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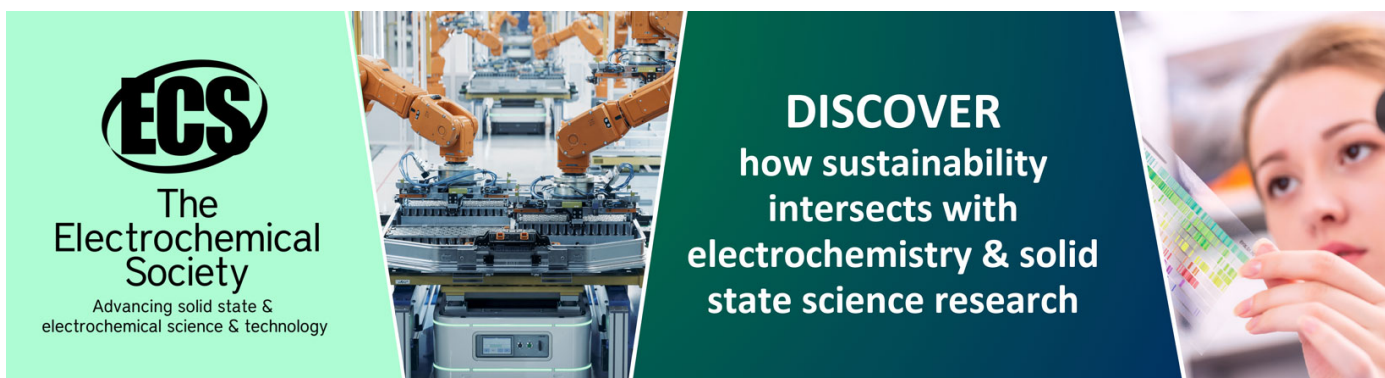
## Analysis of Green Space Characteristic Effect to the Comfort Microclimate in the Simple Flats in Jakarta

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# Analysis of Green Space Characteristic Effect to the Comfort Microclimate in the Simple Flats in Jakarta

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**Abstract.** Existence of green spaces on simple flats (Rusunawa), especially trees, greatly affect the ambient temperature outside and inside the building. Density of tree canopy can modify air temperature under trees or buildings by reducing solar radiation on building facade. The aims of this study is to analyze the characteristics of green space in Rusunawa and its influence on the microclimate. The experiment was conducted at four Rusunawa building located in Jakarta, i.e. Rusunawa Jatirawasari, Tambora, Pulogebang, and Marunda Cluster A. Species and number of trees were identified, while the ground cover was identified by its species and coverage. Physical characteristics of trees were measured by tree trunk, tree height, and width crown. Measurement of temperature, relative humidity (RH), and wind velocity was conducted at seven points in each Rusunawa to determine their effects. The results showed the presence of trees can modify the temperature of building outside similar with in the building. The decrease of temperature was influenced by green coverage area, green coverage index, and environmental condition around Simple flats. In this study, the best microclimate was modification by the ability to reduce largest temperature differences. Further more, green space in Rusunawa Marunda Cluster A was considered as the most effective one in reducing temperature.

Keywords: *simple flats, green space, temperature, tree*

## 1. Introduction

Jakarta as the capital city was very dynamic, infrastructure development continue to be in line with population growth. Due to limited land, development tends to be done by utilizing natural lands with ecological functions. The tendency for change the natural land as a potential green space in the city into smaller plots will continue if not controlled properly and will have an impact on the balance ecosystem of the city, and consequently the quality of the urban environment will decrease (flooding during the rainy season, UHI in the dry season, lack availability of clean water and quality of urban air) [1]. The development of Simple flats (Rusunawa) is one of Jakarta municipality's program in overcoming both high level of urbanization and land limitation issues. Simple flats that dominated by massive multi-storey buildings and pavement areas needs to be balanced by the development of green spaces.

Green space is one of the important indicators regarding quality of life to establish a sustainable landscape development in urban areas. Construction of the green space facility has begun now to meet the psychological needs and comfort for the residents. The presence of green spaces as part of the environment, not only contribute positively to the environment and aesthetic quality, but also a gathering place for residents to socialize and recreation. Green space in the outdoor is able to control and improve thermal comfort and air temperatures. For areas in the room, shade trees can reduce the radiation from the sun on the facade of the building, improve thermal comfort and



saves energy spent to maintain a healthy environment [2]. Based on the above, it is necessary to analyze the influence of the temperature characteristics of green spaces in simple flats.

