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Analysis of vegetation diversity as an indicator of environmental quality in the green open space

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ABSTRACT

Background : The availability of Green Open Space/*Ruang Terbuka Hijau* (RTH) in Kendari City is decreasing along with the increase in population and city activities. Bumi Praja Anduonohu Urban Forest as one of the RTHs can be threatened by pollution and land conversion. This study aims to analyze the diversity of vegetation in Bumi Praja Anduonohu City Forest, Poasia District, Kendari City. **Methods:** This research was conducted from December 2023 to January 2024. This research uses vegetation diversity data using a random method (purposive sampling) and is analyzed using the Shanon-Wiener Biodiversity Index. **Findings:** The results showed that the Diversity Index (H') at the tree level was worth 1.78 and the seedling was worth 2.48 including in the medium category. It was classified as low at the pole level with a value of 0.51 and sapling with a value of 0.58. The Pinus species dominates at the tree level with an INP of 72.32 and the Jelutong species dominates at the pole, sapling, and seedling levels with values of (224.43), (146.69) and (41.40) respectively. **Conclusion:** The study concludes that vegetation diversity in the Bumi Praja Anduonohu Urban Forest varies across growth levels, with moderate diversity at the tree and seedling levels and low diversity at the pole and sapling levels, indicating an imbalance in forest regeneration. **Novelty/Originality of this Study**: This study lies in its detailed analysis of vegetation diversity across multiple growth stages to reveal regeneration imbalances in an urban forest under pressure from environmental change.

KEYWORDS: green open space; urban forest; vegetation diversity.

1. Introduction

The urban environment, especially in Kendari City as the capital city of Southeast Sulawesi Province general, has experienced a significant increase in population and urban activities (Sarasidehe et al., 2023). Rapid population growth and dense urban activities increase the availability of Green Open Space/*Ruang Terbuka Hijau* (RTH), which plays an important role in maintaining environmental quality and, especially in addressing air pollution problems (Auliandari et al., 2023).

According to Law Number 26 of 2007, green spaces consist of various elements such as urban forests, urban parks, and other open lands. Green open space not only functions as a city cooler through diverse vegetation, but also as a CO sink, helping to reduce vehicle emissions, and creating habitats for various types of vegetation that support biodiversity (Regita et al., 2021). Vegetation diversity in green spaces reflects ecosystem conditions that

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can be influenced by environmental factors, one of which is influenced by the effects of air pollution (Oktaviani et al., 2021).

Kendari City, with its increasing population growth, faces challenges in maintaining the availability of green spaces. According to Handa (2018), the need for green space based on population in 2011 is 3,265.83 ha of available green space, while in 2030 the remaining green space balance is 2,515.58 ha and claims that the existing condition of green space in Kendari City in 2011 is 3,777.46 ha which continues to increase from year to year, thus threatening the fulfillment of green space availability of 30% of the area, as mandated by the Minister of Public Works Regulation No.5/PRT/M/2008.

Residential development in Kendari City, especially in Baruga, Poasia, and Abeli sub-districts, requires adaptation to the development of green spaces, as stated by Dahrma et al., (2019). The increase in settlements in Kendari City also contributes to an increase in motor vehicle ownership, which consequently affects the increase in CO_2 emissions (Indriyani et al., 2016). The impact of pollutants from vehicles, industry, and construction materials needs to be considered, which is related to air quality in green spaces (Dharma et al., 2019).. These impacts, in turn, have the potential to worsen the environmental quality of Bumi Praja Anduonohu Urban Forest.

One green space that can potentially reduce CO_2 emissions in Kendari City is Bumi Praja Anduonohu Urban Forest. Bumi Praja Anduonohu Urban Forest is an urban forest area that is regulated and managed by the Kendari city government. The urban forest currently faces the threat of air pollution due to surrounding activities, such as the number of incoming vehicles that can increase CO_2 gas emissions and other hazardous pollutants in the air. The attached observation shows that Bumi Praja Anduonohu Urban Forest has experienced land conversion due to the expansion of office buildings, reducing its area from 16 ha to15.48 ha.

Understanding the important role of RTH as life support for city residents, it is necessary to conduct vegetation diversity research, where the assessment of vegetation diversity parameters is important, to be able to know the complexity of forest ecosystems in an area (Safe'i et al., 2018). The purpose of this study was to identify and analyze the level of vegetation diversity in RTH Bumi Praja Anduonohu Urban Forest, Poasia District, Kendari City.

