Maintaining Environmental Sustainability through Existing Environment's Vegetations

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Abstract. Demands for building in urban areas have been increasing lately, especially educational buildings as support for the human development index. Unfortunately, only a few educational buildings can support green buildings as pilots and educational materials for their users. One of the initiators in becoming educational materials and examples of green buildings is the i-cell multipurpose educational building at the Universitas Indonesia. This study aims to find evidence of how reliable and sustainable planning of an educational building in Depok, Indonesia, can accommodate the needs of its users while being environmentally friendly for its surroundings. It observes the influences of vegetation in the surrounding building, one of which is by maximizing the function of vegetation around the building. The research methods include collecting data from the weather archive, vegetation literature, observing the subject, and analyzing the vegetation's effect. This study shows that vegetation has an important role in generating a sound environment for humans and buildings, including healing and providing calmness. This study concludes that vegetation plays a role in generating a good environment by decreasing temperature, sound pollution, sun glare and providing shading areas for people. Those conditions lead to the sustainability of the environment surrounding the building.

1. Introduction

Today's rapidly growing population encourages faster development on a large scale. This results in the loss of green open spaces and endemic habitats. It also reduces the quality of abiotic elements in the area that changes its function [1]. One example of the decline in environmental carrying capacity due to unplanned and unmeasured development is the issue of land subsidence. Jakarta already faces this issue due to the loss of soil carrying capacity caused by the loss of groundwater due to changes in the function of green open land, which is converted into permanent buildings [2]. This condition is resulted from the lack of prolonged sustainable development in a massive area and is worsened by careless development of rural areas [3].

To balance the impacts and benefits of the development, careful planning must be done so that planner can accommodate human needs while producing minimal adverse impacts [4]. One way to reduce the risk of development is the concept of sustainable development. The utilization of existing potential becomes a priority in development [3] according to this concept. One of the potentials that can be maximized is by having vegetation around the building [4].

To collect literature data about sustainability environment development, the Author started from previous research that had the same aim and objective with this study, such as previous research about sustainability development titled "Evaluation of passive cooling methods to improve microclimate for
natural ventilation of a house during summer" (2019), building and environmental journal titled "Vegetation cover and plant-trait effects on outdoor thermal comfort in a tropical city" (2021), Earth and Environmental Science journal titled "Preservation of the natural potential of vegetation. Assessment" and Environmental Science and Pollution Research journal titled "Integrated management of the environment for sustainable development" (2016). The Author tried to elaborate the relation between vegetation, humans and building around a multipurpose educational building in Universitas Indonesia to generate evidence about sustainable environmental development. The evidence should contain the influence from vegetation to humans and building directly and indirectly.

Utilizing this potential around the building will positively impact the environment and the building. Quoting from "Preservation of the natural potential of vegetation. Assessment in landscape planning", each vegetation type can have a different impact on the surrounding environment [5].

The planner should also follow local authorities and rules from the Minister of Public Works Number 05/PRT/M/2008 regarding Guidelines for the Provision and Utilization of Green Open Space in Urban Areas. This regulation proposed to maintain the proportion of green space and solid space in the project area. A balanced proportion between green space and solid space is aimed to maintain environmental quality, including air, earth, and water quality [3].

The study aims to look at a case study of vegetation planning and its influence at a multifunctional education building at the University of Indonesia. The emergence of this building as a study case was to generate evidence if the building has good vegetation management to maintain environmental sustainability as a support system of building and to study the potential of vegetation. This building will also be a pilot project and education for architecture students in Universitas Indonesia to inspire the design for future projects. This massive building was built on 13,256 m² with a solid area of 5,994 m² and an infiltration area of 7,262 m². The observation would be based on ecological theory about the relationship between vegetation, humans, and building [3]. The theory would show evidence in passive cooling effect, windbreaker effect, sound barrier effect, sun shading provides and long term influence such as water storage and micro-ecosystem support.

