Conference Paper

Analysis of Correlation Betweeen Urban Structure Parameters and Climatic Variables in Heritage Area of Rajawali-Surabaya as Urban Heat Island Mitigation

Dini Faza Illiyin[1], Widjaja Martokusumo[2], and Mochamad Donny Koerniawan[3]

[1]Student, Departement of Urban Design, School of Architecture, Planning and Policy Development, Bandung Institute of Technology, Ganesha 10 Bandung 40132, Indonesia
[2]Professor, Departement of Urban Design, School of Architecture, Planning and Policy Development, Bandung Institute of Technology, Ganesha 10 Bandung 40132, Indonesia
[3]Asistant Professor, Departement of Urban Design, School of Architecture, Planning and Policy Development, Bandung Institute of Technology, Ganesha 10 Bandung 40132, Indonesia

Abstract

Nowadays, Surabaya experience Urban Heat Island (UHI) phenomenon because of the increase of surface temperature from 1994 until 2011. The urban structure parameters have a role in decreasing the UHI phenomenon. Rajawali is a historic area where it can be sensitive to climatic condition and urban heat island. This paper aimed to analyze the correlation of urban structure parameters toward climatic variables (as an indicator affecting UHI) in the heritage area of Rajawali. This study focuses on some urban structure parameters that are Building Coverage Ratio (BCR), Floor Area Ratio (FAR), aspect ratio (H/W), Volumetric Compactness (S/V) and land cover in the site. The analysis method is a simulation from Envi-met where simulation performed is run in March 2018. In order to check how far the urban structure affects climatic variable, the urban structure parameters are compared with each variable of climatic using the statistical package, R. For correlation analysis Pierson's r coefficient is used. The result shows that not all urban structure parameters correlate with climatic variables in the Heritage Area. The findings of this study are expected to be the basis for designing the heritage area in Rajawali so that the design can respond to the UHI phenomenon in Surabaya.

Keywords: Urban Structure Parameters, Climatic Parameters, Heritage Area, UHI (Urban Heat Island)

Corresponding Author:
Dini Faza Illiyin

Received: 24 May 2019
Accepted: 25 July 2019
Published: 4 August 2019

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ISTEcS 2019 Conference Committee.

1. Introduction

Surabaya is one of the big city in Indonesia that experience Urban Heat Island (UHI) phenomena. The phenomenon of Urban Heat Island (UHI) due to fluctuations in the temperature increase from 1994 to 2011 concentrated in the north-south region of Surabaya [1]. In 1994, 10.25% of the Surabaya area had a surface temperature of more

How to cite this article: Dini Faza Illiyin, Widjaja Martokusumo, and Mochamad Donny Koerniawan, (2019), "Analysis of Correlation Betweeen Urban Structure Parameters and Climatic Variables in Heritage Area of Rajawali-Surabaya as Urban Heat Island Mitigation" in *Equity, Equality, And Justice In Urban Housing Development*, KnE Social Sciences, pages 206–220. DOI 10.18502/kss.v3i21.4969

than 28°C concentrated in the north-south region of Surabaya. This condition increased to 58.58% in 2011 which extends to the west-east of Surabaya, one of them is Rawajali. The condition due to the increasing number of people so that the built area is also increasing to the area. Therefore, the UHI region which clustered initially in the center of the city became increasingly widespread to the west-east of Surabaya, in line with the development of the built area.

Some researchers explain that the climatic conditions in the city affected by climate and the built environment [2]. The built environment accelerates the absorption of the heat during daytime and slows down to release the heat at night time, which is known as the Urban Heat Island where the hot region surrounded by the cooler adjacent area such as experienced in Surabaya.

Rajawali area locates on the north side of Surabaya City, where this area is a growth point of the old city in 1900 to 1940s. Besides, this area also has a reasonably strong historical value shown by the Jayengrono Park as a memorial park, Jembatan Merah Surabaya and historic buildings built in the Dutch colonial era with modern colonial architecture. Therefore, in the Strategic Plan of Surabaya's Old City Area in 2012, Rajawali is directed as one of the core zones in the cultural heritage area of the old city of Surabaya. Based on the plan, the area is also addressed as a shopping area and historical tourism activities, so that the area will create many outdoor activities.

Currently, Rajawali has a reasonably high surface temperature of about 35°C from 1994. Based on data BMKG, Rajawali has an average temperature of 25°C - 33°C and average humidity of 54.9% - 88.3% in 2016. Meanwhile, according to Lippsmeir, the comfort limit for an equatorial or tropical area is in the range of air temperature 22, 5°C - 29°C and air humidity 20-50% [3]. Based on the statement, it can be concluded that there is thermal discomfort in Rajawali. Meanwhile, a thermally comfortable area is needed to support activity in Rajawali.