The objective of this study is:

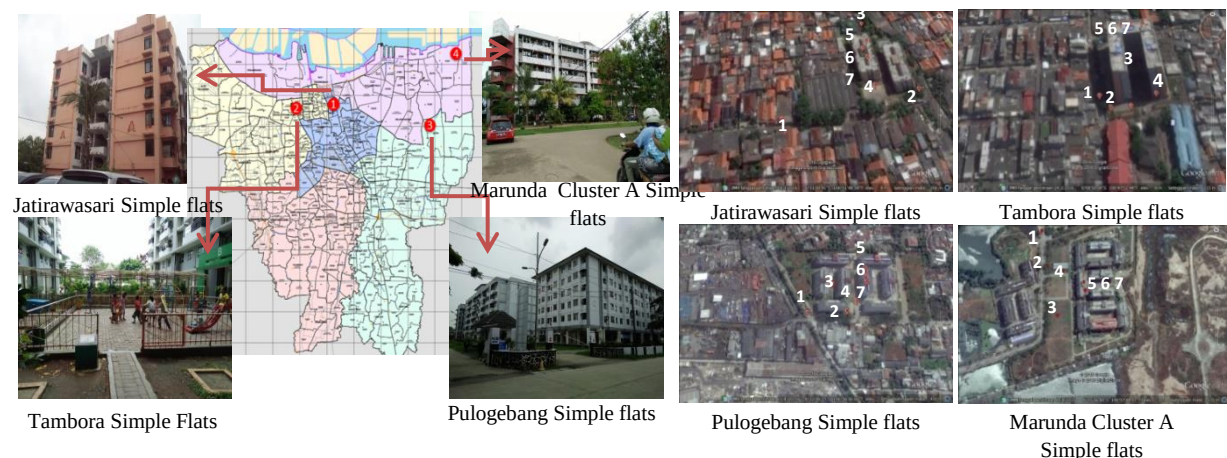
1. analyze the characteristics of green space in Jakarta's Simple flats;
2. analyze the effect of green space on the comfort climate.

## 2. Methods

Observations in this study made in four simple flats (Rusunawa) in Jakarta. The fourth simple flats are Jatirawasari in Central Jakarta, Tambora in West Jakarta, Pulogebang in East Jakarta, and Marunda Cluster A in North Jakarta (Figure 1 (a)).

### 2.1 Characteristics of the green space

Green space characteristics obtained the large area of Simple flats, Basic Building Coefficient, and the physical characteristics of plants. Physical characteristics of trees were measured by tree trunk, tree height, and width crown. Green coverage area obtained by multiplying the number of trees with an average surface area of tree canopy. Green coverage index calculated by divided green coverage area by its large area. The data obtained from each Simple flats were analyzed and presented in table.



**Figure 1. Site plan of experiment (a); seven observation points of site measurements of temperature, RH, and wind velocity in fourth Simple flats (1. control/outdoor; 2. below tree; 3. ground cover; 4. pavement; 5. 1<sup>st</sup> floor building; 6. 3<sup>rd</sup> floor building; 7. 5<sup>th</sup> floor building)**

