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Analysis of vegetation structure of urban parks and environmental discomfort index in The City of Mataram

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Abstract: The high population growth in Mataram City with the consequence of increasing development has caused a decrease in the area of green open land. Garden parks as part of green open land need to be maintained and evaluated for their vegetation to be able to control the impact of local climate change. This study aims to analyze the vegetation structure of garden parks in Mataram City and assess its ability to reduce the increase in the environmental discomfort index. Vegetation analysis was carried out in six garden parks in Mataram City using the transect-squared method. The observed vegetation variable was the lushness of each vegetation life form. Vegetation data was analysed to produce groups of urban park vegetation structures in Mataram City. Microclimate factors inside and outside the park, which include air temperature and humidity observed on a sunny day according to a two-way line interval design with a direction according to the shape and area of the observed urban park. The data of air temperature and humidity were processed to produce an index of environmental discomfort. The results showed that the six urban parks observed in The City of Mataram were divided into three groups of vegetation structures, namely the form of trees & shrubs (Ampenan Old Town Park, Udayana Garden and Selagalas park), forms of shrubs & trees (Sangkareang Park and Garden of Mayura) and forms of bushes & shrubs (Malomba Park). The existence of city parks with variations in their vegetation structure in Mataram City does not cause variations in their ability to reduce the discomfort index. All city parks observed in Mataram City have moderate ability in reducing environmental discomfort index. Most of the areas outside the city parks in Mataram City have a class c of discomfort index and only Mayura Park, Malomba Park and Selagalas Park are known to reduce the discomfort class, namely from class c (discomfort felt by >50% of the population) outside the park to class b (discomfort felt by <50% of population) in the park.

Keywords: environmental discomfort index, city of Mataram, urban park vegetation structure

Introduction

The population density in Mataram City continues to increase every year and this has an impact on reducing the area of green open land in the city. The increase in population in this city is followed by the growth of economic activities, settlements, education, and culture, which encourage the conversion of non-built land into closed land such as buildings, roads, and other forms of physical cover without vegetation. The city of Mataram experienced a significant increase in built space from 2008 to 2016, which reached almost 5% (BPS Kota Mataram, 2020).

The decrease in the area of non-built land, especially green open land can cause changes in the microclimate in the city Changes in the microclimate, especially the increase in heat and air temperature and a decrease in air humidity can cause an increase in the environmental discomfort index (Alam *et al*., 2014; Annisa *et al*., 2015).

The city of Mataram as one of the cities in the eastern part of Indonesia is experiencing very rapid development, which has an impact in the form of reducing the area of green open land (BPS Kota Mataram, 2020; Ministry of Public Works, 2020). It has also been previously reported that the increase in physical development in Mataram City has caused the need for space to increase, so that the existence of public open spaces is increasingly threatened (Fitrasari *et al*., 2018; Suripto *et al*., 2019).

The implementation of development is always faced with the challenge of environmental quality degradation. Development carried out by means of massive exploitation of the environment to meet needs usually occurs because it uses physical and economic indicators as evidence of success (Akbari, 2022; Fauzan *et al*., 2018). Thus, in the future, development policies are needed that are able to encourage the preservation of environmental quality or sustainable development.

The omission of the remaining non-built land, including city parks as part of green open land with a certain area and distribution in developing cities, is a compensation for the implementation of green open land conversion (Fitrasari *et a*l., 2018). Compensation for the conversion of open land in the form of the construction of city parks and the development of existing city parks has also occurred in the city of Mataram (Sosman, 2014).

Compensation in the form of urban park development is intended to reduce the impact of micro-climate change due to a decrease in the area of green open land. Changes in the microclimate, especially the increase in temperature air and decrease in humidity can cause an increase in the environmental discomfort index (Annisa *et al*., 2015). The role of urban parks in reducing the environmental discomfort index is mainly determined by the structure (Destriana & Zain, 2018), and number or area of vegetation cover and spescies (Aluyah & Rusdianto, 2019) of the vegetation in the park.

