

# Evaluation of Aesthetic Function and Thermal Modification of Vertical Greenery at Bogor City, Indonesia

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**Abstract.** Bogor city currently develops vertical greenery due to counter the decreasing of green space quantity. Vertical greenery is a planting method using vertical structure similar to retaining walls. There are some benefits of vertical greenery, such as providing aesthetics value of the landscape, to protect from the heat, to reduce noise, and to reduce pollution. The purpose of this study were to identify thermal modification by vertical greenery in Bogor city, to assess the aesthetics value from vertical greenery, and to provide a recommendation in attempt to manage and improve the quality of vertical greenery in Bogor city. The study was conducted using Scenic Beauty Estimation method, and was done by providing questionnaires to the respondents in order to assess the aesthetics value of vertical greenery. Infrared thermometer was also used to measure the surface's temperature to evaluate thermal modification function of the vertical greenery. The result of study proved that vertical greenery in the Bogor city has considerably good aesthetic. It also showed that there is a decreasing in surface temperature of the vertical greenery structure.

## 1. Introduction

Green open spaces become a most important constituent element of the city's the function of aesthetic, ecological, social, even in economic terms. Decreasing availability of green open space in urban areas lead to serious problems such as urban heat island, flooding, and so on. The decreasing availability of land for building a green open space made the community and the government chose vertical spaces as an alternative to increasing the quantity of green open space in the city. Planting is done on vertical structures such as embankments or retaining walls commonly called vertical greenery. According Blanc [4], the vertical garden concept provides benefits, among other things: add to the natural beauty of the environment, creating a beautiful garden in a limited area, hold heat from the outside, reducing noise levels, reduce air pollution, capture particles of dirt, reduce the effects of run off, and increase the supply of oxygen. Another function of planting this way is to make a wall or slope is more attractive and can create a habitat for wildlife [2].

One of the city today that is developing a vertical greenery is the Bogor city. Vertical greenery is expected to improve the visual quality of the landscape and improve comfort for its users. The function of vertical greenery can not be felt significantly. This is caused by various problems like crop conditions are relatively bad as well as the loss of some plants on vertical greenery. Evaluation of the effectiveness of vertical greenery in the city to accommodate the aesthetic function needs to be done. The assessment is conducted to determine the usability aspects of the aesthetic function, thermal modification, and assist in the preparation of recommendations to the City Government, especially at



the Dinas Kebersihan dan Pertamanan Bogor city in managing and developing vertical greenery is already existing and planned.

## 2. Methodology

### 2.1. location and time

The location of the study (Figure 1) is in the province of West Java, precisely in the city of Bogor, which is in three locations namely Stasiun Bogor, Terminal Baranangsiang, dan *Underpass*.



**Figure 1.** (a) Bogor Station (b) Terminal Baranangsiang (c) *Underpass*

The time needed to conduct this research that for two months in June and July 2016. Furthermore, the process of data analysis and writing take one month from the month of August 2016.

### 2.2. Methodology

#### 2.2.1. Preparation

The preparation phase is done with a selection site research and obtain licenses. The chosen location is Bogor Station, *Underpass*, and Terminal Lunch Baranang

#### 2.2.2. Inventaritation

This stage is to conduct the activities carried out field survey and interview related agencies regarding the type of plant, structures, planting media and so on, to capture data in the field is divided into phases and stages questionnaires surface temperature calculation.

Stage questionnaire using a questionnaire distributed to 40 students of Landscape Architecture semesters 6 and 8. With a scale of 1 (worst) to 10 (most excellent) by displaying a slide that contains 10 photos. Phase measurement of surface temperature using a infrared thermometer GM320 Thermometer Temperature Laser Gun with range  $-50 \sim 330^{\circ}\text{C}$ ,  $0.1^{\circ}\text{C}$  resolution and an accuracy of  $\pm 1.5^{\circ}\text{C}$  for  $0 \sim 330^{\circ}\text{C}$  and  $3^{\circ}\text{C}$  to  $-50 \sim 0^{\circ}\text{C}$ . Sampling will be conducted temperature for 7 days and with three repetitions on each day (morning, day, afternoon) to compare whether there is climate modification to the structure of the vertical greenery.