Rajawali as a part of the cultural heritage area will have design limitation, especially the design relating to the urban structure parameters such as the height of the building, the border of buildings, facades and building materials. On the other hand, the urban structure can affect how the microclimate conditions in an area. Therefore, the purpose of this study is to find out how the correlation between the urban structure parameters on the site to the microclimate conditions created in the region.

2. Literature Review

According to Valsson [4] characteristics that affect the microclimate region can be divided into four as follows:

2.1. Building configuration

The aspect ratio is a determining factor of canyon geometry. It is defined as the ratio of H/W, where H is the average height of the canyon wall and W is the canyon width. The ratio of building height and width of the road (H / W) which affects the temperature of the area due to the influence of shadowing in the area. High aspect ratio means the strong level of shadow and the low-temperature of an area [5].

2.2. Land use and materials

This area covers material effect on the level of reflectance, permeability, and temperature of the material. Reflectance level, permeability, and temperature of the material are influenced by the material color, texture, and material bulk thermal properties. Some research results show that the material of land cover can affect thermal comfort. In his research, stated the quality of the material in the open space will affect the microclimate of open space, that the old building materials will be worse in its albedo [6]. Emmanuel stated that land use and land cover changed affect the microclimate of open space [7]. Land cover is divided into two types: hard cover (buildings, roads and pavement of the soil) and soft cover (trees, green area/grasslands, shrubs and water bodies).

2.3. Urban structure

Urban form indicators describe the component of urban fabric, that give the details on the urban structure components (buildings, streets, and urban networks). Bourdic stated that volumetric Compactness is the urban structure indicators to analyze urban heating [8]. There are three variables in the volumetric Compactness; traditional compactness, equal to surface area, S, of the building's envelope divide the volume of the buldings; size Factor, to the equivalent cube of its length; and Form Factor is the bias introduced by the different size of the analysed objects has been removed. Another factor that related to the urban microcimate parameters is Street form Index (H/W).

2.4. Vegetation

Trees can reduce the level of incoming solar radiation in the open space using shadowing and minimize the amount of sunlight that reaches the ground [9]. The value of vegetation in an area can be expressed in Green Plot Ratio (GnPR) [10]. GnPR is the value used to calculate how green the area. GnPR expressed in units of the numbers. In calculating the value of GnPR can be distinguished into three categories, namely vegetation of trees, shrubs and grass.

3. Method

This research overall uses two methods that are ENVI-met simulation and regression. The methods are used to analyze the correlation urban structure parameter and microclimate in Rajawali as a heritage area. The result can show how the urban structure parameters affect the microclimate in there, so it can be a basis for designing area. This study will divide the area to be six areas for analyzing how the character of the urban structure parameters and climatic parameter and then will be analyzed how the correlation between urban structure and microclimate (fig.1).

Figure 1: Boundary of the study area and the division of the site.

3.1. Study area

The Rajawali is located on the north side of Surabaya where this area is a growth point of the old city from 1900 to 1940. In addition, Rajawali also has a reasonably strong historical value. The historical buildings with modern colonial architecture are on the main street of Rajawali. Therefore, in the Strategic Plan of Surabaya's Old City Area 2012, Rajawali is planned to be one of the core zones of cultural heritage areas in Surabaya with a shopping and historical tourism area meant to attract people to do outdoor activities such as walk or photography.

Rajawali has a hot and humid climate. It has an almost uniform air temperature during the year with an average maximum of 33,00°C, an average minimum of 25°C, an average temperature of 29°C and average humidity of 74,00%. The wind is generally light and variable with speeds averaging around 1.4 m/s. Based on the climate conditions, Rajawali is not thermally comfortable and suffers from heat waves with low wind speeds. Sunrise in Rajawali-Surabaya starts at about 5.00 h and sunset at 17.30 h, receiving approximately 12 h of sunshine throughout the year. Surabaya has two dominant seasons in the year that is the dry season (April-August) and a rainy season (September-March).

Figure 2: Orientation of Study Area and distribution of historic buildings.

The characteristic of urban structure in this study will use six parameters that are Building Aspect Ratio (BCR), Floor Aspect Ratio (FAR), aspect ratio (H/W), Green Plot Ratio (GnPR), land cover and waterbody. The parameters affect the climate condition, especially for the microclimate. Aspect ratio is a parameter that can influence air movement and shadowing that can decrease the temperature in the site. Green Plot Ratio (GnPR) affects reducing the temperature, and it can also influence the air movement too. In addition, based on the research, waterbody has an effect of making the temperature in the surrounded area decreasing, besides that waterbody also has a function as a path