Thus, the existence of city parks, which are part of green open land in the city, should be able to compensate for the reduction in the area of open land in the city, namely parks with existing vegetative structures that are able to prevent or reduce the increase in air temperature and decrease in humidity). Prevention of increasing air temperature and prevention of decreasing air humidity is the basis for preventing an increase in the environmental discomfort index (Suripto et al., 2021)

Based on the background of the problem above, it is necessary to conduct research on the analysis of the vegetation structure of the city park and assess the ability of the city park to reduce or prevent an increase in the environmental discomfort index in Mataram City.

Materials and Methods

City parks were selected as samples with the criteria of having the status of Public Open Space according to the Mataram City Spatial Plan, located in the central area of public activity and traversed by heavy motorized traffic lanes. Based on the above criteria, six urban parks were selected as study samples in Mataram City, namely 1) Ampenan Old Town Park, 2) Malomba Park, 3) Udayana Park, 4) Sangkareang Park, 5) Mayura Park, and 6) Selagalas Park.

Analysis of city park vegetation structure

The analysis of the park's vegetation structure was carried out using the transect-square method in two mutually perpendicular directions. The length and direction of the transects were made according to the shape and size of the park area. Similarly, the size, number and distribution of squares are made according to the shape and size of the observed garden area (Figure 1).

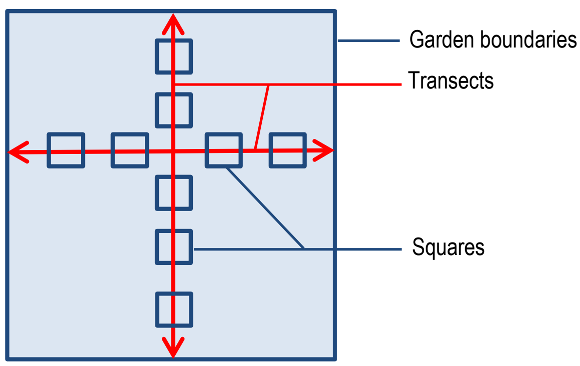

Figure 1. Map of urban park vegetation structure analysis

The park vegetation variable observed was overgrowth, namely the percentage of vegetation cover along the transect by herbaceous and bush life forms, and the percentage of canopy cover by shrubs and tree

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vegetation in each square. All species of vegetation observed were sampled for identification in the laboratory.

Measurement of microclimate variables

Measurements of microclimate variables, namely air temperature and humidity, were carried out in the middle of a sunny day inside the park and outside the park according to a regular line interval design in two perpendicular cardinal directions (Figure 2).

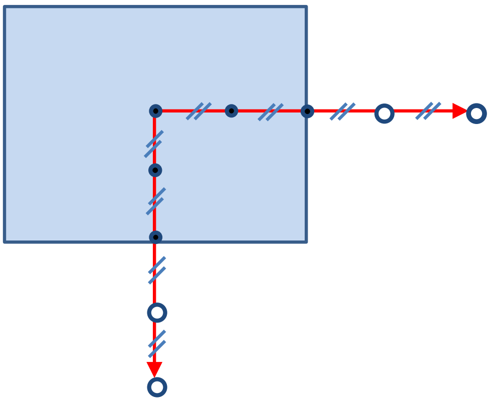

Figure 2. Map of urban park microclimate observations

The length and direction of the corner lines are made according to the shape and size of the park area. However, the interval between observation points is made the same, namely 5 meters, so that the number of observation points on each corner line can be determined and can vary according to the shape and area of the city park.

Measurements of air temperature and relative humidity at all observation points on the same line are carried out at relatively the same time using the on-line Weather Station application.

Data analysis

Vegetation structure

Data on the percentage of area covered by each vegetation form in each park was processed to determine park groups based on their vegetation structure. The group or name of the park vegetation structure is determined by the two most dominant forms of vegetation.

There are four forms of vegetation, namely (1) herbs; (2) bush; (3) shrubs; and (4) trees. Thus in total there are 12 groups of park vegetation structures (Roemantyo (2021), namely:

(1) Herb-bush structure	(7) Shrub-herb structure
(2) Herb-shurb structure	(8) Shrub-bush structure
(3) Herb-tree structure	(9) Shrub-tree structure
(4) Bush-herb structure	(10) Tree-herb structure
(5) Bush-shrub structure	(11) Tree-bush structure
(6) Bush-tree structure	(12) Tree-shurb structure.