#### 2.2.3. Analysis

The method of analysis used by the method of SBE (Scenic Beauty Estimation) to analyze the function of aesthetics with SBE formula of formula [5].

$$SBE_x = (ZL_x - ZL_s) \times 100$$

SBE<sub>x</sub> = Value SBE simulated images to x

ZL<sub>x</sub> = The average value of the simulation to the image Z x

ZL<sub>s</sub> = average value of Z picture simulations are used as standard

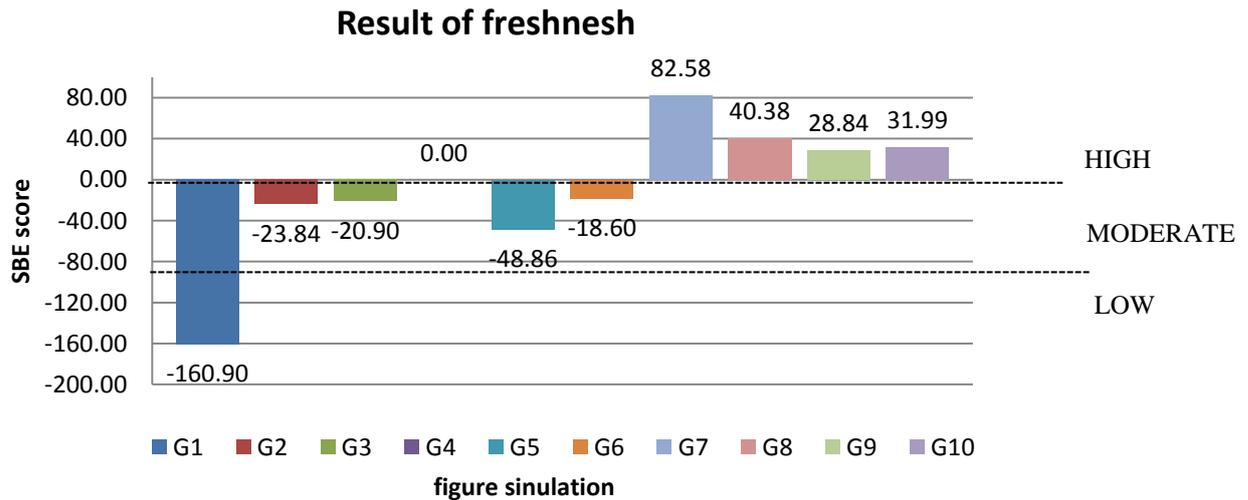
The control variable is the surface temperature does not have the plants and to the independent variables are each plant species found on the vertical greenery. Data obtained will be processed using t-test to see the effects of such vegetation, with an initial hypothesis affect plants in the modification of the surface temperature of vertical greenery.

## 3. Result and discussion

### 3.1. Analysis of Aesthetic Quality in Bogor city

#### 3.1.1. Color freshness

SBE analysis on aspects of the freshness of color produces a diverse SBE value. Results of the assessment are grouped into an low aesthetic landscape (s.d -160.90 -79.74), moderate (-79.75 s.d 1.42), and high landscape (1.43 s.d 82.59) (Figure 2). Dominated by a picture with moderate value total of five images (G2, G3, G4, G5 and G6) with G4 as standard (most close to the value 0).



**Figure 2.** SBE color freshness value charts

Accordinging Metha A, the use of color combinations can make any colors used to be preferred color of people. But the bad combination of color can cause a decline in the value of aesthetics. Based Whiting and de Jong, the principles of design consists of unity, balance, simplicity and variety, emphasis, and the sequence.

On the vertical greenery in underpass G7 got the highest score (82.58) while the lowest value is G1 (-160.90). The magnitude of the difference is caused by a number of plant species in the Vertical greenery on the image G1 seen only two types of plants with the color of the plant's air-tone dull causing the impression of freshness of color is reduced, while the image G7 There are eight species of plants with three color variations: green red, purple and yellowish green color that contrasts create vertical greenery becomes more alive.