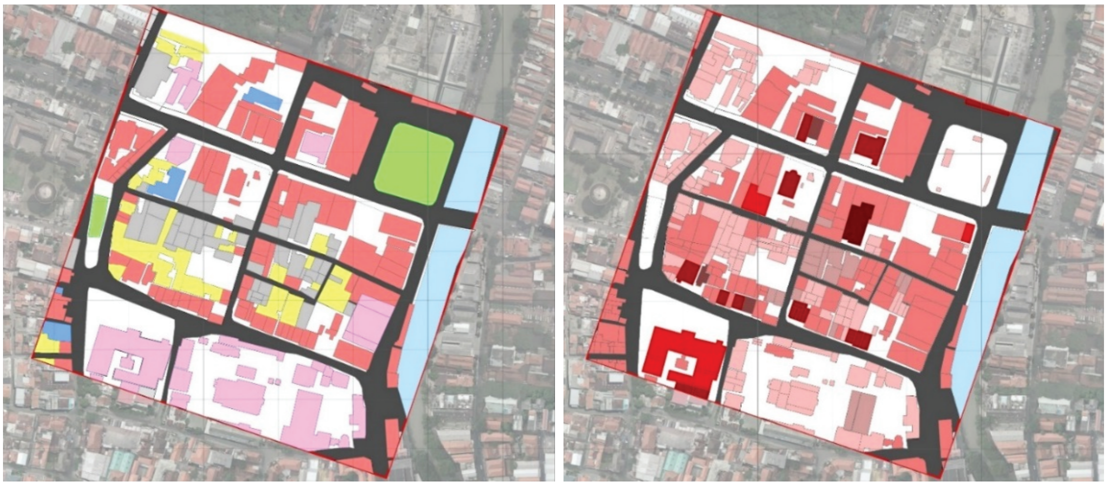


Figure 3: Land use of Study Area and Height of Building.

of wind movement. So, this study tries to analyze how the correlation the urban structure parameters to climate parameters in Rajawali. The characteristic of urban structure in Rajawali is shown in **Table 1**.

Table 1: Characteristic Of Urban Structure in Rajawali.

	Building form & Massing	Aspect Ratio (H/W)	GnPR	Land Cover	Waterbody
Area 1	BCR: 28,44%; FAR: 0,56	0,5 (Height: 4-10 m)	0,21	59,67%	7,33%
Area 2	BCR: 55,44%; FAR: 0,51	0,8 (Height: 4-48 m)	0,15	44,22%	0,00%
Area 3	BCR: 53,11%; FAR: 0,77	0,2 (Height: 4-12 m)	0,11	41,67%	0,00%
Area 4	BCR: 61,44%; FAR: 1,07	0,5 (Height: 4-16 m)	0,20	33,22%	0,00%
Area 5	BCR: 58,22%; FAR: 1,11	1,1 (Height: 4-16 m)	0,12	39,56%	0,00%
Area 6	BCR: 52,78%; FAR: 1,02	1 (Height: 4-8 m)	0,15	39,44%	4,33%

3.2. Analysis of climatic paramerters

This study uses the microclimate model Envi-met to assess the microclimate in three-three dimensional space. EnviMet model is a simulation model of the microclimate in the 3-dimensional shape. The ENVI-met end the result is a color scale that shows the value of climatic conditions (Fig. 3). Color values which represent the value of PMV when linked with environmental characteristics can describe positions that cause the space into hot or cold in a thermal comfort scale. So that environmental aspects can be assessed spatially using this EnviMet.

The simulation uses climatic data from BMKG especially climatic data in March because in this month the climate condition in Rajawali experience extreme condition. The input set up and configuration file for simulation can be seen in Table.2. Climatic parameters of the simulation results used in the analysis process consist of air

Figure 4: The Examples of EnviMet Result.

temperature, relative humidity, and wind speed. Furthermore, the parameters are used to analyze the correlation with the urban structure parameters. The climatic data from the simulation results used in the next analysis phase using sample data at 08 am, 12 am and 4 pm on each climatic parameter.

Table 2: Initial set up of the model domain and configuration file.

Input Set Up	
Orientation (degree from the north)	-19,20
Number of x,y,z grids	90,90,30
Size of grid cell in m (dx),(dy),(dz)	4.3; 4.3; 2
Name of location	Indonesia
Position on earth	Latitude (-7.15) longitude (112.44)
Soil profile for nesting grid	Soil A and B = Loamy Soil
Input for configuration file	
Date	March 5, 2018
Duration	24 h (1 pm March 5 to 1 pm March 6)
Wind Velocity	1,4 m/s
Wind Direction	175
Temperature	29.02°C
Relative Humadity	74,00%
Rougness lenght	0.01

3.3. Analysis of correlation urban structure parameters and climatic variables

In order to calculate and analyze the urban structure parameter, such as BCR, FAR, aspect ratio (Building Height/Street Width), land cover, and Green Plot Ratio (GnPR) were compared with microclimate variables using the statistical package, R. Pierson's R coefficient (for normally distributed data) was used to analyze the correlation. Each

R-value must be more than 0.25 to indicate that there is a correlation between these variables.