### 2.2 Influence of the green space characteristic to the microclimate

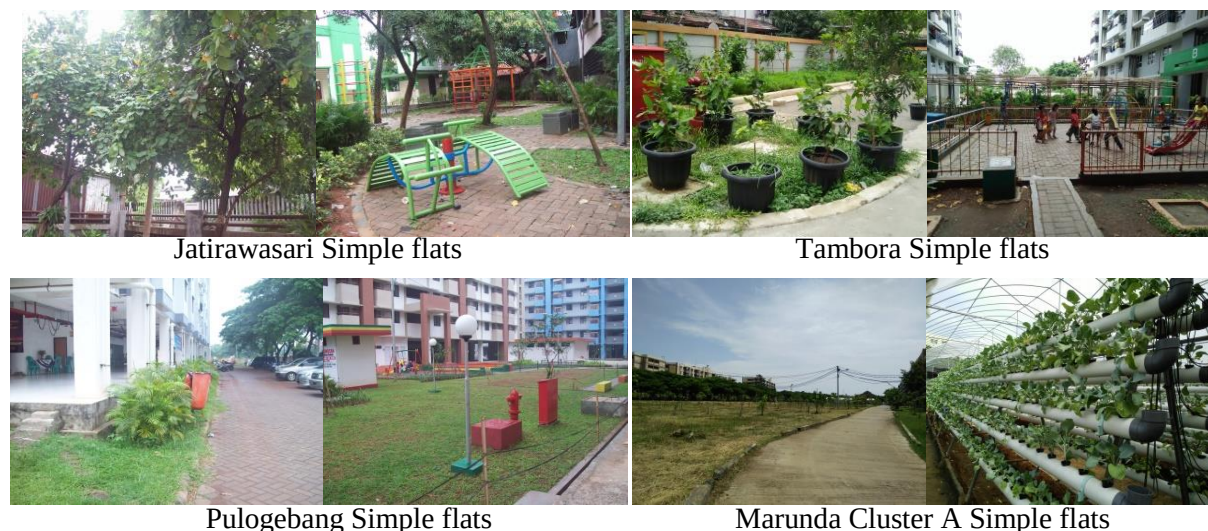
Green space elements microclimate done by measuring temperature, relative humidity (RH) and wind speed three times in the morning, afternoon and evening at seven observation points: 1. outside area of Simple flats as a control; 2. under tree; 3. ground cover; 4. Pavement; 5. 1<sup>st</sup> floor of the building; 6. 3<sup>rd</sup> floor of the building; 7. 5<sup>th</sup> floor of the building. The temperature on the outside area of Simple flats served as the control measurement to obtain relative temperature, i.e. the difference temperature between the control and six other observation points. Data measurement of temperature, RH and wind speed is done twice, in March and April 2016. Seven observation points of the data measurements can be seen in Figure 1 (b).

Anova and Duncan's Multiple Range Test (DMRT) did to see the difference between observation location variance. DMRT conducted to determine the best type based on its rank, the test is also used to see their influence among the treatments tested. Equipment used in the measurement of physical characteristics is gauge or meter roll to measure tree trunk diametry and width crown, Abney level to measure the height of the plant. Measurement of climatological data is

done by termohygrodigital to record the temperature and RH automatically. Anemometer used to measure wind speed. Climatological data measurement is done by placing the equipment at breast height,  $\pm 1.1$  m.

### 3. Results and Discussion

Simple flats in Jakarta generally already has a green space for playground, socialization, and climate amelioration. Types of trees present at front area around the fence on Tambora, Pulogebang and Marunda Cluster A Simple flats dominated by Sengon (*Albizia chinensis* (Osbeck) Merr.), whereas in Rusunawa Jatirawasari types of trees planted in the area of the fence varies from Angsana (*Pterocarpus indicus* Willd), starfruit (*Averrhoa carambola* L.), Dutch teak tree (*Guazuma ulmifolia* Lamk.), jambu air (*Syzygium aqueum* (Burm.f.) Alston), mango (*Mangifera indica* L.) and cherries (*Muntingia calabura* L.). Front area of Marunda Cluster A is also used by Farmers Group as agricultural land, planted with mango trees, eggplant and peppers, as well as the Guest House for hydroponic. Playing area and socializing in the fourth Simple flats generally located in the area between the blocks. In Pulogebang, they had Integrated Child Friendly Public located in the middle area of Simple flats. Children's playground in Jatirawasari located in the rear area of Simple flats, they also had socializing area at inter block building. Areas between blocks on Marunda Cluster A generally in the form field used for sports, playing areas/socialization. Marunda Cluster A Simple flats do not having playing ground area specifically for children. Playing Activity or socializing in Tambora is generally done in the field as well as a park area in the middle of the tower. The green space on the fourth Simple flats can be seen in Figure 2. Green space characteristics in four Rusunawa can be seen in Tabel 1.