G6 (-18.60) located in Bogor Station which is one focus of this research was included in the group of high value. Basically Vertical greenery has a contrasting color (emphasis) between green and light green color yellow, but the lack of unity in it caused too massive of its *Asplenium nidus* causes the focus divided because basically yellowish-green tint looks pale and impressed unhealthy and there are some parts of the *Asplenium nidus*, which seem less healthy. So that reduced the value of unit.

Vertical greenery on Terminal Baranangsiang G9 (28.84) included in the group of high value, This is caused by G9 has a color and plant species varied set with a pattern of organic and arranged randomly makes the only vertical greenery visible sequence (rhythm / repetition) and looks so varied because large scale creates the impression of a smooth texture and color produced is much brighter.

The reason why respondent not gave maximal value on G5 (-48.86) is because by less bright purplish red color in plants and not the creation of the design principles. G3 (20.90) which is similar to G5 (-48.86) has a greater value because respondents tend to think of a fresh green color than red owned G3 and looks neat because of the size of the plants that are not too big and smooth looks impressed balance and simplicity. Figure G2 (-23.84) despite having more types of plants to the color of dark green and yellowish. But a merger between colors less felt their unity and was not impressed balance.

Figure G4 (0.0) which is used as a standard because it has ZLx value (average value of Z) by 0.09 most nearly zero. A mix of green and red colors create a balance but simple. However, when viewed from the freshness of color, the color in the center is one of the negative values in the G4. That's why the G10 (31.99) which is similar to the G4 enter the group of high value. Because the G10 is much more unity and more focussed on the bright green color than the G4. Figure G8 (40.38) contrasts with G9. Although it has the same position both tall and large-scale G8 has only one fresh green vegetation and greatly accentuate simplicity .but can get a value far greater than the G9.

### 3.1.2. Density

Analysis SBE on aspects density diverse generating value. Results of the assessment are grouped into an low aesthetic landscape (s.d -166.13 -82.13), moderate (-82.12 s.d 1.87), and high landscape (1.88 s.d 85.51) (Figure 3). Dominated by high-value images of five images (G2, G6, G7, G8 and G9) with G10 as standard (most close to the value 0).