4. Result and Discussion

4.1. Climatic paramerters based on simulation result

Based on the simulation results show that the average air temperature in the study area has a relatively high temperature of 29.57°C. The reasonably high-temperature increase occurred at 9 am from 25.74°C to 29.32°C. The highest average temperature in the study area occurred at 3 pm at 35.26 °C, and the lowest average temperature occurred at 4 am of 22.74 °C. Based on Figure 5 shows that the highest average temperature occurs in area 4 which is 30.10°C. Meanwhile, area 5 has the lowest average air temperature of 29.23°C. Meanwhile, for 24 hours area 6 and area 5 which tend to have the lowest temperature.

The simulation result shows that relative humidity in the area has a relatively high average which is 51.22%. The highest average humidity in the study area occurred at 3 am at 79.36%, and the lowest relative humidity average occurred at 3 pm 36.17%. The average relative humidity in each area has a value that is not much different and tends to be quite high, ie the range of 59,45% to 63,08% (see Figure 5). The highest RH value of 63.08% located in area 5 and the lowest RH value of 59.45% are in area 4. Relative humidity values also tend to have the same average value for 24 hours in each area. Based on the map (see Table 3) the relative humidity tends to be higher on the north side of the area that is in area 1, area 2 and area 3. However, the humidity in the whole area tends not much different and still within normal limits that is 44,00% -50,00%.

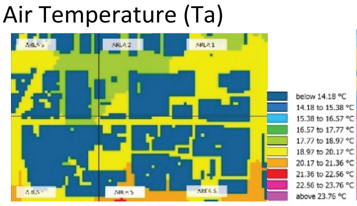
The average wind speed in the area based on simulation results tends to be the same for 24 hours. In the study area, the lowest wind speed is in area 5 which is 0.38 m / s, and the highest wind speed is in the area of 1 that is 0.74 m / s. Based on the simulation results (see Table 3), the wind speed is relatively high on a road oriented in the direction of wind movement, ie South-North with a range of 0.65 m / s-1 m / s. Besides, wind speed also tends to be high in adjacent areas with water bodies ranging from 1-1.3 m / s. As for the open space adjacent to the building, the wind speed tends to be normal and is in the thermal comfort standard range of 0.20 m / s - 0.50 m / s.

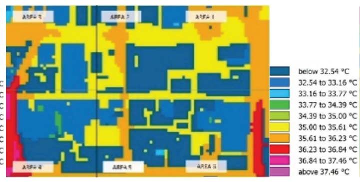
Based on the simulation results show that the value of Tmrt in the morning tends to be low at 2 am-6am and increase quite drastically from 7 am until 4 pm. The highest value of Tmrt is in area 1 which is 38,28°C (see **Figure 5**). Meanwhile, the value of Tmrt in other areas is relatively the same ie 36,00°C to 37,00°C. Based on the simulation results (see **Table 4**) shows that the mean radiant temperature tends to be high on the main road with a 10-15 meter road dimension. While the area around the road with a dimension of 5 meters mean radiant temperature tends to be lower, especially around 12 am

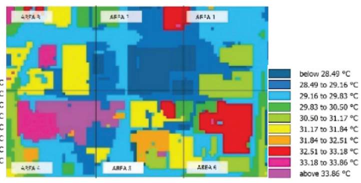
Table 3: Simulation Result.

AREA 1	AREA 2	AREA 3	AREA 4	AREA 5	AREA 6
BCR : 28,44%;	BCR : 55,44%	BCR : 53,11%	BCR : 61,44%	BCR : 58,22%	BCR : 52,78%
FAR : 0,56	FAR : 0,51	FAR : 0,77	FAR : 1,07	FAR : 1,11	FAR : 1,02
(H/W) : 0,5	(H/W) : 0,8	(H/W) : 0,2	(H/W) : 0,5	(H/W) : 1,1	(H/W) : 1
GnPR : 0,21	GnPR : 0,15	GnPR : 0,11	GnPR : 0,2	GnPR : 0,12	GnPR : 0,15
Landcover : 59%	Land Cover : 44%	Land Cover : 41%	Land Cover : 33%	Land Cover : 39%	Land Cover : 39%
Waterbody : 7,3%	Waterbody : 0%	Waterbody : 0%	Waterbody : 0%	Waterbody : 0%	Waterbody : 4,33%

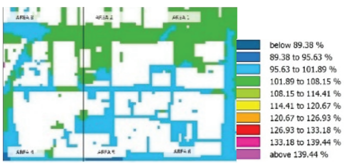
Air Temperature (Ta)

