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Spatial Pattern Analysis of Vegetation on Surakarta Urban Fringe Area

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ABSTRACT

The urban fringe area is a transitional area between urban and rural areas which supports urban ecological functioning. Vegetation is an element of biodiversity that is important for the sustainability of urban life. The balance of the ecosystem is maintained with the help of the biodiversity of the urban fringe area where environmental functions and services will be able to run optimally. The important value index (IVI) in the vegetation structure is a quantitative measurement used to assess the health of vegetation in an area. Vegetation in the urban fringe region of Surakarta is dominated by types of *Tectona grandis*, *Senna siamea*, *Mangifera indica*, *Switenia macrophylla* and *Leucaena leucocephala*. *Tectona grandis* (220.02%), *Falctaria moluccana* (164.63%) and *Pterocarpus indicus* (142.55%) have the highest IVI vegetation in Karanganyar District. In Sukoharjo Regency, variations for the highest IVI were diverse with the highest IVI being *Falcataria mollucana* (171.49%), *Tectona grandis* (97.46%) and *Gluta rengas* (89.54%). *Tectona grandis* (230.99%) and *Mangifera indica* (145.53%) are the species with the highest IVI in Boyolali District. The high importance of *Tectona grandis* is based on the IVI count. The dominance of vegetation species in urban fringe is considered to be of high economic value for the community.

1. INTRODUCTION

Urban areas are dynamic environments. Intervention of anthropogenic activities is a key factor in changing the urban environment. Meeting the needs of the population is the main thing in the development of a city where the balance of the urban environment is the key to the sustainability of life [1]. Biodiversity plays an important role in providing ecological functions in urban areas, where soil, water, air and plants interact and are linked in protecting the environment [2].

Vegetation is a major component in maintaining sustainable environmental conditions for urban areas [3]. It plays a multifunctional role, one of which is the control of the microclimate of urban areas [4] by mitigating the impacts of rising temperatures and global climate change, providing habitat for several types of animals, maintaining a balance of the material and energy cycle, and the hydrological cycle [5]. It is therefore an essential component within the context of urban areas vegetation and the monitoring of the condition of urban vegetation is a necessary thing in order to manage properly the functioning of urban ecology [6]. Vegetation analysis plays a crucial role in determining environmental management policies as it provides the necessary data to make informed decisions. It serves as a reliable source of information and helps weigh the options when formulating effective strategies for environmental conservation. The development of Surakara region has been so rapid in recent times that it has resulted in a significant lack of open space where land use changes have been sustained by an accelerated development and infrastructure. This necessitates urgent and holistic mitigation and adaptation measures are needed in an effort to maintain the sustainability of urban life.

The transformation of urban land use will undoubtedly have consequences for the state of open land, leading to further reduction in available habitat for vegetation growth. This condition is a problem that must be faced considering the function of vegetation as an urban buffer system. Environmental services obtained from vegetation are a major focus in the life balance of the city area [7] since the function of urban ecosystem services is highly dependent on vegetation conditions. The interaction between abiotic and sociocultural factors has an effect on the structure and function of vegetation [8].

To achieve a sustainable city, it is essential to have a well-developed environmental management plan. A holistic and ecological approach is the best step towards the balance of urban ecosystems [9]. Large anthropogenic pressures on urban areas should be minimized so that environmental degradation does not occur massively. The conditions of the urban environment are closely related to the sociocultural conditions of the settled population [10].

Vegetation has a major role in maintaining the homeostasis

of urban life. The provision of ecosystem services is closely related to the health condition of vegetation [11]. The study of open lands as habitats for vegetation makes it easier to plan since vegetation is a biotic component that interacts with physical and social environmental conditions in a certain way [12]. Optimal conditions are expected to support the existence of vegetation so that its structure and function as a provider of ecosystem services can be maintained properly [13].

2. STUDY AREA

The study area is an urban fringe of Surakarta city which includes 3 regencies, namely Sukoharjo, Karanganyar and Boyolali Regencies (Figure 1). All three areas have undergone significant land use changes as a result of the agglomeration of Surakarta City. Of the three districts, the Karanganyar Regency area, which is located in the south of Surakarta City, still has potential open land. Karanganyar regency has a large open space area than others with temperature average 30.1°C, humidity 66.57% and soil organic matter 2.68%. This region consists of more green and open land. Karanganyar shows urban spreading to the south where most of the development on this area consists of urban settlement. Boyolali District shows the narrowest urban fringe in Surakarta. Air temperature of this area averages around 30.7°C and humidity 56.6%, soil pH 7.1 and soil organic matter content 1.78%. Sukoharjo District shows rapid development to the south of this area with a central commercial district known as Solo Baru area.

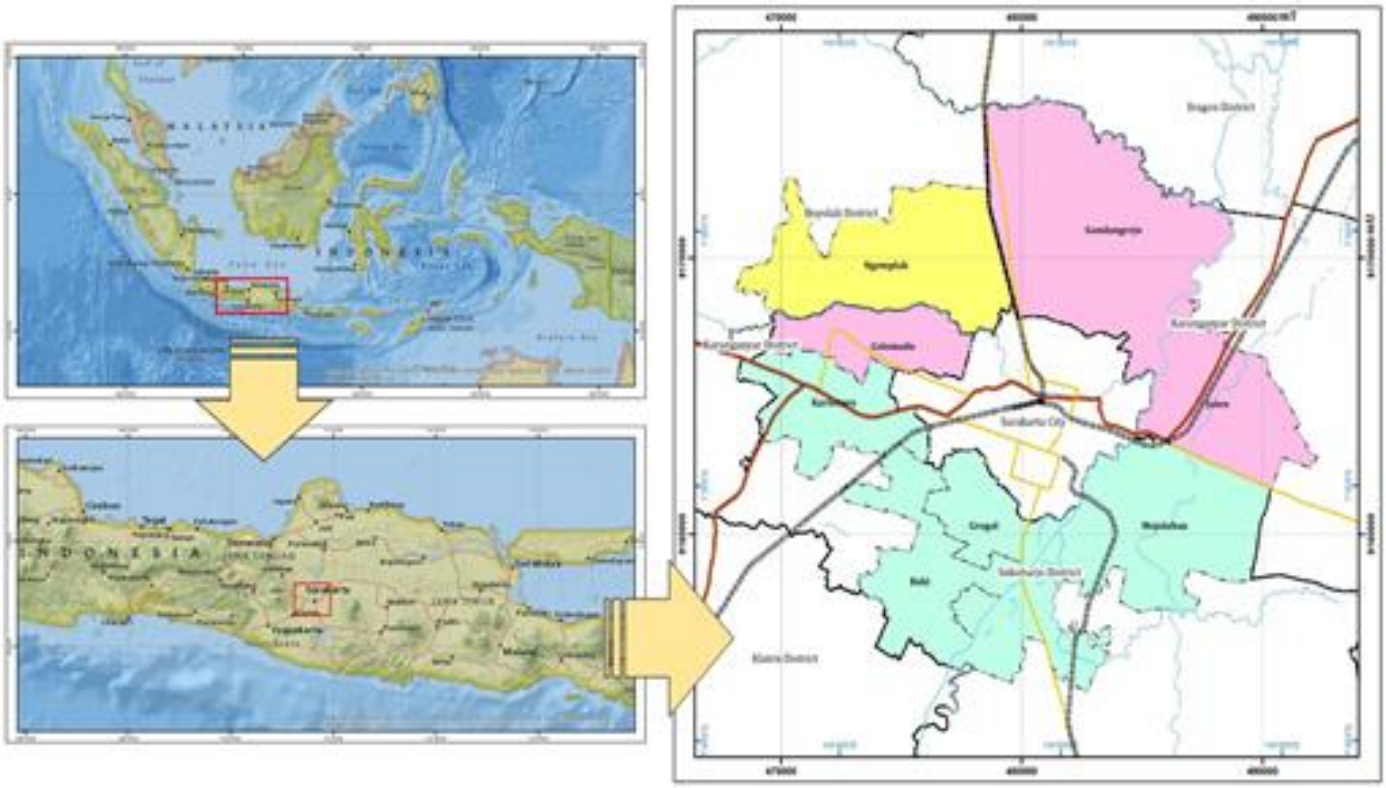

Figure 1. Map of research area

2.1 Determination of ecological unit

The determination of ecological units is based on the interpretation of sentinel 2A satellite imagery acquired on August 20th, 2020 and the results of overlapping maps of soil type, land use and topography. Ecological units are obtained from the results of the map overlap (Figure 2). The landscape approach is hereby used in the determination of ecological units. Biophysical factors are closely related to the habitat conditions of vegetation. Differences in physical factors will affect the type and growth of vegetation in an area.