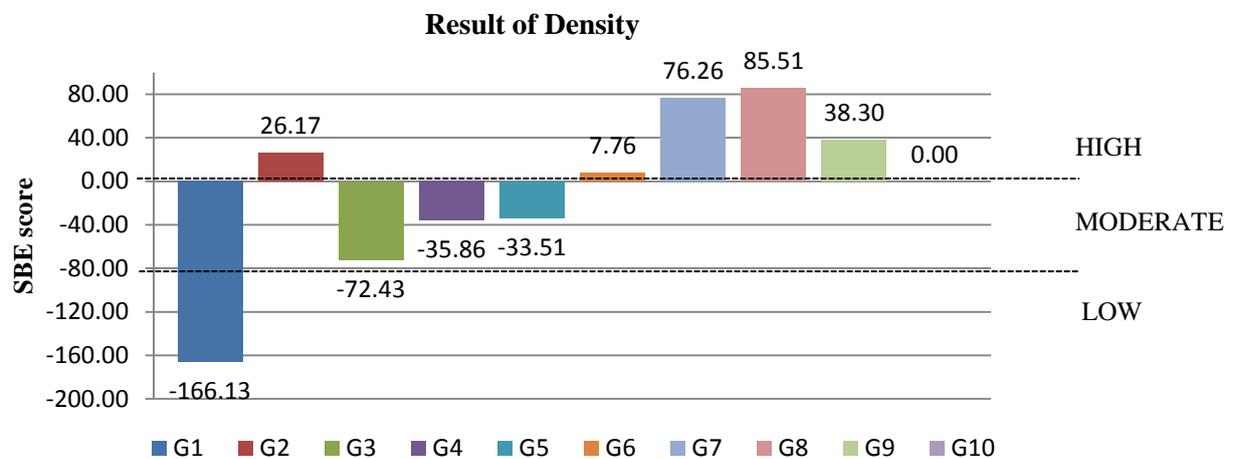


fig. simulation

Figure 3. SBE density value charts

Density is very influential on aesthetics, according to the 2011 criteria Aprilis plants as aesthetic functions in the selection of plant species that form the canopy and branching very interesting, skalatis size, there are variations in color (stems, leaves, flowers and fruit) and interesting textures. SBE value for G1 (-166.13) located on the left Underpass is the only value in the group of low value. G1 only had two types of plants, *Bromelia* sp. in the middle, and *Chlorophytum* sp. that is around. Comparison scale plants that are too small a spacing coupled with branching *Chlorophytum* sp. less makes causes a lot of holes that are created everywhere. As for the G7 (76.26) is the second highest value in the group tinngi value, this is because in addition to the diversity of plant species vertical greenery dominated by the *Philodendron scandens* plants that are vines so it looks very solid and tight.

Vertical greenery located in Bogor Station G6 (7.76) included in the group of high value because it has a plant with height canopy spread, but less precise planting layout causing poor plant growth because it was blocked from the sun and many plants that die making vertical greenery into the lack of value. G9 (38.30) located in Terminal Baranngsiang included in the group of high value because basically at a very large scale plants in it has ramifications that spread and looks very solid with a smooth texture, but the number of plants that are drought and die making it not beautiful.

As for the G4 (-35.86), G3 (-72.43) and G5 (-33.51) has a pot as cropping media. The distance created between pot is suspected to be the main cause less preferred G4, G3, and G5. G10 (0.00), which became the standard is basically similar to G4 for using the same pot and plant species are the same except for the G10 circular shape as basically causes no side formation and thus become more tightly and neatly.

G2 (26.17) included in the group of high value because the density of plant species plus branching plants that spread making it look very tightly, but because of too much difference size making it uneven because there are plants who blocked the smaller size plant and cause visible like a hole, G8 (85.51) is the highest value of SBE, despite only having one type of plant, but the plant is very solid for almost the entire surface is covered. Three research sites in the aspect of color only vertical greenery Bogor station is not included in the group of high value but the group is, while the density of the aspects of the entire vertical greenery in the group of high. This proves that the aesthetic value of the three vertical greenery is already very good.

### 3.2. Surface temperature

#### 3.2.1. Bogor Station

The t-test results for the surface temperature on the vertical greenery on Bogor station which has seven types of plants. Data were divided into three groups: the data in the morning, day, and afternoon and see whether the effect is real or not as in table 1.

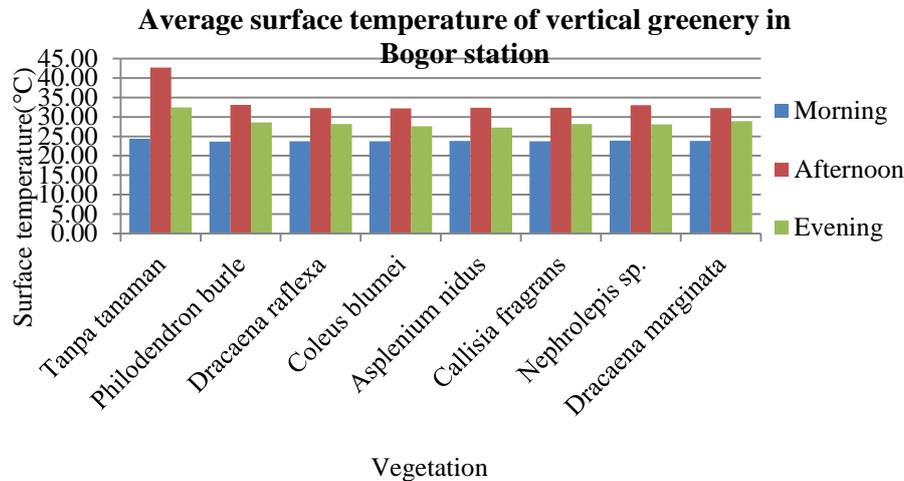
**Table 1.** the average value of the surface temperature in the morning, day, afternoon, and the t-test results on the vertical greenery Bogor City Station