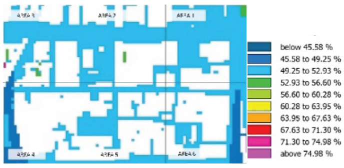

08.00

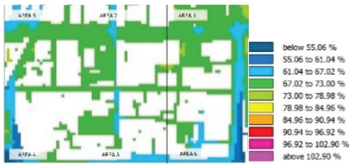

12.00


16.00

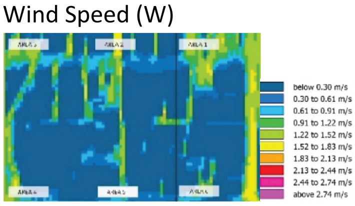
Relative Humidity (RH)

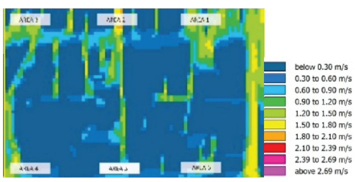

08.00

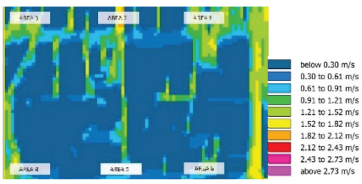

12.00


16.00

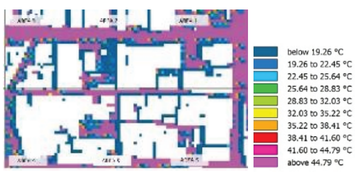
Wind Speed (W)

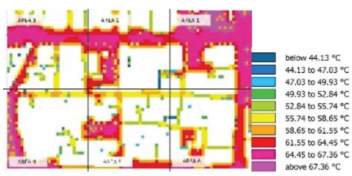

08.00

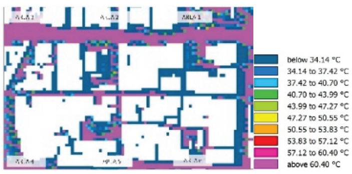

12.00


16.00

Mean Radiant Temperature (Tmrt)


08.00


12.00


16.00

4.2. Correlation urban structure parameters and climatic variables

The correlation between urban structural parameters and microclimate use regression analysis (statistical package R). Each R-value must be more than 0.66 to indicate that

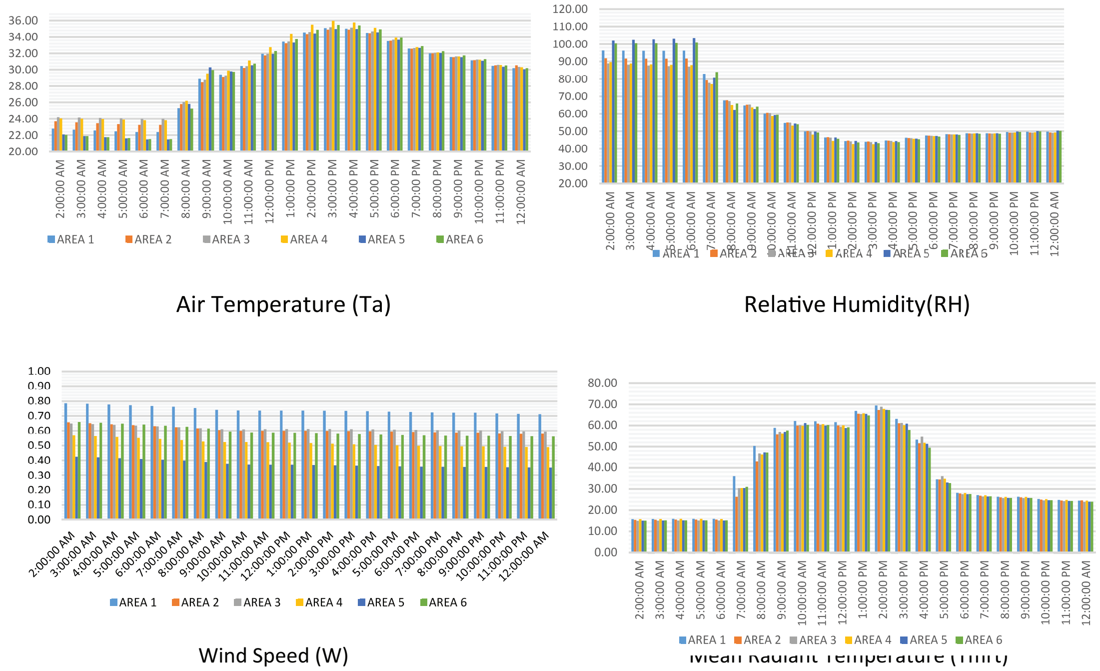


Figure 5: Graphic of Climatic Condition on March Based on Simulation Result.

there is a significant correlation between these variables. They will have a moderate correlation if they have an R-value more than 0.33. The urban structures parameters will be correlated to the microclimate conditions of the study area consist of Building Coverage Ratio (BCR), Floor Area Ratio (FAR), Volumetric Compactness (S / V), aspect ratio (H / W), Green Plot Ratio (GPR) land cover pavement and water bodies (waterbody). All parameters will be seen how much correlation to the microclimate conditions of the study area, which will later be used as the basis for the formulation of the concept of designing the area.