2. Methods

This research was conducted in the urban forest of Bumi Praja Anduonohu, Poasia Subdistrict, Kendari City, Southeast Sulawesi Province with coordinates 04°01'20"–04°01'40"N and 122°32'15"–122°32'25" WEST. This research was conducted in December 2023–January 2024.

Fig. 1. Research location

The materials used in this study are administrative maps, maps of green space areas, and plant/vegetation identification guidebooks. The tools used were one Global Positioning System (GPS) to determine coordinate points, one pair of scissors to cut plot ropes, one-meter roller to take plot measurements, stationery and working paper to record the results of measurements in the field, one jumbo raffia rope to make plots, wooden stakes to mark the observation area, one camera for documentation, Google Lens and Plant Net applications to identify vegetation types.

The population in this study is the entire area contained in the RTH area of Bumi Praja Anduonohu Urban Forest, Poasia District, Kendari City covering an area of ±16 Ha. The research sample is all vegetation contained in the plot using a Sampling Intensity (IS) of 5%.

The type of data used in the study is quantitative data, which refers to data that can be measured, calculated, and described using numerical values. Based on the source, the data utilized in this study can be categorized into two types. The first is primary data, which was obtained directly through observation and includes information on vegetation types at various growth levels, such as seedlings, saplings, poles, and trees. The second is secondary data, which was collected from the results of previous relevant studies conducted by related agencies.

The variable used in this study is Vegetation Diversity in RTH Bumi Praja Anduonohu Urban Forest, including vegetation diversity from seedling, pole, sapling, and tree levels. The data analysis used in this study is the analysis of the Important Value Index (INP) data. Analysis is used to determine the composition and dominance of the species of a stand. The important Value Index formula by Soerianegara & Indrawan (1982) in Sari (2021) is as follows:

$$Density\ (K) = \sum \frac{Number\ of\ Individuals\ of\ a\ Type}{Sample\ Plot\ Area} \quad \text{(Eq.1)}$$

$$Relative\ Density = \sum \frac{Density\ of\ a\ Type}{Density\ of\ All\ Types}\ x\ 100\% \quad \text{(Eq.2)}$$

$$Frequency = \sum \frac{Number\ of\ Plots\ found\ Type}{Number\ of\ All\ Plots} \quad \text{(Eq.3)}$$

$$Relative\ Frequency = \sum \frac{Frequency\ of\ a\ Type}{Frequency\ of\ All\ Types}\ x\ 100\% \quad \text{(Eq.4)}$$

$$Domination = \sum \frac{LBDS\ Area\ of\ a\ Type}{Sample\ Plot\ Area} \quad \text{(Eq.5)}$$

$$Relative\ Dominance = \sum \frac{Dominance\ of\ a\ Kind}{Domination\ of\ All\ Kinds}\ x\ 100\% \quad \text{(Eq.6)}$$

The formulas used in the study differ according to the vegetation level being analyzed. For seedlings, saplings, and understory levels, the calculation employs the Important Value Index, which is the sum of Relative Density (KR) and Relative Frequency (FR). Meanwhile, for pole and tree levels, the Importance Index is used, calculated as the sum of relative density (KR), relative frequency (FR), and relative dominance (DR).

The Shannon Wiener Species Diversity Index is used to determine the level of diversity of a species. Calculation of the formula Shannon Wiener based on Magguran (1988) in Safe'i et al. (2018) as follows:

$$H' = -\sum_{i=1}^{S} \text{Pi. Ln. Pi} \quad \text{(Eq. 7)}$$

The description of the variables used in this study includes H', which represents the Shannon-Wiener species diversity index, and Pi, which refers to the proportion of the *i*th species relative to the total number of species.

$$Pi = \frac{ni}{N} \quad \text{(Eq. 8)}$$

The variable S represents the total number of species in the community. Ni refers to the number of individuals of the ith species, while N denotes the total number of individuals across all species. The criteria for the diversity index are categorized into three levels based on the value of H'. A diversity index (H') value of less than 1.5 indicates low diversity, a value ranging from 1.5 to 3.5 signifies moderate diversity, and a value greater than 3.5 reflects high diversity.