2.2 Vegetation analysis

For each ecological unit, vegetation analysis was carried out by calculating the Important Value Index. The calculation of the IVI was carried out at three growth rates, namely trees, saplings and seedlings. Each ecological unit has three measuring plot sizes: 20×20m, 10×10m and 5×5m. Sampling was carried out with ten consecutive repeats. The plot at each growth rate was then used to calculate the IVI. The IVI is calculated using the Mueller-Dombois and Ellenberg (1974) formulas, as follows:

$$IVI=RD+RF+RA$$

where,

IVI=Important Value Index

$$\text{Relative Density}=\frac{\text{Number of individulas of one species}}{\text{Total number of all individuals counted}}\times 100\%$$

$$\text{Relative Frequency}=\frac{\text{Frequency of one species}}{\text{Total frequency of all species}}\times 100\%$$

$$\text{Relative Abundance} = \frac{\text{The abundance of one species}}{\text{Total all species counted}} \times 100\%$$

The IVI calculation is a synthetic index for classifying species that combines their frequency, density, abundance, and relative values and is used in this work as an indication of their local availability [9].

3. RESULTS

The ecological units based on the results of the map overlay consists of 48 pieces with 19 variations. The ecological units are spread across 3 areas of the urban fringe district of Surakarta. Sukoharjo District (12.5%), Boyolali District (8.33%) and Karanganyar District (79.2%) as shown in Figure 3. The calculation of the IVI of ecological units in each growth rate describing the vegetation structure is presented in the following Table 1, Table 2 and Table 3. Each ecological unit is categorized according to the tree species with the highest importance value index. The description of vegetation conditions is expected to facilitate steps in ecosystem service management in general.

The soil type is dominated by latosol and alluvial types. Topography of these ecological units can be described as gentle, flat and wavy. The dynamics of the landscape are specific so that they affect the biotic components in it in that changes in the landscape will be followed by changes in the structure and function of the vegetation in it. Most of the ecological units are located in the Karanganyar Regency area (Figure 4) where land use changes have not occurred much and vacant land is still widely found. Ecological units have experienced significant growth and expansion in the Karanganyar District. This has led to the gradual development of the southern area within this district. The development resulted in further settlement where more public facilities are required. Sukoharjo and Boyolali (Figure 5 and Figure 6) have more little open space because on Sukoharjo District has developed as a satellite city with a stronger center of trade and economy activities.

3.1 Important value index

Important value index (IVI) of tree species is determined as the sum of relative frequency (RF), relative density (RD), and relative abundance (RA). It measures how dominant a species is in a given area. This is the IVI count on trees, saplings and seedlings. Table 1 shows IVI calculated from trees structure, Table 2 shows IVI calculated from saplings structure and Table 3 shows IVI calculated from seedlings structure.