Table 4: Urban Structure Characterictic of Point measurements in Rajawali and average Ta, Rh, v, and Tmrt on March.

	Urban Structure Parameter						Climatic Parameter			
	BCR (%)	FAR	V/C	Land Cover (Paved Area)	GnPR	Aspect Ratio (H/W)	TA	RH	WIND	Tmrt
AREA 1	28,44%	0,56	57%	59,67%	0,21	0,5	29,36	62,13	0,74	38,28
AREA 2	55,44%	0,51	65%	44,22%	0,15	0,8	29,55	60,99	0,61	36,73
AREA 3	53,11%	0,77	32%	41,67%	0,11	0,2	29,83	59,96	0,61	37,14
AREA 4	61,44%	1,07	33%	33,22%	0,20	0,5	30,10	59,45	0,52	37,20
AREA 5	58,22%	1,11	39%	39,56%	0,12	1,1	29,23	63,08	0,38	36,83
AREA 6	52,78%	1,02	40%	39,44%	0,15	1	29,37	62,71	0,60	36,64

In order to check how far the correlation urban structure such as aspect ratio, Green Plot Ratio, and paved area are compared with each variables of climatic using the statistical package, R. For correlation analysis the Pierson's r coefficient (for normally distributed data) is used. The correlation can be seen as follows, Table 5.

Table 5: Correlation of Urban Structure Parameters and Climatic Variables on March.

	BCR	FAR	Aspect Ratio (H/W)	GnPR	Land Cover	Waterbody
Ta	0.166	0.0088	0.4733	0.0300	0.2370	0.2202
RH	0.095	0.0201	0.6041	0.0167	0.1105	0.2255
Wind Speed	0.598	0.5924	0.2924	0.2462	0.5230	0.4648
Tmrt	0.711	0.1918	0.2866	0.6818	0.5900	0.4265

A significant correlation value should be more than 0.33 to get a parameter having a moderate correlation, and if the R-value is higher than 0.67, so the parameter has a significant correlation [11]. The Building Coverage Ratio (BCR) has a significant correlation with Tmrt because it has R-value, ie 0.598. However, BCR does not have a strong correlation to air temperature and RH because of their R-value bellow 0.33, ie 0.166 and 0.095. Based on the graph (see in Figure 7) shows that wind speed will decrease if the BCR value is more significant. The less open space will affect the wind movement in the study area because the building will block the movement of the wind. Besides, BCR and Tmrt have an inversely proportional correlation where the higher the BCR value then Tmrt in the study area will decrease.

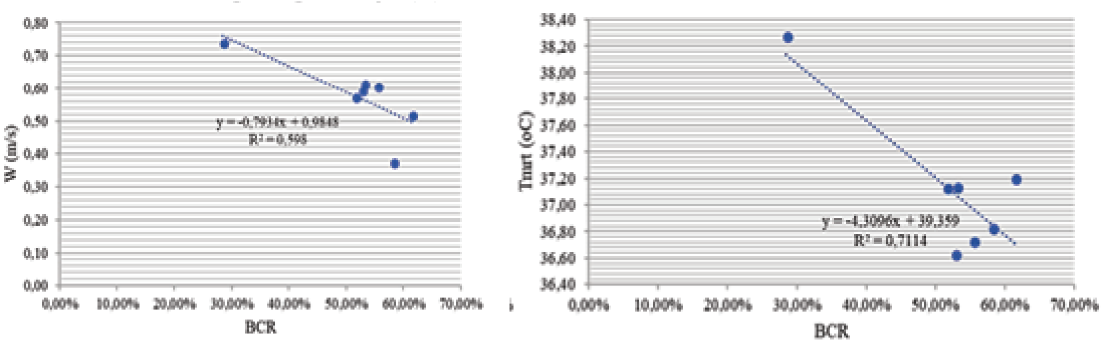


Figure 6: Scatter plot of BCR to Windspeed value and BCR to Tmrt value in March.

FAR has a moderate correlation with wind speed with R 0,5924. However, FAR does not have a strong correlation to Tmrt and there tends to be no correlation between Ta and RH because of very small R-values, ie 0.0088, 0.0201 and 0.0077. Based on the graph in Figure 8 shows that the correlation between FAR and wind speed is inversely proportional. FAR is a comparison between the floor area of the building and the land area. Then the building area, the height of the building and the amount of open space will affect the value of FAR. Thus, the wind speed can be increased by increasing the amount of open space or limiting the height of the building so as not to block the movement of the wind in the area.