Plant name	morning		result	day		result	afternoon		result
	$\bar{t}$	$\bar{t}_0$		$\bar{t}$	$\bar{t}_0$		$\bar{t}$	$\bar{t}_0$	
<i>Philodendron burle</i>	23.64	25.29	*	33.10	42.70	*	28.60	32.44	*
<i>Dracaena reflexa</i>	23.76	25.29	*	32.27	42.70	*	28.19	32.44	*
<i>Coleus blumei</i>	23.77	25.29	*	32.20	42.70	*	27.63	32.44	*
<i>Asplenium nidus</i>	23.79	25.29	*	32.40	42.70	*	27.29	32.44	*
<i>Callisia fragrans</i>	23.74	25.29	*	32.40	42.70	*	28.14	32.44	*
<i>Nephrolepis sp.</i>	23.91	25.29	*	32.99	42.70	*	28.07	32.44	*
<i>Dracaena marginata</i>	23.84	25.29	*	32.26	42.70	*	28.94	32.44	*

Information: \* shows affect significantly

Table 1 shows that the seven plants on vertical greenery Bogor City Station affect significantly on surface temperature vertical greenery where the t-test showed that  $(t \text{ Stat}) > t\text{-table}$  (t Critical one-tail) or states that  $H_0$  is rejected. The most significant temperature differences occur during the day with a range of different temperatures of 9.60°C until 10.50°C, on the morning 0.46°C to 0.73°C, and at 3.50°C until 5.16°C in the afternoon. It is influenced by each difference in the intensity of the sun for the morning sun is not as strong as the sun during the day, and also the presence of dew on the plants in the morning that perhaps went wet the surface behind him, in the day due to begin the reduction in light and watering in vertical greenery that done at 12.00 as in Figure 4.

The most influential plant is the *Philodendron Burle* in the morning, the lowest temperature during the day is a *Coleus blumei* and in the day is *Asplenium nidus*. Thirdly this plant has the characteristic features are almost similar compared to other plants in vertical greenery is a pattern that spreads except for *Coleus blumei*, the leaves are large and wide. Powered by Grey and Deneke statement [6] stating Effectiveness plant in capturing solar radiation depends on the density of the leaves, leaf shape and branching pattern.



**Figure 4.** Average surface temperature charts in Bogor station

### 3.2.2. Underpass

The t-test results for the surface temperature on the vertical greenery on Underpass which has 8 plants. Data will be divided into three groups: the data in the morning, day, and afternoon and see whether the effect is real or not as shown in Table 2.

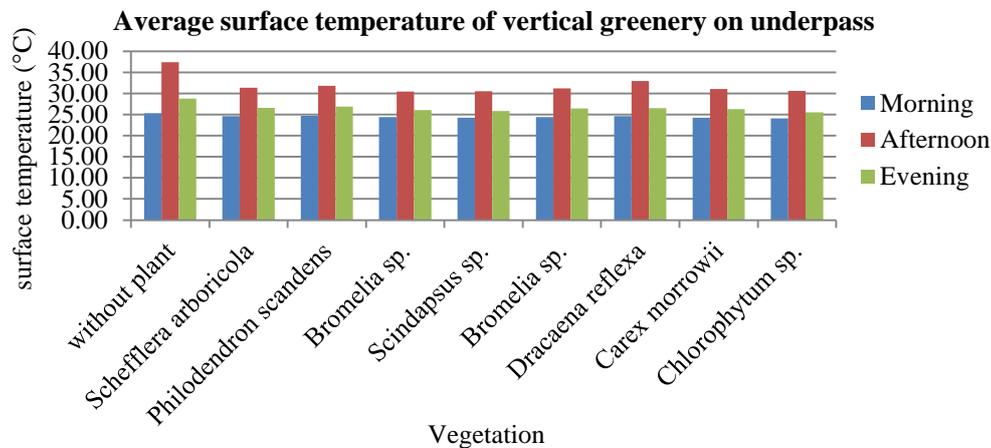
**Table 2.** the average value of the surface temperature in the morning, day, afternoon, and the t-test results on the vertical greenery Bogor City Station