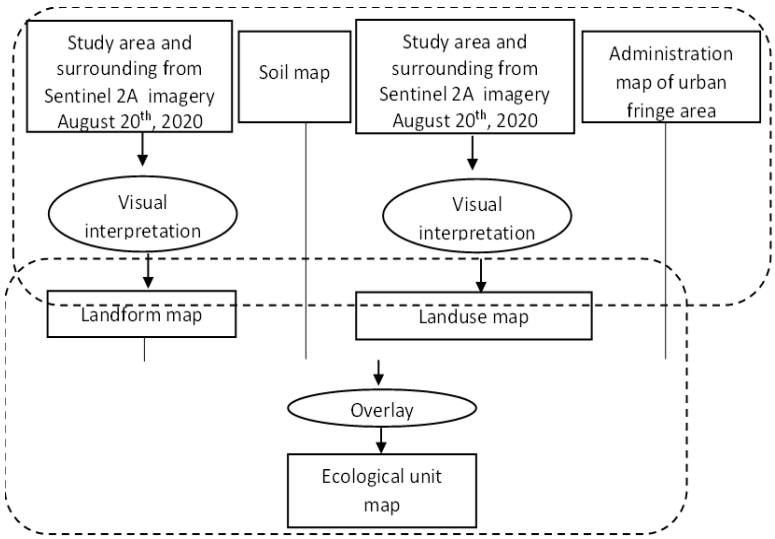

Figure 2. Flow chart of mapping unit

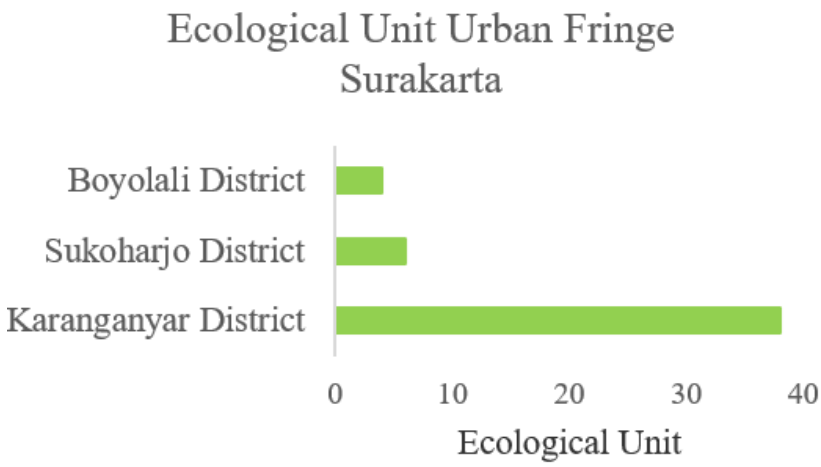

Figure 3. Chart of ecological unit urban fringe Surakarta

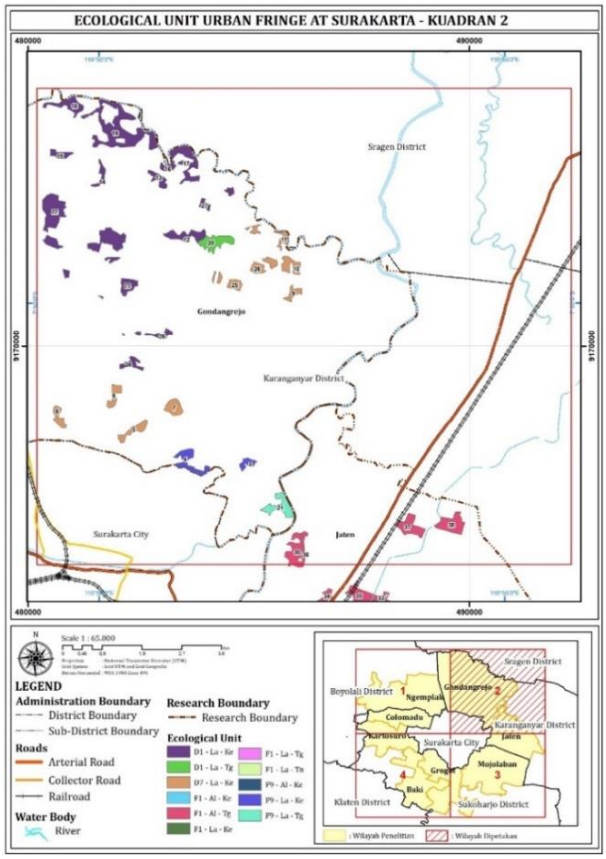

Figure 4. Map of ecological unit urban fringe Surakarta, Kuadran 1

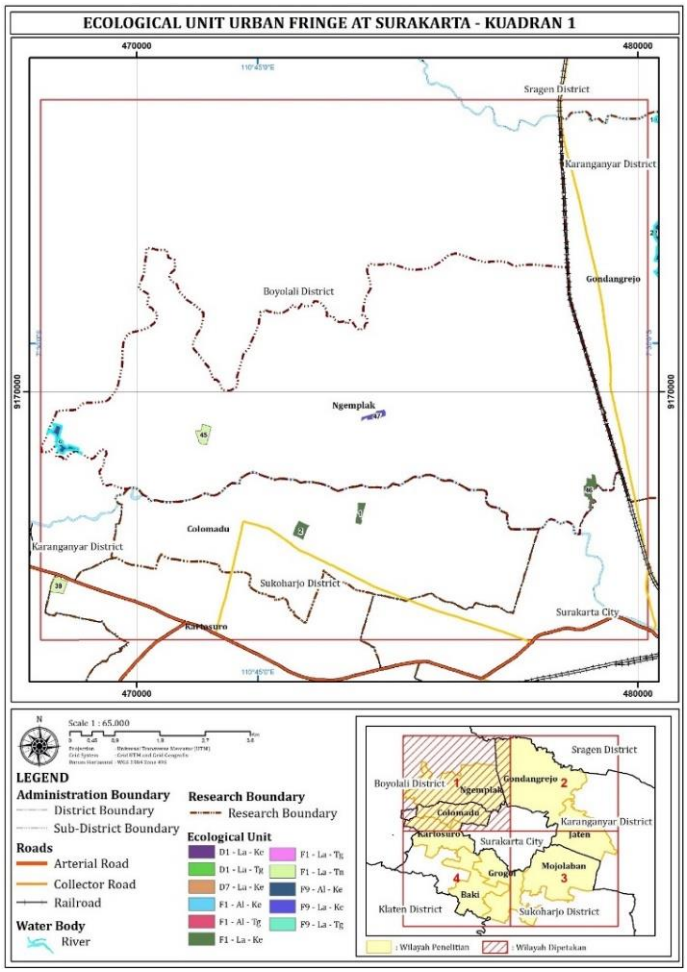

Figure 5. Map of ecological unit urban fringe Surakarta, Kuadran 2

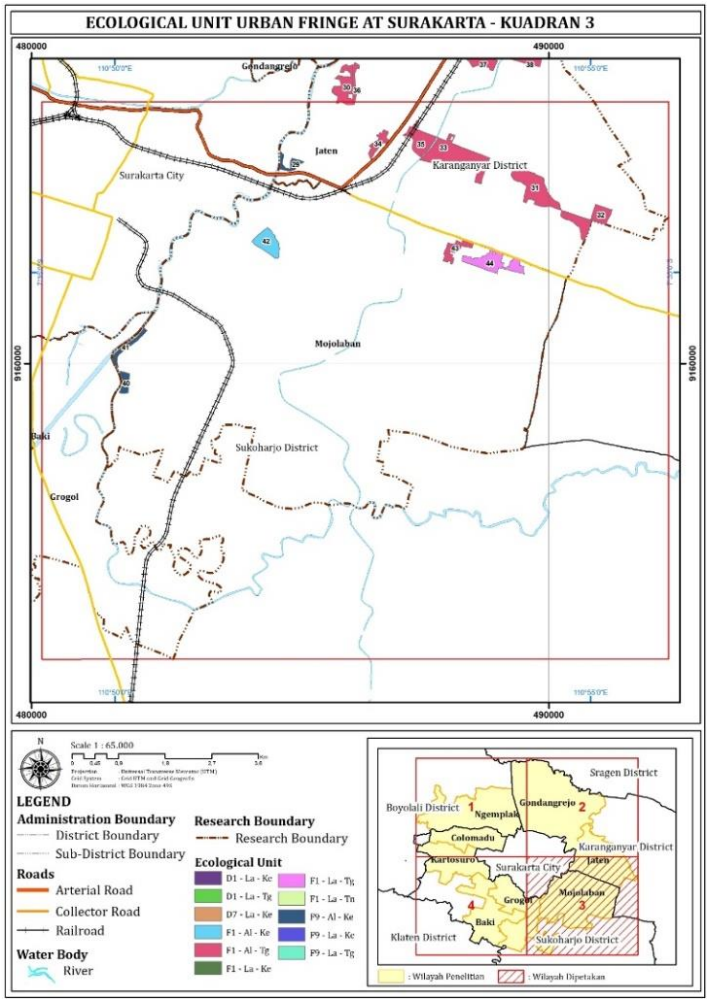

Figure 6. Map of ecological unit urban fringe Surakarta, Kuadran 3

Table 1. Important value index of tree

Ecological Unit	*Vegetation Type*	RD (%)	RF (%)	RA (%)	IVI (%)
1	*Tectona grandis*	33.33	35.36	17.14	85.83
	Plumeria acuminata	12.12	15.10	2.86	30.07
	Leucaena leucocephala	9.09	4.03	14.29	27.40
2	*Tectona grandis*	30.56	33.15	25.00	88.71
	Senna siamea	13.89	14.12	8.33	36.34
	Gnetum gnemon	13.89	9.82	12.50	36.21
3	*Tectona grandis*	58.67	53.97	37.04	149.67
	Senna siamea	10.67	8,81	14.81	34.29
	Ficus racemosa	1.33	19.57	3.70	24.60
4	*Leucaena leucocephala*	21.88	21.35	21.62	64.85
	Tectona grandis	18.75	19.63	13.51	51.90
	Senna siamea	10.94	10.92	10.81	32.67
5	*Tectona grandis*	22.22	24.79	13.79	60.80
	Senna siamea	11.11	10.15	10.34	31.60
	Delonix regia	8.33	11.38	10.34	30.05
6	*Tectona grandis*	43.84	45.37	27.59	116.80
	Senna siamea	35.62	36.56	31.03	103.21
	Mangifera indica	5.48	5.89	10.34	21.71
7	*Tectona grandis*	32.05	28.49	20.59	81.13
	Senna siamea	19.23	19.92	14.71	53.85
	Ficus benjamina	1.28	21.10	2.94	25.32
8	*Senna siamea*	29.41	26.80	18.18	74.39
	Mangifera indica	15.69	21.66	15.15	52.50
	Tectona grandis	15.69	18.69	12.12	46.50
9	*Tectona grandis*	35.38	46.36	21.88	103.62
	Senna siamea	20.00	21.40	21.88	63.27
	Acacia auriculiformis	24.62	0.01	18.75	43.37
10	*Mangifera indica*	22.97	22.25	20.59	65.81