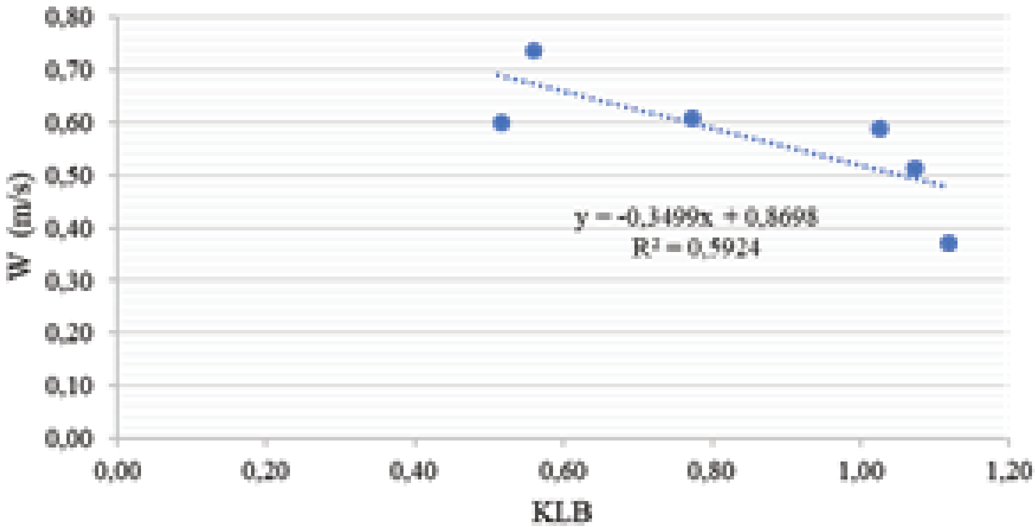


Figure 7: Scatter plot of FAR to Windspeed value in March.

Generally, Volumetric compactness (S / V) does not have a significant correlation to the micro-climatic conditions in the area due to the R-value relative small. However, volumetric compactness parameters still tend to correlate with wind speed but not strong enough because the value of R is only 0.2204.

The aspect ratio (H / W) has a moderate correlation with Ta and RH. Based on simulation's result, it shows that Ta has a stronger correlation with RH (R-value of Ta, i.e. 0,6041 and RH, i.e. 0.4733). Aspect ratio is the ratio between the height of the building and the width of the road. So the aspect ratio will be closely related to the open spaces on the site. Based on the graph in Figure 8, the aspect ratio has a correlation that is directly proportional to the RH condition in the study area, where the higher the aspect ratio (H / W), the RH in the region will increase. Meanwhile, the aspect ratio has a correlation that is inversely proportional to the condition of Ta. The higher the aspect ratio value then Ta in the region will decrease further.

The Green Aspect Ratio (GnPR) has a significant correlation to Tmrt with R-value of 0.6818. But, the GnPR parameter has no significant correlation to wind speed, Ta and RH. The condition is caused by many land cover in the form of grass and on the other hand in Rajawali dominated by trees with a shade that is not too big. Thus, GnPR in Rajawali does not have a significant effect on the air temperature in there.

The paved area has a moderate correlation to Tmrt and wind speeds of 0.5900 and 0.5230. The paved area has a directly proportional relationship with Tmrt and wind

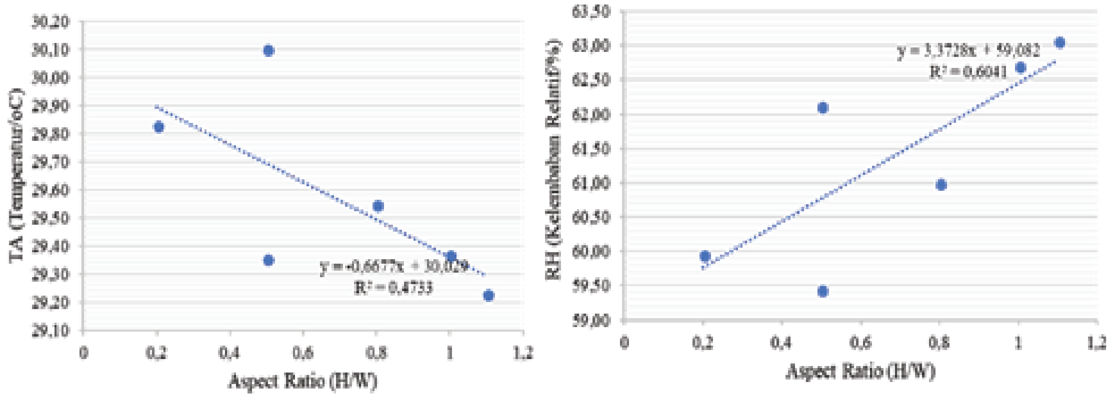


Figure 8: Scatter plot of FAR to Ta, RH, Tmrt and W value in March.

speed. The condition is influenced due to the increase in the amount of open space in the area so that the movement of the wind in the area is not blocked. Besides, the increase in the paved area in the study area also affects the increasing number of Tmrt. The condition is caused by reflected radiation. The influence of pavement to temperature is not too significant that is 0.2370.