Environmental discomfort index (DI)

Microclimate data, namely air temperature and humidity inside and outside the park in each sample area of city parks were processed to determine environmental discomfort index. The discomfort index (DI) was calculated using the following formula (Georgi & Zefiriadis, 2016):

$$DI = T - 0.55\ (1 - 0.01\ RH)(T - 14{,}5)$$

Where,

DI = discomfot index
T = air temperature (^{0}C)
RH = relative humidity

The level or class of environmental discomfort index is determined using the following criteria (Table 1):

Table 1. Criteria for the level (class) of the discomfort index

Expression	DI (^{0}C)	Class
No discomfort	< 21	a
Discomfort is felt by < 50% of the population	21 – 24	b
Discomfort is felt by > 50% of the population	24 – 27	c
Discomfort is felt by the majority of the population	27 – 29	d
Discomfort is felt by all	29 – 32	e
Medical alarm stages	> 32	f

Source: Georgi & Zafiriadis, 2016)

Results and Discussion

Based on the two most dominant forms of vegetation among herbs, shrubs, shrubs and trees, city parks can be grouped into 12 groups.

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In Mataram City, there are three groups of urban park vegetation structures, namely 1) tree-shrub structures (Ampenan, Udayana and Selagalas), 2) shurb-tree structures (Sangkareang and Mayura), and 3) bush-shrub structures (Malomba) (Table 2) (Figure 3).

Table 2. Groups of city parks based on their vegetation structure in City of Mataram.

City Park	D	Herb	Bush	Shrub	Tree
Ampenan	1				25*
	2			15*	
	3		5		
	4	3			
Malomba	1		24		
	2			12***	
	3				4.8***
	4	2			
Udayana	1				17*
	2			13*	
	3		8		
	4	3			
Sangkarean g	1			15**	
	2				10**
	3		10		
	4	5			
Mayura	1			19**	
	2				18**
	3		5.5		
	4	5			
Selagalas	1				20*
	2			16*	
	3		6		
	4	3			

Note : * Vegetation form: tree-shrub
** Vegetation form: shrub-tree
*** Vegetation form: bush-shrub

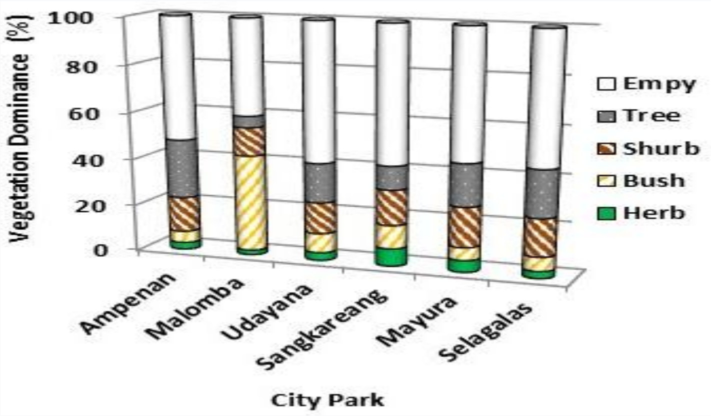
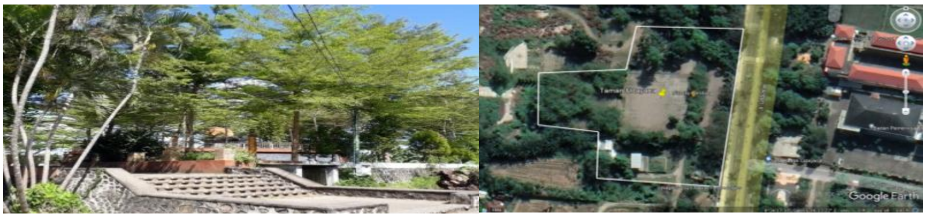


Figure 3. Vegetation structure of urban parks in Mataram City

Ampenan Old Town Park, Udayana Park, and Selagalas Park have the same class of vegetation structure, namely the tree-shrub structure (vegetation is dominated by trees and shrubs). Herbs and bushes actually also grow in these parks, but they are very rare with a cover area of 5 to 8% (Figure 4).

Ampenan Old Town Park (0.20 ha)



Udayana Park (3.51 ha)

Selagalas Park (2 ha)

Figure 4. Tree-shrub vegetation structure in Ampenan Old Town Park, Udayana Park, and Selagalas Park.