3. Results and Discussion

3.1 Vegetation Diversity in the Bumi Praja Anduonohu forest

Based on the results of the research, 30 different types of vegetation were found in Bumi Praja Anduonohu Urban Forest, Poasia Subdistrict, Kendari City which will be described in Table 1 below.

Table 1. Vegetation types found in Bumi Praja Anduonohu urban forest

No	Species	Scientific Name	Total
1	Acacia	*Acacia mangium* Willd.	16
2	Angsana	*Pterocarpus indicus* Willd.	8
3	Bintaro	*Cerbera manghas* L.	3
4	Bodhi	*Ficus religiosa* L.	1
5	Cempaka Wangi	*Magnolia champaca* (L.) Bail. ex Pierre	1
6	Cratok	*Ficus racemosa* L.	1
7	Ilat-ilatan	*Ficus callosa* Willd.	7
8	Red Jabon	*Anthocephalus macrophyllus*	5
9	White Jabon	*Anthocephalus cadamba*	4
10	Jamblang	*Syzygium cumini* (L.) Skeels	3
11	Water Guava	*Syzygium cumini* (Burm.f.) Alston/Psidium guajava	1
12	Teak White	*Gmelina arborea* Roxb.	38
13	Jelutong	*Dyera costulata* (Miq.) Hook.f.	100
14	Johar	*Senna siamea* (Lam). H.S.Irwin & Barneby	27
15	Ketapang/Tropical Almond	*Terminalia catappa* L.	1
16	Kiacret	*Spathodea campanulataP*.Beauv	3
17	Mahogany	*Swietenia mahagoni* (L.) Jacq.	20
18	Maja	*Aegle marmelos* (L.) Corrêa	1
19	Malapari	*Pongamia pinnata* (L.) Pierre	7
20	Mango	*Mangifera indica* L.	5
21	Mangsian	*Phyllanthus reticulatus* Poir.	1
22	Melinjo	*Gnetum gnemon* L.	1
23	Neem	*Azadirachta indica* A. Juss	1
24	Nusa Indah Putih	*Mussaend philippica* A. Rich	1
25	Pine (Tusam)	*Pinus merkusii* Jungh. & de Vriese	146
26	Red Shoots	*Syzygjum* jambos (L.) Alston	1
27	Rambutan	*Nephelium lappaceum* L.	5
28	Salam	*Syzygjum polyanthum* (Wight) Walp.	4
29	Suren Kapar	*Toona ciliata* M. Roem.	13
30	Cape	*Mimusops elengi* L.	20
Total			445

Based on Table 1. It can be seen that in Poasia Sub-district of Kendari City in Bumi Praja Anduonohu Urban Forest, 30 (thirty) types of vegetation were found with vegetation types such as Acacia, Angsana, Bintaro, Bodhi, Cempaka Wangi, Cratok, Ilat-Ilatan, Red Jabon, WhiteJabon, Jamblang, Water Guava, White Teak, Jelutong, Johar, Ketapang, Kiacret, Mahogany, Maja, Malapari, Mango, Mangsian, Melinjo, Neem, Nusa Indah Putih, Pinus (Tusam), Red Pucuk, Rambutan, Salam, Suren Kapar, Tanjung. The diversity of vegetation types in Bumi Praja Anduonohu Urban Forest shows a close relationship with forest resilience to environmental impacts, provides an overview of good environmental quality, has the potential to increase forest resilience to climate change, and provides ecosystem functions, especially in absorbing carbon dioxide produced by human activities and motorized vehicles.

Table 2. Species Diversity Index in Bumi Praja Anduonohu Urban Forest

No	Vegetation Tier Type	(H')	Category
1.	Trees	1.78	Medium
2.	Mast	0.51	Low
3.	Stake	0.58	Low
4.	Seedlings	2.48	Medium

Based on Table 2. The results showed that the tree and seedling levels were classified as moderate diversity where H' 1.78 for the tree level and H' 2.48 for the seedling level. The pole and sapling levels have low diversity with a value of H' 0.51 for the pole level and H' 0.58 for the sapling level. Tree species at the pole and sapling levels in Bumi Praja Anduonohu Urban Forest reflect lower species diversity due to environmental adaptation factors such as humidity, rainfall, and the length of sunlight that occurs, and other supporting factors that affect the research area.