**Figure 2. Green space available in Simple flats**

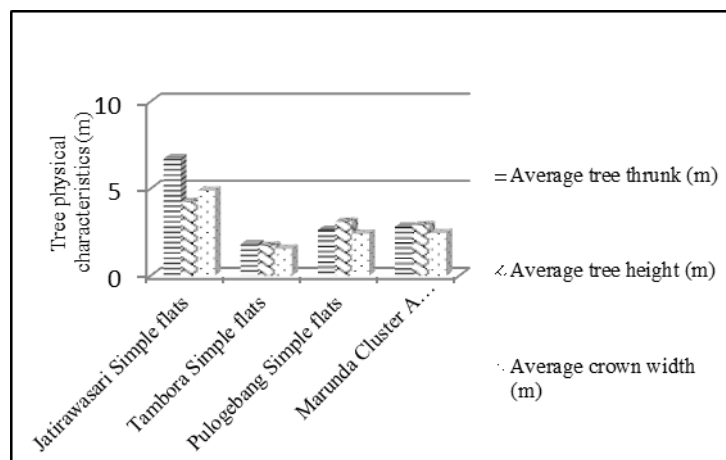
Comparison of the average tree thrunk, tree height and width crown or tree canopy of the four Rusunawa showed in Figure 3. Marunda Cluster A Simple flats still have many space to be planted in with trees that can be utilized to maintain the balanced ecosystem as a result of the construction of the buildings and other massive pavements such as roads and parking lots. Those flats has large area and small KDB value. Tambora has more number of trees than Pulogebang despite having a smaller area, it is because the trees in Tambora Simple flats especially the tower flats majority measured as small trees. The placement of the trees has not considered and less attention to it developments that will occur in a few years later. Although it has less number of trees than Tambora Simple flats, Pulogebang has a bigger an average tree thrunk, tree height and width crown than Rusunawa Tambora. Rusunawa Jatirawasari has the smallest number of trees because it does have the smallest area and is located in



the middle of densely settlement, eventhough have trees in mature enough to have an average size of tree thrunk, tree height and width crown or tree canopies.

**Table 1. Green space characteristics in fourth Simple flats**

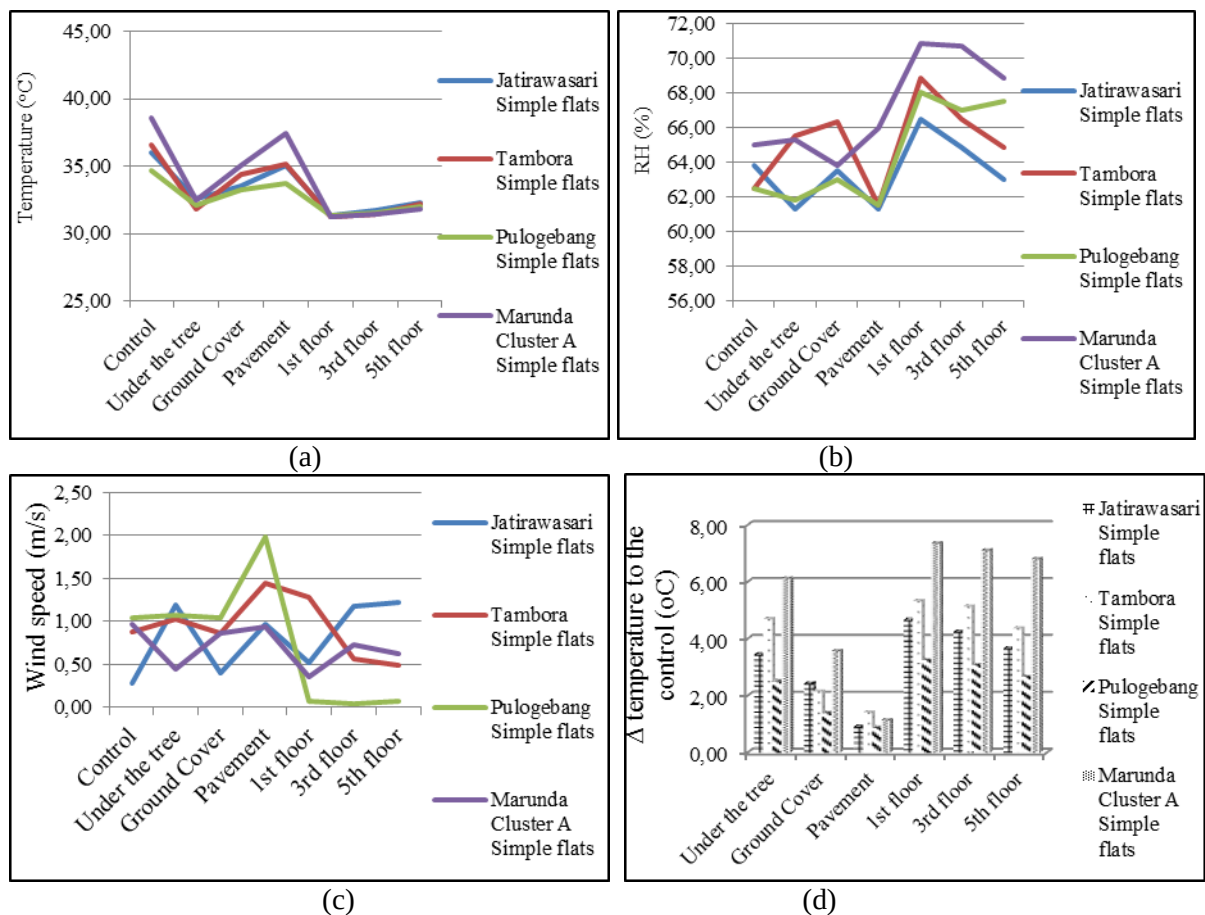
| Characteristic             | Jatirawasari                                      | Tambora                           | Pulogebug                               | Marunda Cluster A                       |
|----------------------------|---------------------------------------------------|-----------------------------------|-----------------------------------------|-----------------------------------------|
| Large area                 | 5.875 m <sup>2</sup>                              | 19.917 m <sup>2</sup>             | 43.395 m <sup>2</sup>                   | 69.815 m <sup>2</sup>                   |
| Basic Building Coefficient | 50 %                                              | 31,49 %                           | 20,94 %                                 | 20,9 %                                  |
| Total number of tree       | 59                                                | 422                               | 337                                     | 1156                                    |
| Green coverage area        | 1102,96 m <sup>2</sup>                            | 785,64 m <sup>2</sup>             | 1536,50 m <sup>2</sup>                  | 5402,65 m <sup>2</sup>                  |
| Green coverage index       | 0,19                                              | 0,04                              | 0,04                                    | 0,08                                    |
| Dominant tree species      | dutch teak tree ( <i>Guazuma ulmifolia</i> Lamk.) | Orange trees ( <i>Citrus</i> sp.) | Mango ( <i>Mangifera indica</i> L.)     | Mango ( <i>Mangifera indica</i> L.)     |
| Total area of ground cover | 82,88 m <sup>2</sup>                              | 65,25 m <sup>2</sup>              | 246,03 m <sup>2</sup>                   | 20 m <sup>2</sup>                       |
| Total area of other plant  | 18 m <sup>2</sup> (productive plant)              | 32,85 m <sup>2</sup> (TOGA plant) | 341,6 m <sup>2</sup> (productive plant) | 1.440 m <sup>2</sup> (productive plant) |



