria of 43.48%. There is 15 similar vegetation in the two parks such as golden flowers (*Rueilla* sp.), spider lilies (*Hymenocallis speciosa*), mahogany (*Swietenia mahogani* Jacq) and others. Sempur Park and Kaulinan Park have a similarity of 36.36%, still classified as moderate similarity there is ten similar vegetation in both parks. The similarity between parks is then classified as low, there is seven similar vegetation in Kresna Field Park with Peranginan Park with a similarity of 30.43%. Then Sempur Park and Corat-coret Park have a similarity of 26.42%.

| Park(%) | CC<sup>a</sup> | KR<sup>b</sup> | SP<sup>c</sup> | KN<sup>d</sup> | PR<sup>e</sup> | FK<sup>f</sup> |
|--------|----------------|----------------|----------------|----------------|----------------|---------------|
| CC<sup>a</sup> | **6.67** | 26.42 | 18.18 | 16.67 | 0.00 |
| KR<sup>b</sup> | **15.87** | 15.87 | 12.50 | 30.43 | 14.63 |
| SP<sup>c</sup> | **36.36** | 36.36 | 36.36 | 43.48 | 3.13 |
| KN<sup>d</sup> | **10.53** | 10.53 | 10.53 | 0.00 | 13.04 |
| PR<sup>e</sup> | **13.04** | **13.04** | **13.04** | **13.04** | **13.04** |
| FK<sup>f</sup> | **13.04** | **13.04** | **13.04** | **13.04** | **13.04** |

<sup>a</sup>Corat-Coret Park.
<sup>b</sup>Kresna Park.
<sup>c</sup>Sempur Park.
<sup>d</sup>Kaulinan Park.
<sup>e</sup>Peranginan Park.
<sup>f</sup>Fasosfasum Katulampa Park.
Kaulinan Park with Corat Coret Park has a similarity of 18.18%. A similarity of 16.67% was obtained from Peranginan Park with Corat Coret Park, then 15.87% was the similarity between Sempur Park and Kresna Park. Katulampa Fasosfasum Park and Kresna Field Park have a similarity of 14.63%. Then, the Fasosfasum Park with Peranginan Park had a similarity of 13.04%. Furthermore, Kaulinan Park with Kresna Park, Peranginan Park with Kaulinan, and Fasosfasum Katulampa Park with Sempur Park had similarities of 12.50%, 10.53%, 6.67%, and 3.13%. Fasosfasum Park with Corat Coret Park and Fasosfasum Park with Kaulinan Park has 0% similarity. Mahogany (*Swietenia mahogani* Jacq) and spider legs (*Osmoxylon lineare*) are the most common plants, but only in 4 parks.

4.5. Correlation between vegetation biodiversity and connectivity

Based on the results of the Spearman Rank Correlation Test, there is a significant and unidirectional relationship between biodiversity and park connectivity. The greater the diversity of plants in the park, the greater the connectivity value. If an area is fragmented, it causes disturbed habitat connectivity, it will trigger a decline in biodiversity [10]. The structure and composition of the best vegetation can provide habitat and territorial movement for wildlife, especially small animals and birds [11].

4.6. Recommendations

4.6.1. Selection of multifunctional plants. Based on biodiversity analysis results in six parks in Bogor City, horizontal diversity is dominated by plants with ornamental functions in strata I (Figures 5 and 6). Although in social aspects the aesthetic function of ornamental plants is important, this condition can reduce the level of plant biodiversity in the park. Ecologically homogeneous plantings will be more susceptible to disturbances. Therefore, it requires heterogeneous or diverse planting, both in terms of function and strata. Planting plants that have more than one function will give the park a higher value. Therefore, to increase plant diversity it is necessary to add multi-functional plants and strata II-V plants.

4.6.2. Inter park network/connectivity model. Spatially, the network model can be formed from city parks that have high similarity to each other to stabilize connectivity. The six parks that have been analyzed are used as core patches because they are located close to the Ciliwung watershed which has a natural landscape structure that functions as a habitat for various types of animals and plants, both terrestrial and aquatic [12], in addition to the six parks there are other parks in Bogor City that can be used as stepping stones.

![Figure 7. Connectivity network between parks in Bogor City](image-url)
The network illustration can show the connectivity that forms between one park and another. This is expected to increase network connectivity/connectivity between parks in urban landscapes.

4.6.3. Selection of bird host plant. Park serves as a stepping stone to improve connectivity. Following the function of the stepping stone as a connecting path for movement, especially the movement of animals from one habitat to another, animals that can be indicators of connectivity are birds. A diverse selection of plants can invite the presence of birds because of the fruit, flowers, seeds, and canopy as a place to find food and reproduce. The tree species recommended as a bird-attracting tree are by the respective tree criteria [13], namely, the Flamboyant Tree (*Delonix regia*) and the Butterfly Tree (*Bauhinia purpurea*) which have flowers that invite nectar-eating birds, Tanjung (*Mimusops elengi*), and Salam (*Syzygium polyanthum*) has a distinctive smell, Buni (*Antidesma bunius*) and banyan (*Ficus benjamina*) have small fruit and water content of many of these plants were not found in 6 park samples. Meanwhile, Ki Hujan (*Samanea saman*) and Mahogany (*Swietenia mahagonia*) had a large canopy as a place to perch and Angsana which had seeds that attracted bird seeds.

5. Conclusion

The biodiversity values of the six urban parks in Bogor City are generally classified as medium to high. Sempur Park has the highest Shannon Wiener (H’) index with H’ of 3,14. Meanwhile, Coret Coret Park has the lowest Shannon-Wiener index (H’) with H’ of 1,71. The horizontal diversity of the garden was dominated by plants that had an ornamental function of 43%, then the highest vertical diversity of 31% was found in strata I plants which were less than 1 meter tall. The middle region has the highest biodiversity index than the other two regions, namely upper and lower. Park connectivity analysis, which is carried out through the Sorensen Index calculation, shows that the similarities between urban parks in Bogor City are generally low to moderate.

Based on the results of the Spearman Rank Correlation Test analysis, biodiversity and connectivity have a significance/correlation value. The level of correlation between the two variables is strong and unidirectional, which means that if the biodiversity value of the vegetation is high, connectivity between parks will also be high. Therefore, recommendations for city park management in the City of Bogor include the selection of multi-functional plants, network models/connectivity between parks, and the selection of bird hosts as an indicator of connectivity.

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