3.2 Index of importance (INP) in the Anduonohu Bumi Praja forest

The data in Table 3. shows that there are 22 types of vegetation at the tree level, the Pinus vegetation type has the highest density value of 182.50 with the highest INP value of 72.32 and the lowest INP is found in the Malapari vegetation type with a value of 1.87.

Table 3. Tree level importance index in Bumi Praja urban forest green space

No	Tree Name	K	KR	F	FR	D	DR	INP
1.	Acacia	18.75	5.49	0.20	5.80	0.24	23.51	34.80
2.	Angsana	2.50	0.73	0.05	1.45	0.04	4.34	6.52
3.	Bintaro	3.75	1.10	0.05	1.45	0.02	2.20	4.75
4.	Bodhi	1.25	0.37	0.05	1.45	0.00	0.13	1.94
5.	Cempaka Wangi	1.25	0.37	0.05	1.45	0.02	1.88	3.70
6.	Ilat-ilatan	1.25	0.37	0.05	1.45	0.00	0.20	2.02
7.	Red Jabon	2.50	0.73	0.10	2.90	0.01	0.79	4.42
8.	White Jabon	5.00	1.47	0.10	2.90	0.02	2.42	6.79
9.	Jamblang	2.50	0.73	0.05	1.45	0.00	0.19	2.37
10.	Water Guava	1.25	0.37	0.05	1.45	0.00	0.20	2.02
11.	Teak White	42.50	12.45	0.50	14.49	0.20	19.96	46.91
12.	Johar	30.00	8.79	0.40	11.59	0.17	17.36	37.75
13.	Mahogany	13.75	4.03	0.30	8.70	0.11	10.58	23.30
14.	Maja	1.25	0.37	0.05	1.45	0.00	0.22	2.03
15.	Malapari	1.25	0.37	0.05	1.45	0.00	0.06	1.87
16.	Mango	1.25	0.37	0.05	1.45	0.00	0.18	2.00
17.	Neem	1.25	0.37	0.05	1.45	0.01	1.06	2.87
18.	Pine (Tusam)	182.50	53.48	0.65	18.84	0.00	0.00	72.32
19.	Greetings	1.25	0.37	0.05	1.45	0.00	0.25	2.07
20.	Rambutan	6.25	1.83	0.20	5.80	0.01	0.91	8.54
21.	Suren Kapar	6.25	1.83	0.20	5.80	0.07	7.30	14.93
22.	Cape	13.75	4.03	0.20	5.80	0.06	6.26	16.09

Total	341	100	3.45	100	1.00	100	300

Data in Table 4 shows that there are 4 types of vegetation at the pole level, Jelutong vegetation type has the highest density value of 600 with the highest INP value of 224.43 and the lowest INP is found in the Jamblang vegetation type with a value of 14.48.

Table 4. Pole level importance value index in Bumi Praja urban forest green space

No	Type Name	K	KR	F	FR	D	DR	INP
1.	Mango	44	6.45	0.22	18	0.11	10.71	35.34
2.	Jamblang	11	1.61	0.11	9	0.04	3.77	14.48
3.	Jelutong	600	87.10	0.67	55	0.83	82.79	224.43
4.	Kiacret	33	4.84	0.22	18	0.03	2.73	25.75
	Total	689	100	1.22	100	1.00	100	300

The data in Table 5 shows that there are 5 types of vegetation in the sapling level, the Jelutong vegetation type has the highest density value of 1600 with the highest INP value of 146.49 and the lowest INP is found in the Mahogany, Nusa Indah Putih and Salam vegetation types with a value of 12.70.

Table 5. Importance value index of stake level in Bumi Praja urban forest rth

No	Type Name	K	KR	F	FR	D	DR	INP
1.	Red Jabon	100	5.41	0.13	10	0.06	6.25	15.41
2.	Jelutong	1600	86.49	0.75	60	0.82	81.53	146.49
3.	Mahogany	50	2.70	0.13	10	0.07	7.02	12.70
4.	Nusa Indah Putih	50	2.70	0.13	10	0.02	1.76	12.70
5.	Greetings	50	2.70	0.13	10	0.03	3.44	12.70
	Total	1850	100	1.25	100	1.00	100	200

The data in Table 6 shows that there are 17 types of vegetation at the seedling level, the Jelutong vegetation type has the highest density value of 2917 with the highest INP value of 41.40, and the lowest is found in the Acacia, Cratok, and Red Jabon, Ketapang, Mangsian, Melinjo, and Red Pucuk vegetation types with a value of 5.07.