**Figure 3. Comparison of average tree trunk, tree height and width crown in four locations of Simple flats**

Observations of temperature, RH and wind speed on the field in twice (on March and April 2016 for each Rusunawa) shows the average temperature in Jatirawasari Simple flats 33,21°C, RH 63.48 %, and wind speed of 0.82 m/s. The average temperature in Tambora Simple flats 33,25°C, 65.14% RH, and wind speed of 0.94 m/s. Pulogebug Simple flats has an average temperature 32,66°C, 64.48% RH, and wind speed of 0.76 m/s. The average temperature in Marunda Cluster A Simple flats 34°C, RH 67.21%, and wind speed of 0.7 m/s. Figure 4 (a), (b), and (c) shows the results of measurements of temperature, RH, and the wind speed at each measurement point in four Simple flats. Comparison of the differences temperature at four Simple flats in six measurement locations to control shown in Figure 4(d). Measurement of the temperature in the outdoor space of Simple flats, trees provide the greatest temperature reduction effect to the control, with an average reducing temperature is 4.2°C. Measurement of the temperature in ground cover area provide an average reducing temperature of

2.39°C, while measurements on the pavement gives the average reducing temperature of 1.09°C. Measurement of the temperature in the area of the building gives the average reducing temperature by 4-5°C. Trees shades can improve the energy balance of human heat when doing outdoor activities, as well as improve the conditions of space in the building with reduce solar radiation on the facade of the building [3]. Shading by trees – provided by single trees, clusters of trees or urban forests – may decrease air temperature and reduce considerably the solar radiation income of the ground and other surfaces in the shade [2,4]. Shading interventions greatly reduce vulnerability to heat stree, and changed thermal sensation ratings from danger to vulnerable [5]. Apartment in massive building below tree canopy correctly manages the building's envelope, it makes indoor temperatures become cooler [6]. Trees contribute to their environment by supplying the needed oxygen, absorbing CO<sub>2</sub>, improving air quality, enhancing the microclimate, conserving water, preserving soil and filtering air pollution as well as increasing the quality of life by hosting natural elements and wildlife habitats into urban settings [3]. Urban morphology, materials, urban forests and the local microclimate must be in balance with the built environment, which promotes sustainability of the city [10].