	Tectona grandis	21.62	21.62	11.76	55.00
	Samanea saman	10.81	13.32	5.88	30.02
11	*Tectona grandis*	61.73	62.10	33.33	157.16
	Senna siamea	14.81	14.25	20.00	49.07
	Leucaena leucocephala	7.41	6.87	13.33	27.62
12	*Tectona grandis*	17.50	35.10	21.43	74.03
	Anacardium occidentale	42.50	0.08	28.57	71.15
	Swietenia macrophylla	12.50	22.08	14.29	48.87
13	*Tectona grandis*	70.31	47.85	47.62	165.78
	Senna siamea	18.75	12.31	23.81	54.87
	Ceiba pentandra	3.13	35.68	4.76	43.57
14	*Tectona grandis*	69.57	71.46	42.11	183.14
	Mangifera indica	10.87	11.95	15.79	38.61
	Swietenia macrophylla	6.52	6.82	10.53	23.87
15	*Schleichera oleosa*	27.45	37.57	12.12	77.14
	Tamarindus indica	15.69	27.46	18.18	61.33
	Senna siamea	15.69	6.27	18.18	40.14
16	*Tectona grandis*	58.62	72.70	41.67	172.99
	Acacia auriculiformis	20.69	0.01	20.83	41.53
	Senna siamea	5.17	7.20	12.50	24.87
17	*Tectona grandis*	43.94	46.35	38.46	128.75
	Swietenia macrophylla	25.76	27.86	19.23	72.85
	Senna siamea	18.18	19.57	19.23	56.98
18	*Hibiscus tiliaceus*	14.29	20.34	5.13	39.75
	Senna siamea	14.29	13.58	7.69	35.56
	Swietenia macrophylla	9.52	7.61	17.95	35.08
19	*Senna siamea*	34.04	31.70	26.67	92.41
	Tectona grandis	23.40	23.69	20.00	67.10
	Swietenia macrophylla	21.28	20.64	23.33	65.25
20	*Tectona grandis*	43.06	45.92	21.43	110.41
	Senna siamea	29.17	29.12	25.00	83.28
	Leucaena leucocephala	9.72	8.59	14.29	32.60
21	*Tectona grandis*	34.85	48.50	36.36	119.71
	Senna siamea	28.79	45.74	27.27	101.80
	Acacia auriculiformis	31.82	0.01	27.27	59.10
22	*Tectona grandis*	39.66	43.08	18.92	101.65
	Mangifera indica	10.34	10.91	13.51	34.77
	Senna siamea	10.34	10.64	10.81	31.80
23	*Senna siamea*	34.38	38.31	21.88	94.56
	Tectona grandis	28.13	31.21	31.25	90.59
	Terminalia catappa	9.38	10.98	9.38	29.73
24	*Tectona grandis*	49.09	51.62	34.48	135.19
	Senna siamea	14.55	11.93	13.79	40.27
	Acacia auriculiformis	5.45	5.82	10.34	21.62
25	*Tectona grandis*	57.58	76.36	40.91	174.84
	Acacia auriculiformis	25.76	0.01	27.27	53.04
	Senna siamea	10.61	14.67	18.18	43.46
26	*Tectona grandis*	47.83	54.15	34.62	136.60
	Senna siamea	14.49	27.45	15.38	57.32
	Acacia auriculiformis	26.09	0.01	26.92	53.02
27	*Tectona grandis*	50.00	55.67	28.57	134.24
	Mangifera indica	13.16	13.25	21.43	47.84
	Artocarpus heterophyllus	9.21	15.04	10.71	34.96
28	*Tectona grandis*	59.68	69.95	36.36	166.00
	Acacia auriculiformis	19.35	0.01	18.18	37.54
	Senna siamea	8.06	12.53	13.64	34.24
29	*Pterocarpus indicus*	44.44	73.10	25.00	142.55
	Tectona grandis	28.89	13.34	35.00	77.23
	Mangifera indica	8.89	4.13	15.00	28.02
30	*Tectona grandis*	82.50	84.58	52.94	220.02
	Neolamarokia cadamba	7.50	6.40	11.76	25.67
	Leucaena leucocephala	2.50	2.13	11.76	16.40
31	*Tectona grandis*	27.16	26.92	15.56	69.64
	Swietenia macrophylla	11.11	11.42	11.11	33.64
	Senna siamea	11.11	8.83	8.89	28.83
32	*Leucaena leucocephala*	28.89	23.44	23.53	75.86
	Tectona grandis	20.00	17.27	20.59	57.86
	Swietenia macrophylla	11.11	20.26	5.88	37.25
33	*Samanea saman*	12.20	37.94	16.67	66.80
	Leucaena leucocephala	21.95	14.31	16.67	52.92
	Hibiscus tiliaceus	19.51	13.03	12.50	45.05

34	*Mangifera indica*	36.00	39.51	26.92	102.43
	Polyalthia longifolia	12.00	10.71	11.54	34.25
	Tectona grandis	10.00	9.14	7.69	26.83
35	*Falcataria moluccana*	67.57	70.75	26.32	164.63
	Hibiscus tiliaceus	16.22	13.83	21.05	51.10
	Musa paradisiaca	5.41	3.97	21.05	30.43
36	*Mangifera indica*	22.86	8.74	19.23	50.83
	Ficus annulate	2.86	41.02	3.85	47.72
	Ficus benjamina	5.71	28.04	3.85	37.60
37	*Samanea saman*	16.33	24.53	8.57	49.42
	Leucaena leucocephala	16.33	12.45	11.43	40.21
	Mangifera indica	10.20	10.30	14.29	34.79
38	*Mangifera indica*	26.23	31.06	17.24	74.53
	Moringa oleifera	14.75	11.56	3.45	29.77
	Leucaena leucocephala	8.20	8.13	10.34	26.67
39	*Falcataria moluccana*	68.18	71.49	31.82	171.49
	Mangifera indica	7.58	7.47	13.64	28.68
	Breonia chinensis	4.55	5.84	9.09	19.47
40	*Gluta renghas*	12.90	66.11	10.53	89.54
	Leucaena leucocephala	29.03	10.71	21.05	60.80
	Samanea saman	12.90	6.56	15.79	35.25
41	*Delonix regia*	15.79	14.45	16.13	46.36
	Senna siamea	14.04	20.35	9.68	44.06
	Tectona grandis	15.79	13.80	12.90	42.50
42	*Tectona grandis*	40.82	36.65	20.00	97.46
	Delonix regia	14.29	17.94	16.00	48.22
	Mangifera indica	10.20	11.56	12.00	33.77
43	*Leucaena leucocephala*	26.56	24.07	14.29	64.92
	Mangifera indica	18.75	18.30	21.43	58.48
	Tectona grandis	17.19	16.12	10.71	44.02
44	*Mangifera indica*	25.00	25.42	26.92	77.34
	Muntingia calabura	16.67	14.34	23.08	54.09
	Hibiscus tiliaceus	18.75	15.67	7.69	42.11
45	*Tectona grandis*	41.07	41.60	22.86	105.52
	Senna siamea	10.71	13.99	11.43	36.14
	Ceiba pentandra	10.71	9.42	11.43	31.56
46	*Tectona grandis*	81.97	90.20	58.82	230.99
	Delonix regia	9.84	0.00	17.65	27.49
	Senna siamea	4.92	5.37	11.76	22.05
47	*Mangifera indica*	57.58	61.29	26.67	145.53
	Tectona grandis	9.09	9.68	13.33	32.10
	Ceiba pentandra	6.06	6.45	6.67	19.18
48	*Tectona grandis*	60.55	65.05	33.33	158.93
	Senna siamea	14.68	13.22	22.22	50.12
	Swietenia macrophylla	5.50	4.98	11.11	21.59

Table 2. Important value index of saplings

Ecological Unit	Vegetation Type	RD (%)	RF (%)	IVI (%)
1	Manihot esculenta	31.58	13.64	45.22
	Musa paradisiaca	18.42	18.18	36.60
	Tectona grandis	13.16	22.73	35.89
2	Manihot esculenta	16.92	9.68	26.60
	Gliricidia sepium	10.77	9.68	20.45
	Bambusa vulgaris	15.38	3.23	18.61
3	*Tectona grandis*	50.00	40.00	90.00
	Leucaena leucocephala	16.67	20.00	36.67
	Senna siamea	11.11	12.00	23.11
4	*Leucaena leucocephala*	14.08	20.00	34.08
	Bambusa blumeana	28.17	4.00	32.17
	Swietenia mahagoni	7.04	20.00	27.04
5	Bambusa blumeana	56.07	15.79	71.86
	Gigantochloa apus	18.69	5.26	23.95
	Mangifera indica	3.74	10.53	14.26
6	*Tectona grandis*	22.48	24.14	46.62
	Senna siamea	20.93	20.69	41.62
	Gluta renghas	19.38	10.34	29.72
7	*Tectona grandis*	37.50	36.84	74.34
	Senna siamea	14.58	15.79	30.37
	Bambusa blumeana	20.83	5.26	26.10
8	*Tectona grandis*	51.69	25.00	76.69