The three city parks have the same ability to reduce the discomfort index (DI), which is in the moderate category. However, of the three city parks, only Selagalas park was able to reduce DI class, namely from class c (discomfort felt by > 50% of the population) outside the park to class b (discomfort felt by <50% of the population) inside the park (Table 3).

Table 3. Environmental discomfort index inside and outside city parks in Mataram City

City Park	Inside The Park	Outside The Park	Index Drop	
			(%)	Category
Ampenan	24.25 (c)	25.24 (c)	7.64	Moderate
Malomba	24.00 (b)	25.94 (c)	7.48	Moderate
Udayana	24.09 (c)	25.90 (c)	6.99	Moderate
Sangkareang	24.23 (c)	26.14 (c)	7.31	Moderate
Mayura	23.76 (b)	25.84 (c)	8.08	Moderate
Selagalas	23.72 (b)	25.05 (c)	8.95	Moderate

Sangkareang Park and Mayura Park have the same vegetation structure, namely the shrub-tree structure, where the vegetation is dominated by shrubs and trees (Figure 5), also have the same ability to lower DI value, with a moderate category. However, in Mayura Park there was a decrease in DI class, namely from class c outside the park to class b inside the park (Table 3).

Sangkareang Park (Luas 0,75 ha)

Mayura Park (3.22 ha)

Figure 5. Shrub-tree vegetation structure in Sangkareang Park and Mayura Park.

Unlike the city parks mentioned earlier, the vegetation structure in Malomba Park is the most different from the others, namely the bush-shrub structure (vegetation is dominated by bush and shrubs) (Figure 6). Malomba Park also has a moderate ability to reduce DI value, the same as other parks, but is able to reduce DI class from class c outside the park to class b in the park (Table 3).

Malomba Park (0.2 ha)

Figure 6. Bush-Shrub vegetation structure in Malomba Park

The results above show that variations in vegetation structure are not the cause of differences in the park's ability to change or reduce the environmental discomfort index class. Even though Ampenan Park and Udayana Park have moderate ability to reduce DI value, each of them cannot reduce DI class. DI class outside and inside the parks are the same, namely class c. It is different with Selagalas Park, although it has a moderate ability to reduce ID, but the park can reduce ID class, namely from class c outside the park to class b) inside the park.

Ampenan Park, apart from having a narrow land area (0.20 ha) and being dominated by vacant land with no vegetation, also has an uneven distribution of trees and shrubs (clumping). The distribution of appropriate vegetation is not effective in reducing air temperature, so it is not effective in reducing class. The relationship between air temperature and the environment has previously been suggested by Sanger *et al*. (2021), namely that changes in the index are a manifestation of changes in the microclimate, especially temperature and humidity. Udayana Park has a much larger area (3.51 ha) than other parks, but its vegetation (trees and shrubs) is uneven (clumped), so its ability to reduce air temperature is low. Thus this park is also not able to reduce the class of discomfort. Selagalas Park, although the vegetation cover area is less than 50% of the total park area (about 2 ha), the distribution of vegetation (trees and shrubs) is almost evenly distributed. It is known that this park is able to reduce DI class from class c outside the park to class b inside the park.

In Sangkareang Park, there is no decline in DI class because apart from the narrow garden area (0.2 ha) it is also due to the uneven distribution of vegetation. The area of vegetation cover in this park is also less than 50% of the total park area. Thus, the park's ability to reduce air temperature is very low and as a result there is no reduction in DI class. Mayura Park has the largest land area (3.22 ha) compared to other parks and has an almost even distribution of vegetation, although the vegetation cover area is less than 50% of the total park area. This park is able to lower the DI class from class c outside the park to class b outside the park.

Even though Malomba Park has a relatively narrow land area (0.2 ha), it has a vegetation cover area of more than 60% of the total land area. In addition, the distribution of vegetation is even, although it is dominated by bush and shrubs. The area and structure of the vegetation like this might cause this park to be able to reduce DI class from class c to class b.