2. Method

In this study, a multi-function educational building in Universitas Indonesia was used as a study case to generate evidence about sustainability vegetation relationship between humans and building based on ecological and vegetation theory applied in the project. The author uses literature from the journal of environment, planning, ecology, and sustainable development to collect data and information about the relationship between vegetation and building. Keywords used to find the literature included "vegetation", "Vegetation function", "Ecological planning", "Sustainable development", and "Nature preservation". Every piece of literature was published in the last ten years. All literature was sorted by criteria such as correlation with vegetation, explaining ecological influence from vegetation to building, and explaining potential and treatment vegetation. The observation was conducted online and offline due to Covid-19 from September 2020 – October 2020. It provided data about local temperature, wind flow direction, sun glare intensity, and a comparison of land conditions between 2015, 2017, and 2019 from Google Maps time lapse. Subsequently, the Author reviewed the theory about ecological concepts between vegetation and the land around the building [4].

Some theories were used in this research, such as integrated sustainable development theory from "Environmental Science and Pollution Research" journal by Ali Sdri (2016), to understand the integrated planning between vegetation and building to gain a balanced condition and minimize the environmental harm [3]. Ecological and environmental theory in a book titled "Essential of Ecology" by Towsend and Harper (2019), explained the vegetation position in ecological aspects for micro and macro scale [4]. Theory about vegetation also described tree function and characteristics based on tree morphology and species in a journal titled "Preservation of Natural Potential" [5]. According to the theories, the vegetation not only directly influences the environment but also indirectly, by serving as, for example, temperature control [7], windbreaker [8], sun shading [9]. Indirect impacts from vegetation include soil health, water storage for the future, and ecological preservation [4].
3. Results and discussion

Result and discussion were generated from the existing condition of I-Cell Building environment. The data come from observation and drafting worksheet of the building. The data including measurement area, timelapse during 2015 till 2019, border, vegetation list and its function and also comparison between green and grey area.

3.1. Existing condition

Figure 1. Green Space And Grey Space Area on the site.

Figure 1 was generated from the drafting worksheet of the building. It shows the border, location, orientation, and composition between green and grey areas on-site project. The building site area was a green open area in 2015 and became a construction area in 2019 (Fig. 2). Based on existing documents in Google Maps time-lapse from 2015 - 2019, it can be seen that the site area has changed. The changes of green open space into a construction area lead to changes in the building's ecosystem and environmental carrying capacity (Fig 1) [3]. With this condition, the planners had to maximize the space to allocate vegetation, building, and people activities [11].

Figure 2. Site Condition in 2015
Figure 3. Site Condition in 2017.

Figure 4. Site Condition in 2019.

Figure 2 shows the degradation of green space area becoming grey space area. From the observation and literature review about the correlation between vegetation and climate [11], it was known that the temperature increased between 2015 and 2019, the top picture shows the existing condition 2015, the middle picture showed the existing condition in 2017, and the last picture on the bottom is the existing condition on 2019 pre-construction. This condition caused degradation of vegetation (Fig 2). The temperature difference between the shaded spot and non-shaded spot was 20 – 40 %. [7] The planner should mention this condition, so planner can reduce the heat and keep the temperature comfortable.

3.2. Existing Trees
The existing trees on the site consisted of several species with various heights and separate tree canopies with different functions that influence the tree's location. Height and tree canopy are parts of a tree that influence the sun shading area; taller trees cast longer shadows while larger tree canopies cast wider shadows [12]. Tree's function depends on its shape and special capacity in a biological way. This study focused on several functions of trees, such as 1) windbreaker, when the tree has a large canopy with massive leaves covering the tree so that the wind speed would decrease [8], 2) Pollution Absorber, which means trees can reduce carbon emission significantly according to the laboratory experiments [13], 3) water storage when it has large and long roots with a huge stem [14], 4) Sound Buffer, their large canopy and massive leaves are short enough to reduce sound from its source [13], 5) Directing tree means that it has a narrow stick and could be placed in a linear way to give direction or sign to the user [11], and 6) wood or supply resource from the tree's huge trunks and fruits along with the canopy [14]. Their role influences the placement of trees to provide benefits for humans and buildings based on the problem and potential on the site [12]. Several lists for existing trees on the site play a role in human and building relations around the site.
### Table 1. Existing tree on the site.