	Senna siamea	19.10	17.86	36.96
	Leucaena leucocephala	12.36	14.29	26.65
9	*Tectona grandis*	45.99	32.26	78.24
	Acacia auriculiformis	34.31	29.03	63.34
	Gliricidia sepium	5.11	9.68	14.79
10	*Tectona grandis*	19.17	17.14	36.31
	Leucaena leucocephala	18.33	11.43	29.76
	Senna siamea	16.67	11.43	28.10
11	*Tectona grandis*	27.68	13.04	40.72
	Senna siamea	16.07	8.70	24.77
	Manihot esculenta	10.71	8.70	19.41
12	Musa paradisiaca	35.29	27.27	62.57
	Leucaena leucocephala	29.41	27.27	56.68
	Swietenia mahagoni	17.65	27.27	44.92
13	*Tectona grandis*	53.33	43.48	96.81
	Senna siamea	18.33	17.39	35.72
	Cascabela thevetia	6.67	13.04	19.71
14	Bambusa blumeana	37.04	6.25	43.29
	Ficus septica	12.96	18.75	31.71
	Musa paradisiaca	11.11	12.50	23.61
15	*Tectona grandis*	29.70	17.07	46.78
	Schleichera oleosa	23.76	19.51	43.27
	Senna siamea	8.91	9.76	18.67
16	*Tectona grandis*	33.33	31.03	64.37
	Acacia auriculiformis	21.21	20.69	41.90
	Senna siamea	9.09	13.79	22.88
17	*Tectona grandis*	37.31	33.33	70.65
	Swietenia macrophylla	23.88	29.63	53.51
	Acacia auriculiformis	13.43	18.52	31.95
18	Gigantochloa apus	46.84	28.57	75.41
	Gigantochloa atroviolacea	32.59	21.43	54.02
	Bambusa blumeana	16.29	17.86	34.15
19	Bambusa blumeana	45.45	18.75	64.20
	Gigantochloa apus	36.36	12.50	48.86
	Swietenia mahagoni	6.36	25.00	31.36
20	Senna siamea	23.81	30.77	54.58
	Cascabela thevetia	28.57	15.38	43.96
	Tectona grandis	14.29	23.08	37.36
21	*Tectona grandis*	26.00	28.00	54.00
	Senna siamea	28.00	24.00	52.00
	Acacia auriculiformis	26.00	24.00	50.00
22	*Tectona grandis*	35.11	9.52	44.63
	Gluta renghas	8.51	11.90	20.42
	Senna siamea	12.77	4.76	17.53
23	*Tectona grandis*	46.62	24.39	71.01
	Senna siamea	16.22	12.20	28.41
	Acacia auriculiformis	10.81	7.32	18.13
24	*Tectona grandis*	52.88	19.57	72.45
	Senna siamea	16.35	13.04	29.39
	Anacardiaceae	3.85	8.70	12.54
25	*Tectona grandis*	38.46	32.00	70.46
	Acacia auriculiformis	33.85	32.00	65.85
	Leucaena leucocephala	12.31	16.00	28.31
26	Acacia auriculiformis	32.31	30.77	63.08
	Tectona grandis	30.77	26.92	57.69
	Senna siamea	23.08	26.92	50.00
27	*Tectona grandis*	21.74	35.71	57.45
	Musa paradisiaca	34.78	21.43	56.21
	Leucaena leucocephala	17.39	14.29	31.68
28	Acacia auriculiformis	34.15	40.91	75.06
	Tectona grandis	28.05	36.36	64.41
	Bambusa blumeana	24.39	4.55	28.94
29	*Tectona grandis*	23.64	20.83	44.47
	Leucaena leucocephala	20.00	20.83	40.83
	Polyalthia longifolia	14.55	12.50	27.05
30	*Tectona grandis*	57.58	36.00	93.58
	Leucaena leucocephala	6.06	12.00	18.06
	Neolamarokia cadamba	9.09	8.00	17.09
31	Senna siamea	21.05	16.00	37.05
	Tectona grandis	19.30	16.00	35.30
	Gliricidia sepium	15.79	8.00	23.79

32	Gigantochloa apus	70.27	26.32	96.59
	Ficus septica	9.73	26.32	36.05
	Leucaena leucocephala	3.78	21.05	24.84
33	Musa paradisiaca	36.59	38.89	75.47
	Hibiscus tiliaceus	41.46	27.78	69.24
	Leucaena leucocephala	14.63	22.22	36.86
34	*Leucaena leucocephala*	17.86	12.50	30.36
	Mangifera indica	12.50	12.50	25.00
	Annona squamosa	10.71	12.50	23.21
35	Hibiscus tiliaceus	29.79	31.58	61.37
	Musa paradisiaca	31.91	26.32	58.23
	Falcataria moluccana	25.53	21.05	46.58
36	*Leucaena leucocephala*	30.77	15.00	45.77
	Tectona grandis	32.31	10.00	42.31
	Annona squamosa	9.23	20.00	29.23
37	*Leucaena leucocephala*	16.67	14.63	31.30
	Gnetum gnemon	18.89	9.76	28.64
	Tectona grandis	14.44	4.88	19.32
38	*Leucaena leucocephala*	23.33	15.22	38.55
	Annona squamosa	10.83	8.70	19.53
	Artocarpus heterophyllus	8.33	10.87	19.20
39	*Leucaena leucocephala*	61.54	35.71	97.25
	Artocarpus altilis	15.38	21.43	36.81
	Mangifera indica	7.69	14.29	21.98
40	*Tectona grandis*	31.58	5.71	37.29
	Leucaena leucocephala	7.89	22.86	30.75
	Schleichera oleosa	13.16	5.71	18.87
41	Bambusa blumeana	42.25	9.09	51.34
	Schleichera oleosa	21.13	18.18	39.31
	Swietenia macrophylla	5.63	18.18	23.82
42	*Leucaena leucocephala*	37.88	26.09	63.97
	Tectona grandis	15.15	13.04	28.19
	Bambusa blumeana	15.15	4.35	19.50
43	*Leucaena leucocephala*	41.18	25.00	66.18
	Moringa oleifera	14.12	16.67	30.78
	Bambusa vulgaris var. striata	11.76	4.17	15.93
44	Muntingia calabura	18.75	9.84	28.59
	Leucaena leucocephala	16.96	9.84	26.80
	Falcataria moluccana	18.75	3.28	22.03
45	*Tectona grandis*	38.60	25.00	63.60
	Terminalia catappa	1.75	47.99	49.75
	Leucaena leucocephala	22.81	3.57	26.38
46	*Tectona grandis*	36.21	34.78	70.99
	Delonix regia	22.41	30.43	52.85
	Bambusa blumeana	17.24	4.35	21.59
47	*Leucaena leucocephala*	39.02	27.27	66.30
	Polyalthia longifolia	21.95	9.09	31.04
	Tectona grandis	9.76	13.64	23.39
48	Swietenia mahagoni	43.98	23.33	67.31
	Tectona grandis	31.33	23.33	54.66
	Senna siamea	8.43	13.33	21.77

Table 3. Important value index of seedlings

Ecological Unit	Vegetation Type	KR (%)	FR (%)	IVI (%)
1	*Musa paradisiaca*	25.00	16.67	41.67
	Manihot esculenta	25.00	12.50	37.50
	Tectona grandis	15.91	20.83	36.74
2	*Gliricidia sepium*	17.39	9.38	26.77
	Manihot esculenta	10,87	9.38	20.24
	Hibiscus tiliaceus	8.70	9.38	18.07
3	*Tectona grandis*	58.33	41.67	100,00
	Leucaena leucocephala	11.11	16.67	27.78
	Senna siamea	11.11	16.67	27.78
4	*Leucaena leucocephala*	24.00	20.83	44.83
	Swietenia mahagoni	18.00	20.83	38.83
	Senna siamea	16.00	16.67	32.67
5	*Leucaena leucocephala*	15.69	15.38	31.07
	Mangifera indica	11.76	15.38	27.15
	Tectona grandis	7.84	11.54	19.38
6	*Tectona grandis*	40.00	38.89	78.89