Table 6. Important value index of seedling level in Bumi Praja urban forest RTH

No.	Type Name	K	KR	F	FR	D	DR	INP
1.	Acacia	208	1.37	0.1	3.70	0.03	0.026	5.07
2.	Angsana	1250	8.22	0.1	3.70	0.07	0.073	11.92
3.	Cratok	208	1.37	0.1	3.70	0.00	0.002	5.07
4.	Ilat-ilatan	1250	8.22	0.1	3.70	0.04	0.041	11.92
5.	Red Jabon	208	1.37	0.1	3.70	0.04	0.040	5.07
6.	Teak White	833	5.48	0.3	11.11	0.13	0.134	16.59
7.	Jelutong	2917	19.18	0.5	22.22	0.13	0.126	41.40
8.	Johar	625	4.11	0.1	3.70	0.05	0.054	7.81
9.	Ketapang	208	1.37	0.1	3.70	0.06	0.057	5.07
10.	Mahogany	1667	10.96	0.2	7.41	0.32	0.321	18.37
11.	Malapari	1250	8.22	0.1	3.70	0.01	0.014	11.92
12.	Mangsian	208	1.37	0.1	3.70	0.00	0.002	5.07
13.	Melinjo	208	1.37	0.1	3.70	0.00	0.002	5.07
14.	Red Shoots	208	1.37	0.1	3.70	0.01	0.006	5.07
15.	Greetings	417	2.74	0.2	7.41	0.01	0.008	10.15
16.	Suren Kapar	1667	10.96	0.2	7.41	0.04	0.035	18.37
17.	Cape	1875	12.33	0.1	3.70	0.06	0.059	16.03
	Total	15208	100	2.25	100	1.00	1.00	200

3.3 Diversity index and important value index analysis

The level of diversity in trees is high and more dominated by pine species due to human intervention factors, where pine plants have very strong adaptations and are planted and managed deliberately by the Kendari city government in the research area. Ago et al., (2018)

explained the diversity of tree species composition in an area in various growth stages such as seedlings, saplings, poles, and trees, caused by human intervention, the existence of locations or places to grow stands, and other natural factors such as soil nutrients, moisture, forest type, and soil fertility.

The dominance of Pinus species at the tree level is caused by human intervention factors, where Bumi Praja Anduonohu City Forest is a City Forest directly managed by the Kendari City government with a vegetation structure that has been arranged to improve the aesthetics of the City Forest. The pole, sapling, and seedling levels dominated by Jelutong can be influenced by the adaptation process of Jelutong plants at the research site, seeing the structure of Jelutong vegetation stands that grow wildly and irregularly.

The dominance of Jelutong at the pole, sapling, and seedling levels in the Praja Anduonohu Earth Forest suggests a spatial pattern in the vegetation community, as expressed by Kunakh et al. (2022) the existence of spatial patterns in vegetation communities can arise from the influence of spatially structured environmental factors or neutral factors. Environmental factors such as trophicity, humidity, and light intensity play an important role in shaping spatial variation in plant communities (Omar et al., 2018).

The consistent dominance of Jelutong at the pole and sapling levels indicates that this plant species is well adapted to certain environmental conditions that support its growth in the study area. According to Dueñas et al. (2021) also showed that environmental changes, such as temperature or rainfall patterns, can affect the survival and reproductive responses of plant species over time. The spatial pattern of dominance of certain plant species in Bumi Praja Anduonohu Urban Forest can be an indicator of vegetation response to environmental changes.

4. Conclusions

The conclusion obtained from this research is based on the results of the Diversity Index (H') data at the tree level with a value of 1.78 and seedlings with a value of 2.48, including in the medium category and classified as low at the pole level with a value of 0.51 and saplings with a value of 0.58. Pinus species dominate at the tree level with an INP of 72.32 and Jelutong species dominate at the pole level with a value of 224.43, saplings 146.69, and seedlings 41.40.

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