| Name                  | Height | Tree Canopy | Function                                | Location   |
|-----------------------|--------|-------------|-----------------------------------------|------------|
| *Pterocarpus indicus* | 5 m    | 3.4 – 5.7 m | Wind Breaker, Pollution Absorber        | North Building |
| *Swietenia*           | 7.75 m | 0.9 – 2.24 m| Canopy, Wind Breaker, water storage     | North Building |
| *Polyalthia longifolia* | 6 m    | 0.6 – 2.1 m | Wind Breaker, Director, Bordering.      | West Building |
| *Syzygium paniculatum* | 1.5 m  | 0.3-2.5 m   | Sound Buffer, Windbreaker, Director.    | North Building |
| *Tectona grandis*     | 2.2 m  | 1.2-5.4 m   | Director, Wind Breaker, Wood Resource   | East Building |
| *Filicium decipiens*  | 20 m + | 3 – 8.2 m   | Canopy, Wind breaker glare reduction   | South Building |
| *Durio sp*            | 50 cm  | 1.5 – 5.2 m | Food Supply                             | South Building |

Data in above [Table 1] were collected from observation on the project site. The data bring information about the composition of vegetation in the area. The data also provide evidence about vegetation management and effort to use vegetation's potential on the project area [3]. The vegetation could block wind, sound, and direct way placed near the road to prevent sound pollution from the vehicle, dust wind from the road, and generate aesthetic for vehicle users [13]. Vegetation with a wide canopy placed on a wide-open area provides shading for users and decreases reflecting heat from the ground to the building [12]. Tree with a wide canopy and height above 3m used as a windbreaker and wind flow management does provide a natural cross-ventilation system on the area, so the heat wind would go up, and cool wind would blow along with the building and open area [7]. Trees with fruit potential are also placed on open areas to provide happiness for the user by manipulating the mind to think that if we maintain the tree well, it will reward us.
Figure 5. Existing Tree Management.

From the observation information on figure 5, the Author interpreted the location of trees to generate evidence if vegetation had been well planned. Every tree placement is based on what they could provide for humans and building. *Polyalthia longifolia* is placed along the side of the road because it has the ability to reduce sound and road directing [13]. *Pterocarpus indicus* is placed on the side of the site as a future communal area and provides sun shading, passive cooling, and landmarks for users in the future. Based on the studies about the relationship between psychology and nature, nature can heal the human body by providing them relaxation and calmness [15]. Thus, maximizing the potential of vegetation provides a positive effect on existing land and people and buildings as well.

3.3. The Relationship Between Nature and Building

The relationship between building and vegetation in this study case has been observed, and the result is shown in the figure below (Figure 4 & 5). The figure generates evidence about the relationship between vegetation, human, and building. From the figure, author may know that the potential of vegetation is commonly noticed as direct influence and indirect influence. The vegetation can reduce the sound from the road, as proven by *Polyalthia longifolia* along the site barrier [13]. Vegetation also reduces temperature around the building by providing sun shading and eliminating the heat temperature [16].
The ecology theory suggests that water and soil quality around the vegetation is better than other places where there are no trees [17]. Based on the observation, temperature and sound quality on the other side of the building without trees are higher and more noisy[13]. This is proof that vegetation plays a role in generating a sound environment and reliable building performance.

**Figure 6. Section Concept**

**Figure 7. Section Concept 2**

### 4. Conclusion

It can be concluded from this study, according to the observation and data collection on the tables and figures, that vegetation has a role in generating a sound environment for people and buildings. The tree's functions serve as a sound barrier, passive cooling, sun shading provider, and in terms of sustainability, ecology vegetation. They influence the water storage, food supply, and create micro-ecosystem. Vegetation also affects human emotion by providing healing and calmness. In the future, this study may be evolved to analyze vegetation as a parameter of the existing micro ecological system around the building to generate nature preservation. In the future, the Author suggests studying the relationship between vegetation and an indicator of a good ecology in the environment. This future study will give more evidence of whether a well-maintained existing environment would generate a good ecosystem.
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