	Terminalia catappa	20.00	16.67	36.67
	Senna siamea	6.67	11.11	17.78
7	*Tectona grandis*	5.56	26.67	32.22
	Manihot esculenta	22.22	6.67	28.89
	Senna siamea	11.11	16.67	27.78
8	*Tectona grandis*	28.57	31.25	59.82
	Leucaena leucocephala	28.57	18.75	47.32
	Senna siamea	14.29	25.00	39.29
9	*Acacia auriculiformis*	42.86	33.33	76.19
	Tectona grandis	19.05	20.00	39.05
	Leucaena leucocephala	9.52	6.67	16.19
10	*Tectona grandis*	32.35	25.00	57.35
	Leucaena leucocephala	20.59	18.75	39.34
	Delonix regia	14.71	12.50	27.21
11	*Tectona grandis*	51.11	45.00	96.11
	Leucaena leucocephala	26.67	30.00	56.67
	Ficus septica	8.89	10.00	18.89
12	*Swietenia mahagoni*	29.41	25.00	54.41
	Leucaena leucocephala	23.53	25.00	48.53
	Musa paradisiaca	17.65	18.75	36.40
13	*Tectona grandis*	55.00	50.00	105.00
	Senna siamea	22.50	20.00	42.50
	Leucaena leucocephala	12.50	15.00	27.50
14	*Ficus septica*	20.00	17.65	37.65
	Musa paradisiaca	15.00	11.76	26.76
	Swietenia mahagoni	15.00	11.76	26.76
15	*Tectona grandis*	30.77	33.33	64.10
	Schleichera oleosa	23.08	16.67	39.74
	Ficus septica	17.95	16.67	34.62
16	*Tectona grandis*	51.28	43.48	94.76
	Acacia auriculiformis	17.95	21.74	39.69
	Ficus septica	10.26	13.04	23.30
17	*Tectona grandis*	44.44	41.67	86.11
	Swietenia macrophylla	24.44	25.00	49.44
	Ficus septica	13.33	12.50	25.83
18	*Ficus septica*	23.53	20.00	43.53
	Tectona grandis	11.76	20.00	31.76
	Gigantochloa atroviolacea	20.59	10.00	30.59
19	*Swietenia mahagoni*	28.57	27.27	55.84
	Senna siamea	14.29	18.18	32.47
	Duranta erecta	14.29	9.09	23.38
20	*Senna siamea*	18.18	22.22	40.40
	Tectona grandis	18,18	22,22	40,40
	Cascabela thevetia	22.73	16.67	39.39
21	*Tectona grandis*	32,43	36.36	68.80
	Senna siamea	24.32	22.73	47.05
	Acacia auriculiformis	21.62	22.73	44,35
22	*Tectona grandis*	40.74	26.32	67.06
	Mangifera indica	11.11	15.79	26.90
	Terminalia catappa	11.11	15.79	26.90
23	*Leucaena leucocephala*	23.33	27.78	51.11
	Tectona grandis	23.33	16.67	40.00
	Acacia auriculiformis	13.33	11.11	24.44
24	*Tectona grandis*	27.03	26.32	53.34
	Leucaena leucocephala	21.62	15.79	37.41
	Ficus septica	10.81	10.53	21.34
25	*Tectona grandis*	44.68	45.00	89.68
	Acacia auriculiformis	29.79	30.00	59.79
	Leucaena leucocephala	12.77	15.00	27.77
26	*Tectona grandis*	43.75	37.50	81.25
	Acacia auriculiformis	18.75	20.83	39.58
	Leucaena leucocephala	14.58	20.83	35.42
27	*Musa paradisiaca*	29.63	18.75	48.38
	Leucaena leucocephala	18.52	25.00	43.52
	Tectona grandis	22.22	18.75	40.97
28	*Acacia auriculiformis*	33.33	30.43	63.77
	Tectona grandis	30.95	30.43	61.39
	Senna siamea	23.81	21.74	45.55
29	*Leucaena leucocephala*	24.24	21.05	45.30
	Tectona grandis	24.24	21.05	45.30
	Averrhoa bilimbi	6.06	10.53	16.59

30	*Tectona grandis*	48.84	42.11	90.94
	Leucaena leucocephala	25.58	36.84	62.42
	Gliricidia sepium	9.30	10.53	19.83
31	*Tectona grandis*	21.13	18.52	39.65
	Gliricidia sepium	16.90	18.52	35.42
	Hibiscus tiliaceus	19.72	14.81	34.53
32	*Ficus septica*	40.00	31.25	71.25
	Leucaena leucocephala	16.00	25.00	41.00
	Musa paradisiaca	16.00	12.50	28.50
33	*Musa paradisiaca*	45.10	30.77	75.87
	Hibiscus tiliaceus	25.49	23.08	48.57
	Leucaena leucocephala	15.69	23.08	38.76
34	*Leucaena leucocephala*	46.51	38.10	84.61
	Mangifera indica	9.30	9.52	18.83
	Annona squamosa	6.98	9.52	16.50
35	*Hibiscus tiliaceus*	34.78	30.00	64.78
	Musa paradisiaca	32.61	30.00	62.61
	Falcataria moluccana	15.22	15.00	30.22
36	*Leucaena leucocephala*	47.83	36.36	84.19
	Mangifera indica	8.70	18.18	26.88
	Ficus benjamina	13.04	9.09	22.13
37	*Mangifera indica*	23.53	10.00	33.53
	Persea americana	17.65	10.00	27.65
	Durio zibethinus	11.76	10.00	21.76
38	*Psidium guajava*	20.00	8.33	28.33
	Annona squamosa	13.33	8.33	21.67
	Moringa oleifera	13.33	8.33	21.67
39	*Leucaena leucocephala*	26.67	41.67	68.33
	Artocarpus altilis	11.11	25.00	36.11
	Artocarpus heterophyllus	22.22	12.50	34.72
40	*Leucaena leucocephala*	44.44	37.50	81.94
	Artocarpus heterophyllus	12.12	15.38	27.51
	Senna alata	9.09	7.69	16.78
41	*Leucaena leucocephala*	69.70	53.85	123.54
	Leucaena leucocephala	20.45	17.39	37.85
	Schleichera oleosa	13,64	17.39	31.03
42	*Leucaena leucocephala*	33.33	31.58	64.91
	Delonix regia	22.92	21.05	43.97
	Tectona grandis	16,67	15.79	32.46
43	*Leucaena leucocephala*	72.00	57.14	129.14
	Muntingia calabura	8.00	14.29	22.29
	Tectona grandis	6.00	7.14	13.14
44	*Leucaena leucocephala*	29.41	33.33	62.75
	Muntingia calabura	31.37	13.33	44.71
	Ceiba petandra	21.57	6.67	28.24
45	*Ceiba petandra*	50.00	30.00	80.00
	Artocarpus altilis	25.00	40.00	65.00
	Leucaena leucocephala	25.00	30.00	55.00
46	*Tectona grandis*	41.67	40.00	81.67
	Delonix regia	25.00	25.00	50.00
	Senna siamea	13.89	10.00	23.89
47	*Leucaena leucocephala*	5.88	34.62	40.50
	Mangifera indica	23.53	7.69	31.22
	Nephelium lappaceum	17.65	7.69	25.34
48	*Leucaena leucocephala*	59.69	24.14	83.83
	Tectona grandis	18.60	27.59	46.19
	Senna siamea	3.88	17.24	21.12

Taking into consideration the growth rate of trees, there are 30 types of species with the highest importance value index of 48 ecological units. Plants that predominate by type are *Tectona grandis, Senna siamea, Mangifera indica, Leucaena leucocephala* and *Swietenia macrophylla. Tectona grandis* is a species that is found in 38 ecological units while *Senna Siamea* is found in 28 ecological units. Both tree types are almost evenly distributed throughout the ecological unit. *Tectona grandis* has the highest IVI value of 230.99%. The highest IVI value at 48 ecological units is dominated by *Tectona grandis, Falcataria mollucana* with an IVI value of 171.49%, *Mangifera indica* (145.53%), *Pterocarpus indicus* (142.55%) and *Senna siamea* (103.21%) are plants that have a high IVI after *Tectona grandis*. People in the area prioritize growing crops that have economic benefits, whether intentionally or unintentionally. Woody plants are a priority crop because they are very promising in terms of economy. It is noted that many locals are still not fully aware of the ecological and sociocultural benefits that vegetation can provide. Their understanding on the future needs and investing in ecosystem services is still limited.