**Figure 4. The average temperature (a), RH (b), and wind speed (c) at seven observation points in four locations of Simple flats; and the difference temperature in the six-point observations againts control at four locations of Simple flats (d)**

In tropical climates, vegetation has significant effects to influence the microclimate. Vegetation cover can influence urban microclimates directly by shading surfaces and channeling wind, and indirectly by evapotranspiration of water [7]. Vegetation in built-up area especially in urban centres has positif impact and significantly important to help mitigate the phenomena of UHI [8]. Trees, grass and shrubs will reduce air temperatures near the house and provide evaporative cooling. The type and

species of trees used is very important. They should be selected according to the amount of shade they provide as well as their aesthetic appearance. Shrubs and other low growing foliage provide shading during the morning and late afternoon when the sun is low in the sky. The evapotranspiration process can reduce surrounding air temperature [7]. In hot and humid climates, high-branching and wide canopy trees and low ground covers should be used to promote shade and encourage wind [9].

Results of statistical analysis showed that the point of observation location and group of Simple flats significantly affect the difference in temperature. Based on DMRT test of influence point of observation location to the temperature differences (Table 2), the location within the building, e.g 1<sup>st</sup> floor, 3<sup>rd</sup> floor, and 5<sup>th</sup> floor of the building, and location under the trees has the greatest influence on the temperature differences, the four locations are located within the same subset, meaning that the temperature under the tree is not significantly different from the temperature inside the building. Ground cover have a considerable influence on the temperature difference, followed by pavement. Duncan test of Simple flats group's influence to temperature difference (Table 3) shows Marunda Cluster A Simple flats provide the greatest temperature difference, followed by Tambora and Jatirawasari in the same subset, and the smallest one was Pulogebang. Based on Table 1, Marunda Cluster A has the highest number of trees, broadest green coverage, and 2<sup>nd</sup> rank green coverage index. The environment around Marunda Cluster A still has enough green space and big trees on the green street. Others environmental Simple flats dominated by dense settlements, the surrounding area is dominated by buildings and pavement. Other environmental factors that can affect the results of this research are wind direction and the direction of the measurement position, unfortunately these two things did not measure in this research. Direction and wind speed affect the range effect of vegetation on air cooling. Wind direction and its speed are very important to be considered in the placement of a tree or forest vegetation in the city. It is also determined the effectiveness of vegetation in controlling the temperature [10].

**Table 2. Influence of treatment observation location to the differences temperature by DMRT test**

| Observation location                  | Subset |        |        |
|---------------------------------------|--------|--------|--------|
|                                       | 1      | 2      | 3      |
| Pavement                              | 1,0875 |        |        |
| Ground cover                          |        | 2,3875 |        |
| Under tree                            |        |        | 4,1975 |
| 5 <sup>th</sup> floor of the building |        |        | 4,3775 |
| 3 <sup>rd</sup> floor of the building |        |        | 4,8900 |
| 1 <sup>st</sup> floor of the building |        |        | 5,1500 |

**Table 3. Influence of Simple flats to the differences temperature by DMRT test**

| Simple Flats | Subset |        |        |
|--------------|--------|--------|--------|
|              | 1      | 2      | 3      |
| Pulogebang   | 2,3000 |        |        |
| Jatirawasari |        | 3,2317 |        |
| Tambora      |        | 3,8500 |        |
| Marunda      |        |        | 5,3450 |

Green coverage area, green coverage index, and environmental conditions around Simple flats affects the average temperature difference in Simple flats. When the condition of the green space tightly, it can reducing the air temperature highly. The condition described by the density of vegetation and green coverage by tree canopy. Dense vegetation and its wider canopy cover, can reduce air temperature [11]. Selection of the tree species in the green space should also be considered in order to maximize its influence in reducing the temperature. Plants with dense canopy is more effective in reducing urban air temperatures. The size and shape of the tree crown can improve thermal comfort in

a microclimate, as well as the size and shape of the leaves, tree trunk, and the permeability of the crown [2].

#### 4. Conclusions

Marunda Cluster A Simple flats has the largest number of trees, followed by Tambora, Pulogembang, and Jatirawasari. Marunda Cluster A Simple flats has the largest green coverage area, followed by Jatirawasari, Pulogembang, and Tambora. Pulogembang and Tambora Simple flats has the lowest green coverage index, followed by Marunda Cluster A, and Jatirawasari as the highest one.

Trees provide the greatest temperature reduction effect to the control, with an average reducing temperature is 4.2°C. Green space in Marunda Cluster A Simple flats is considered the most effective one in decreasing air temperature because it has the best green coverage area, 2<sup>nd</sup> green coverage index, and has better environmental condition than other Simple flats.

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