Because the change in the index of environmental discomfort is a manifestation of changes in the microclimate, in this case changes in air temperature and relative humidity of the air, the difference in the index of discomfort above may be due to differences in the area of green area (vegetated land) in the park and the total area of the park. . This supports the results of a study conducted by Suripto *et al*. (2021), who concluded that the variation in the ability of urban parks to soften the microclimate was not significantly related to variations in vegetation structure but was caused by variations in green area. It is also concluded that the low level of ability of urban parks to soften the microclimate is caused more by the lack of green area (less than 40%) in the park. Sanger *et al*. (2021) have also reported that the structure of the park's vegetation has no significant effect on lowering air temperature if the area of the vegetated garden area is less than 50% of the total park area. City parks that have a low ability to reduce the surrounding air temperature are generally caused by the large portion of vacant land without vegetation (> 50% of the total park area), such as concrete floors, asphalt roads, walls, and other physical buildings.

The results above also show that in the Mataram City area it is more often felt less comfortable or rarely comfortable ("DI" outside the park is more than 25, which belongs to class c, i.e. discomfort is felt by > 50% of the population), and the presence of city parks with various vegetation structures, can at least reduce the DI value by 7 to 9%. The park's ability to reduce the discomfort index is actually the park's ability, especially by its vegetation component, in softening climatic factors, namely reducing air temperature and increasing air humidity.

The results of this study strengthen the conclusions of previous research conducted by Suripto *et al*. (2021), namely city gardens in Mataram City with varied vegetation structures but have the same level of ability (low level) in softening the microclimate. They also added that although the vegetation structure affects the park's ability to soften the microclimate, it turns out that the low ability of urban parks in Mataram City to soften the microclimate is caused more by the low portion of green area (vegetated land) in the park than the total park area. . Green areas with a variety of vegetation structures only control about 40 to 48% of the total park area. Thus, more than 50% of the park area is open land, in the form of vacant land, concrete or asphalt floors, pool water and buildings.

The decrease in the index of environmental discomfort by garden vegetation through the microclimate softening mechanism is influenced by two vegetation factors, namely physical and physiological factors. Physically, plants generally have a darker color than buildings, such as walls, asphalt roads, concrete floors and so on. Darker colored surfaces absorb more and reflect less heat from the sun than lighter colored surfaces, which absorb less heat and reflect more of it. Thus, vegetation can physically reduce the heat and temperature of the surrounding air. Plants generally have a rougher body surface compared to other physical building surfaces. Objects with a rough surface have a larger surface area so they can absorb more and less heat from the environment than those with a smooth surface (Aluyah & Rusdianto, 2019; Suripto *et al*., 2021).

Physiologically, plants during the day carry out photosynthesis. In the process of photosynthesis, CO_2 gas in the air is used. The reduction of CO_2 gas in the air due to photosynthesis can reduce the heat of the air, because the CO_2 gas that stores (absorbs) the heat of the air is reduced. On the other hand, photosynthesis produces oxygen (O_2), which gives a fresh impression to heterotrophic organisms, including humans who are in the vicinity. In addition, plants are also able to use environmental heat to carry out transpiration, especially by their leaves through stomata, which produce water vapor (H_2O) to the environment, and this can increase the humidity in the surrounding air (Destriana & Zain, 2018; Fauzan *et al*., 2018).

Vegetation that has many small crowns will have a larger surface area in contact with the environment than vegetation that has one large crown of the same size as the combined small crowns. Vegetation that has small leaves but many in number will have a larger surface area than one large leaf of the same size as the combined small leaves (Suripto & Aksari, 2020). Thus, for the softening of the microclimate by garden vegetation, the dominance of shrubs and shrubs with small but abundant leaves is more important than the dominance of trees with large but few leaves.

Conclusion

In the city of Mataram, there are three groups of urban park vegetation structures, namely tree-shrub vegetation in Ampenan Park, Udayana Park, and Selagalas Park; shrub-tree vegetation in Sangkareang Park and Mayura Park; and shrubs in Malomba Park. The ability of parks in the city of Mataram to reduce the level of discomfort is not related to the variation of the vegetation structure, but is more influenced by the large portion of the vegetation cover, especially trees, shrubs and shrubs.

Although all the city parks observed in Mataram City have the same level of ability, namely moderate ability in reducing the discomfort index, only Selagalas Park, Mayura Park, and Malomba Park can reduce environmental discomfort class, from class c (the discomfort felt by > 50% of the population) outside the park to class b (discomfort felt by <50% of the population) inside the park.

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