At the growth rate of saplings (Table 2), 33 types of vegetation were found, resulting in a similar IVI that was calculated for trees. The vegetation at the saplings level is

dominated by the types of *Tectona grandis, Leucaena leucocephala, Gigantchloa apus, Bambusa blumeana, Acacia Auriculliformis* and *Musa paradisiaca*. Highest IVI values *Leucaena leucocephala* (97.25%), *Tectona grandis* (96.81%) and *Gigantochloa apus* (96.59%).

Table 3 shows that at the growth rate of seedlings, the vegetation type is dominated by *Leucaena luecocephala, Tectona grandis, Senna siamea, Ficus septica* and *Moses paradisiaca*. The highest IVI was *Leucaena leucocephla* (129.14%), *Tectona grandis* (100%), *Ceiba petandra* (80%).

4. DISCUSSION

Diverse landscapes in urban areas play a crucial role in determining biodiversity conditions. The survival of the city area relies heavily on the provision of ecosystem services, which in turn depend on the condition of vegetation [14]. The important value that is attributed to biodiversity, especially vegetation, is based on the various roles it has in regulating the cycle and flow of matter within the city area. It is therefore crucial to effectively manage and optimize limited natural resources for the well-being of the population. The environmental carrying capacity of an area should be able to keep pace with the increase in population and the acceleration of development. If there is a decrease in the carrying capacity of an area, it will have an impact on the emergence of various environmental problems.

The increase in the number of resident populations is directly proportional to the increase in the number of needs [15]. Human activities will undoubtedly continue to disrupt the delicate balance of the study area. The process of urbanization will accelerate, leading to the expansion of cities into previously pristine areas. Unfortunately, this expansion will have a significant impact on the habitat conditions for biodiversity. Therefore, it is imperative that actors engage in effective planning efforts to mitigate these negative effects.

In a health ecosystem, it is expected that there is a balance between IVI inputs and outputs. The conditions needed for life to thrive rely on a delicate balance. Any pressure on urban environments, whether from natural factors or human activities, can hasten the decline in environmental quality. It is crucial to maintain an optimal environment to ensure the continuity of life as we know it [16].

Surakarta is a hub of activity for the surrounding cities where people migration occurs every day. The pressure on the environment of Surakarta city is thus inevitable. For example, during the period 1994 - 2000 the area of open land increased by 28.68 ha or 0.61%. Then in the period 2000 - 2017 this land was reduced by 5.06%, which is equivalent to 235.90 ha [17]. For this reason, it is necessary to support the provision of ecosystem services from urban fringe areas.

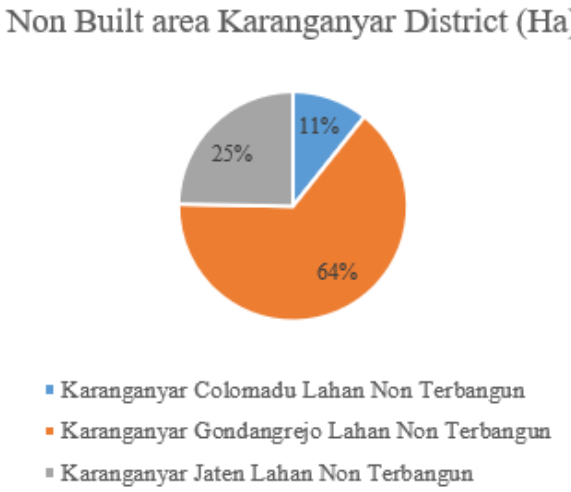

Figure 7. Chart of non-built area Karanganyar District

The open land in urban fringe Surakarta changed from 16435.964 ha in 2015 to 16349.972 ha in 2020, amounting to a decrease by 0.52%. It is therefore hoped that the urban open land fringe of Surakarta will help provide optimization of the function of ecosystem services. Figure 7 shows that Karanganyar Regency has the largest non-built land area which amounts to 7244.41 ha, equivalent to 64% of the non-built land is in Gondangrejo District. Sukoharjo Regency has 6340.85 ha of non-built land area where 43% is located in Mojolaban District. Boyolali Regency only has one sub-district directly adjacent to the Surakarta City area, namely Ngemplak District, with a total non-built land area of 2764.71 ha (Figure 8).

The highest IVI in the Karanganyar Regency is observed for *Tectona grandis* (220.02%), within ecological unit 30. *Tectona grandis* is a type of tree that shows an even geographical distribution and has the highest IVI in 8 ecological units (Figure 9). *Falctaria moluccana* (164.63%) and *Pterocarpus indicus* (142.55%) were the types that show the highest IVI after *Tectona grandis*. The highest distribution of types is *Tectona grandis, Senna siamaea* and *Mangifera indica.*