Plant name	morning		result	day		result	afternoon		result
	$\bar{t}$	$t_0$		$\bar{t}$	$t_0$		$\bar{t}$	$t_0$	
<i>Schefflera arboricola</i>	24.59	25.29	*	31.39	37.43	*	26.59	28.79	*
<i>Philodendron scandens</i>	24.69	25.29	*	31.83	37.43	*	26.90	28.79	*
<i>Bromelia sp.</i>	24.37	25.29	*	30.46	37.43	*	26.04	28.79	*
<i>Scindapsus sp.</i>	24.21	25.29	*	30.49	37.43	*	25.81	28.79	*
<i>Bromelia sp.</i>	24.39	25.29	*	31.23	37.43	*	26.41	28.79	*
<i>Dracaena reflexa</i>	24.59	25.29	*	32.97	37.43	*	26.53	28.79	*
<i>Carex morrowii</i>	24.26	25.29	*	31.06	37.43	*	26.30	28.79	*
<i>Chlorophytum sp.</i>	24.06	25.29	*	30.57	37.43	*	25.50	28.79	*

Information: \* shows affect significantly

Table 2 shows that the eight plants on vertical greenery Underpass significant effect on surface temperature vertical greenery where the t-test showed that  $(t \text{ Stat}) > t\text{-table}$  (t Critical one-tail) or states that  $H_0$  is rejected. The temperature difference most significant occurred during the day with a range of different temperatures of 4.46°C to 6.97°C, for the morning at 0.60°C until 1.23°C, and by 1.89°C until 5.16°C in the afternoon as in the show to Figure 5.

Plants that are most influential in the morning was *Chlorophytum sp.*, The lowest temperature during the day is a plant *Bromelia sp.* pink grass And in the afternoon is *Chlorophytum sp.* This is slightly different than the vertical greenery on Bogor Station as the most significant drop in temperature occurs in plants *Chlorophytum sp.* and *Bromelia sp.* pink grass which visually and physical characteristics although less suitable for *Bromelia sp.* pink grass leaves are thick and there are other plants that better meet the criteria of Grey and Deneke [6] As, *Philodendron scandens*. One is probably because the distance between vegetation and surface in his blekang very close and almost stuck to make the surface behind it perfectly protected and also because its position is surrounded by *Philodendron scandens*.



**Figure 5.** Average surface temperature charts in Underpass

According Wilmers [7] Greening the city can bring benefits to micro-climate through several physical processes, such as plants and shade trees can reduce solar heat gain in buildings, Shading reduces terrestrial radiation because over its surface temperature is lower, and the latent heat of the cooling in the atmosphere increases because the added moisture in the air through evapotranspiration of the plant. This statement is supported by Badruzaman et al. [3] stated that the vertical greenery system that uses plants to a building can cool the building and the surrounding area through shading, which reduces the heat emitted by evapotranspiration. Shading produced by the plant became a major factor in the reduction in surface temperature. Based on the results above it can be concluded that the main factor affecting the decrease in temperature and shading is the density of leaves, leaf shape and branching pattern. Indirectly types of vegetation also influence the ability of vertical greenery in reducing the surface temperature.

#### 4. Conclusion

There is a decrease in temperature on the surface of vertical greenery Bogor Station  $0.46^{\circ}\text{C}$  to  $0.73^{\circ}\text{C}$  in the morning,  $9.60^{\circ}\text{C}$  until  $10.50^{\circ}\text{C}$  during the day, and at  $3.50^{\circ}\text{C}$  until  $5.16^{\circ}\text{C}$  in the day, and the lowering the temperature on the surface of vertical surface greenery at Underpass  $0.60^{\circ}\text{C}$  to  $1.23^{\circ}\text{C}$  in the morning,  $4.46^{\circ}\text{C}$  to  $6.97^{\circ}\text{C}$  during the day, and by  $1.89^{\circ}\text{C}$  to  $5.16^{\circ}\text{C}$  in the day. It is caused by shading in plants that protect the surface behind it from direct sunlight. Shading can be affected by several factors in plants such as leaf density, leaf shape and branching pattern. The evaluation results indicate that the aesthetic value of the average vertical greenery in the city of Bogor has aesthetic value both in terms of the freshness of color and density aspects. Vertical greenery still need a lot of development and is focused on the types of plants with high density and good color freshness to increase the aesthetic value and thermal modifications.

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