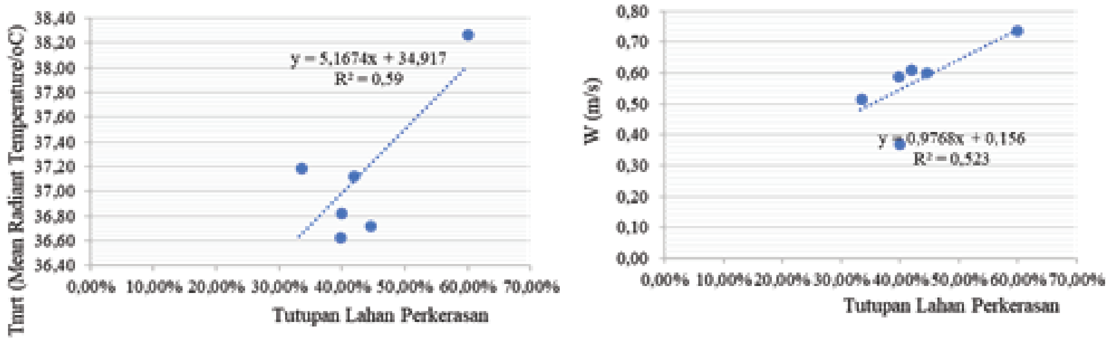


Figure 9: Scatter plot of Paved Area to Tmrt and W value in March.

Waterbody parameters as a whole do not have an enormous influence on local microclimate conditions. Water bodies have moderate correlations to wind and Tmrt of 0.4648 and 0.4265. The relationship between water bodies to wind and Tmrt is directly proportional, the higher the percentage of water bodies in the site, the wind speed, and Tmrt will increase. In principle, water bodies, especially rivers in a city is a form of ventilation or wind room. Theoretically, water can reduce the air temperature in an area but not significantly where the maximum distance that can be affected is 10 meters

5. Conclusion

BCR is the parameters of urban structure which has strong correlation to climatic parameter in Rajawali. BCR has a strong correlation to the increasing and decreasing mean radiant temperature (Tmrt). The condition is due to BCR related to the percentage of open space in the study area. While the urban structures have a moderate correlation with climatic parameters that are Green Plot Ratio (GnPR), land cover, waterbody. The GnPR has moderate correlation with Ta and RH. The aspect ratio is also associated with the creation of open space and shadowing in the study area, so that the aspect ratio will affect the microclimate conditions. The increasing aspect ratio should consider the location of the historic building because it is related to building height which usually controlled by policy. Meanwhile, the urban structure parameters have also a moderate correlation i.e. land cover and waterbody Tmrt and wind speed. Overall, these conditions will support the activity and sustainability of the study area.

References

[1] Fatimah, R.N. (2012). *Pola Spasial Suhu Permukaan Daratan Kota Surabay Tahun 1994, 2000 dan 2011* University of Indonesia.

[2] Landsberg, G.H. (1981). *The Urban Climate*. (New York: Academic Press)

[3] Lippsmeier, George, (1997), Bangunan Tropis, Erlangga, Jakarta.

[4] Mengi, O. (2009). Analysis of Climate Sensitive in Outdoor Space: Evaluating Urban Patterns in Different Climates. Master's thesis, Izmir Institute of Technology Turkey.

[5] Algeciras, J., Matzarakis, A. (2016). Spatial-temporal Study on The Effect of Urban Street Configurations on Human Thermal Comfort in The World Heritage City of Camaguey-Cuba *Journal Building and Enviroment Elsevier* pp 85-101

[6] Akbari, H., Pomerantz, M., Taha, H., (2001). Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. Solar Energy 70: 295–310.

[7] Emmanuel, Rohinton. (2005). An Urban Approach to Climate-Sensitive Design in The Tropics. New York: Spon Press

[8] Koerniawan, M. D. (2016). *Effect of Urban Structure on Thermal Comfort and Walking Comfort in Jakarta* (The University of Kitakyushu, Faculty of Enviromental Engineering)

[9] Eliasson, I. (2000). The use of climate knowledge in urban. Journal Landscape and urban Planning 48 pp 31-44

[10] Ong, B. L. (2002), Green plot ratio: an ecological measure for architecture and urban planning. Landscape and Urban Planning, 965 (2002), pp. 1-15

[11] Chin, W. W. (1998). The partial least squares approach to structural equation modeling. In: G. A. Marcoulides (Ed.), Modern Methods for Business Research (pp. 295–358). Mahwah, NJ: Lawrence Erlbaum Associates.