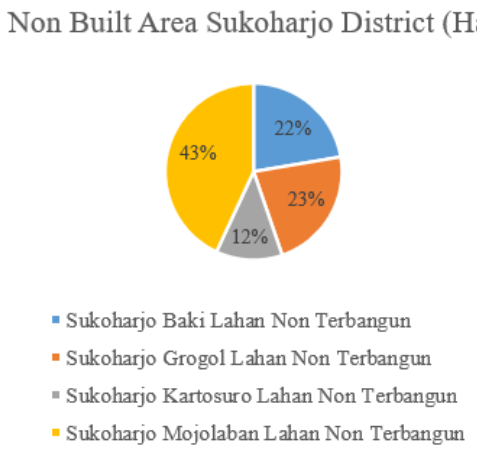

Figure 8. Chart of non-built area Sukoharjo District

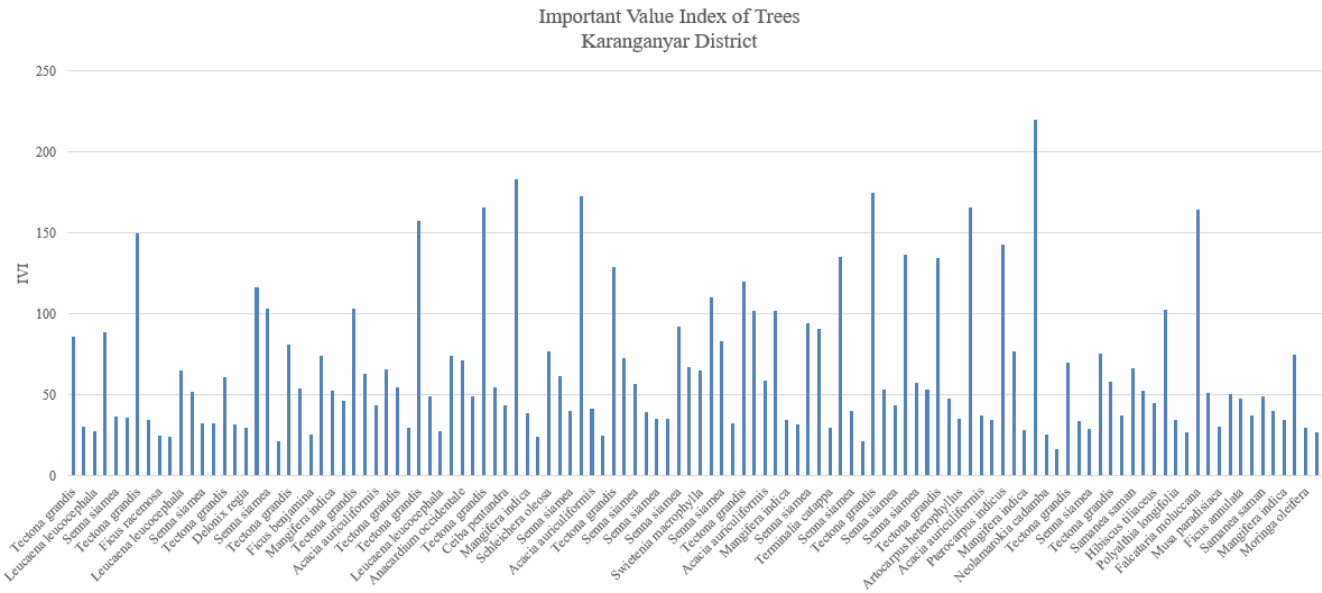

Figure 9. Important value index of Karanganyar District

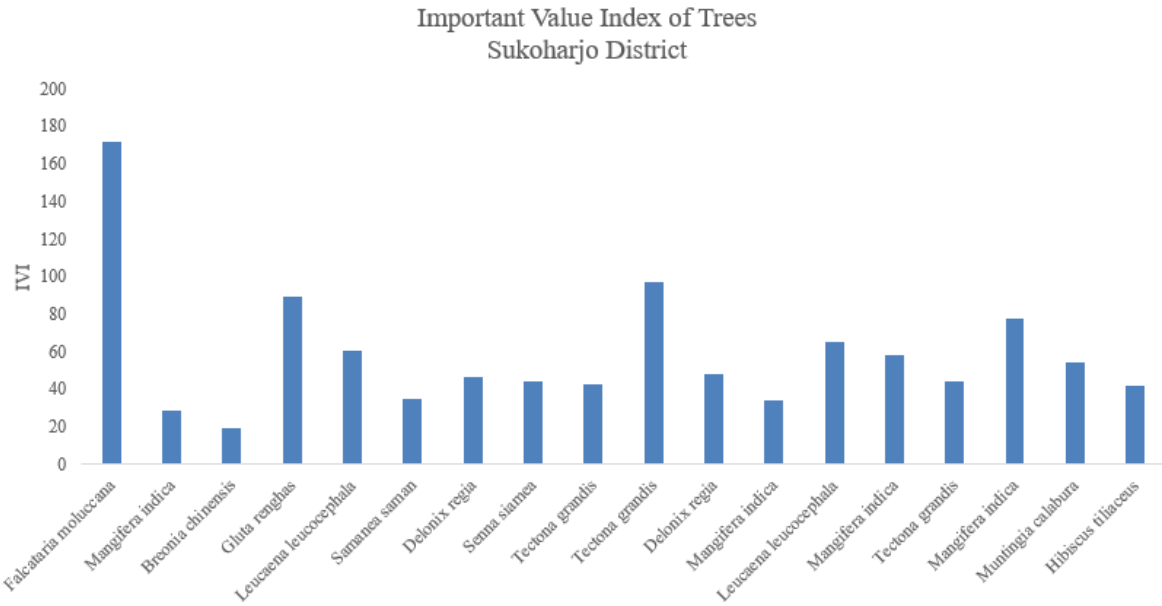

Figure 10. Important value index of Sukoharjo District

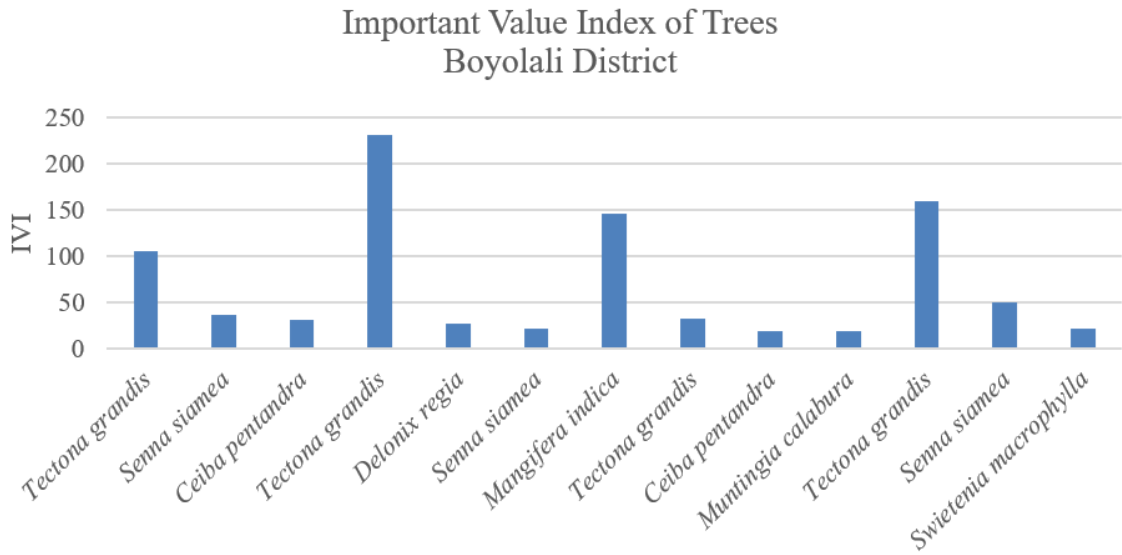

Figure 11. Important value index of Boyolali District

In Sukoharjo Regency (Figure 10), the type variations for the highest IVI varied, with the highest IVI being *Falcataria mollucana* (171.49%), *Tectona grandis* (97.46%) and *Gluta rengas* (89.54%). The highest distribution of plant species on the Sukoharjo District are *Tectona grandis* and *Mangifera indica*. The highest type of crop in the region is one that has a high economic value, which is considered to be the best wood producer with high productivity.

Tectona grandis (230.99%) and *Mangifera indica* (145.53%) are the species with the highest IVI in Boyolali District (Figure 11). *Tectona grandis* and *Senna siamea* are the highest types of distribution in the region. The type of plant with the highest IVI in the urban fringe area of Surakarta is dominated by wood-producing plants. These plant species hold considerable economic value due to their high productivity, which plays a crucial role in the economic sector of the population. *Tectona grandis, Falcataria mollucana* and *Gluta rengas* are promising trading commodities in this respect.

5. CONCLUSIONS

The urban fringe area of Surakarta consists of Karanganyar, Sukoharjo and Boyolali Regencies. The relatively rapid change in use in the city of Surakarta has an impact on reducing the area of open land. As a result, environmental degradation continues to increase leading to suboptimal carrying capacity. The decrease in the area of open land reduces the possibility of the habitat to contain more vegetation. Therefore, the Surakarta urban fringe area needs support in the provision of ecosystem services.

From the analysis of overlay maps based on factors of soil type, topography and landform, 48 ecological units in the urban fringe Surakarta were identified. Karanganyar Regency has 37 ecological units, while Sukoharjo Regency has 6 ecological units and Boyolali Regency has 4 ecological units. For each ecological unit, the IVI calculation was carried out in order to provide an overview of the type and dominance of vegetation. Woody plant species dominate as seen from the highest IVI in the district. In addition to woody types of plants, fruit crops also dominate the types of each district.

Tectona grandis (220.02%), *Falctaria moluccana* (164.63%) and *Pterocarpus indicus* (142.55%) are the plants with the highest IVI in Karanganuay District. In Sukoharjo Regency, the type variations for the highest IVI were diverse with the highest IVI being *Falcataria mollucana* (171.49%), *Tectona grandis* (97.46%) and *Gluta rengas* (89.54%). *Tectona grandis* (230.99%) and *Mangifera indica* (145.53%) are the species with the highest IVI in Boyolali District.

Based on the IVI description of vegetation types in each ecological unit in the Surakarta urban fringe area, it is hoped that it can help biodiversity management and planning. The types of vegetation that dominate are woody plants that are trade commodities and food crops. This is inseparable from the local wisdom of the community which considers woody plants as future savings that can be inherited. Food crops are expected to be able to meet consumption needs and as a trading commodity. Planning efforts related to biodiversity conservation of urban fringe areas are expected to be easier to make and implement. The effectiveness of providing ecosystem services in urban and urban fringe areas with recommendations for these types of plants will be more optimal. It is being recommended that further studies on community perceptions of biodiversity in urban fringe areas are conducted in order to determine the inhabitants' level of understanding on the importance of ecological studies on the provision of urban environmental ecosystem services. In order to ensure the sustainability of urban areas, it is crucial to not only implement dynamic systems, but also closely monitor environmental changes and vegetation structures. By doing so, there can be effective mitigation of any negative impacts and provide informed decisions for the long-term well-being of these urban areas.

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