Evaluation of The Effectiveness of Beach Side Vegetation to Control Wind velocity in Jaya Ancol Dreamland, North Jakarta.

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Abstract. In some resorts established in the coastal areas sea breeze strongly affects human comforts. Vegetation as a wind barrier is used to modify beachside microclimate comfort by controlling, reducing, or redirecting wind. They usually consist of trees and shrubs, but may include perennial or annual plants and fences. Taman Impian Jaya Ancol (Jaya Ancol Dreamland) is one of the most prominent public open spaces in Jakarta that connected directly to Java North Beach. This research evaluated how much of Ancol Beach vegetation helps to increase the community’s comforts. This research was limited to measuring the effectiveness of vegetation wind barriers in controls wind velocity. This research observed four vegetation plot types 1 control plot (bare land), and three vegetation wind barrier plots (one with homogenous vegetation and two with heterogeneous vegetation). Wind velocity was measured at a distance of 0, 10, 20, and 30 m from the edge of the beach and approximately 1.5-2 meters in height. Effectiveness of wind barriers to reduce wind velocity was calculated as the decreased of wind velocity between 30 m and 0 m. The leaf area index (LAI) and plant diversity were also observed. The result of this research showed that wind velocity under vegetation was always lower than the wind velocity in the control plot. Wind barrier type heterogeneous 1 was more effective in controlling wind velocity than other types. This type had the highest species diversity score and the highest LAI and has reduced wind velocity around 81.8%. Other wind barrier types were less efficient and have reduces wind velocity by a smaller percentage. The heterogeneous barrier type 2 for 45% the homogenous for around 35.5% and bare by 29.4%.

Keywords: Coastal area, vegetation, leaf area index, species diversity wind barrier, wind velocity

1. Introduction
Coastal areas are transitional ecosystems influenced by land and oceans, which include several ecosystems. The morphology of the coastal area is affected by various things such as tides, waves, and wind. Winds that blow in long intervals form tides even can form waves if they hit the beach on an incline.[1] Planning and developing of coastal areas has to consider various morphology and physiographic aspects so that they can provide many benefits both in terms of comfort, economic impact, and disaster management can be provided.

Taman Impian Jaya Ancol (TIJA/Jaya Ancol Dreamland) is a 552 Ha integrated tourism area, located on reclaimed beach land at Northern Jakarta, integrated directly with the North Coast of Java. The TIJA complex consists of recreational areas, resorts, convention, shopping, office, and apartment building. Ancol has also succeeded in portraying itself as a recreation area that accommodates tourism activities with a variety of tourist objects to create a better and more environmentally friendly social environment.[2]
The existence of the TIJA recreation area required the management to continue in order to maintain the existence and beauty of its landscape. Green belt that combines efforts to protect and preserve natural resources with tourism, can protect coastal areas from environmental damage such as coastal erosion, seawater intrusion, sedimentation, flooding, inundation, sea winds that are too strong, abrasion, to environmental pollution. One of the functions of the green belt in the coastal area is wind protection. The wind barrier protects the coastal area and creates a comfort zone in the recreation area by reducing wind velocity. Therefore, it is necessary to measure the effectiveness of the protection of coastal vegetation in controlling wind velocity.

2. Methods
Observations were made at Jl. Kawasan Pantai Ancol, Jaya Ancol Dreamland, North Jakarta. The research location is illustrated in Figure 1. The study was carried out on several belt structures (derived from combination of length and vegetation diversity) found on the research site. Belt with no vegetation area was valued as a control variable. Four green belt structures were analyzed at four measurement points. Wind velocity as a variable measurement was done every five minutes for 120 minutes at each observation point in a sunny weather. The following is the categorization of plots observed:

1. A control plot was an area that does not have a vegetation barrier as a wind speed controller. The area was approximately 1,149.5 m² with a width of 35.7 meters and a length of 32.2 meters;
2. The homogeneous barrier was approximately 1,124.55 m², with a width of 31.5 meters and a length of 34.7 meters. The vegetation composition is dominated by Cocos nucifera (97% plants). The average height of vegetation was 8.74 meters;
3. Heterogeneous barrier type 1 has more different plants and a diversity of around 1.89. The length of the barrier was 109.2 meters width of 36.1 meters, approximately 3942.12 m². The average height of vegetation was 6.65 meters.
4. Heterogeneous barrier type 2 was the largest in this study, 209.1 meters long and 37.1 meters wide, in total 7,757.61 m².

Data was collected in the form of barrier width, vegetation height, type of vegetation, diversity of vegetation, and barrier lush by direct observation. Canopy shade was measured with Leaf Area Index (LAI) method, by photographing the plants canopy from below then analyzed with the Hemiview 2.1 Canopy Analysis Software program. Canopy density is classified into three categories [3], <1.7, 1.7 ≤ LAI ≤ 2.3 (within LAI value), and > 2.3. In addition, a vegetation analysis process was also carried out to determine the abundance, frequency, dominance, and diversity of each wind barrier, referred to the Shannon-Wiener Index.[4]
Measurement of the wind protection range was done by estimated wind velocity at four points using a digital anemometer. The range of wind protection seen from the reduced wind velocity before and after the vegetation barrier to show the effectiveness in controlling wind velocity. The wind velocity was observed every five minutes for 120 minutes at 14.30 - 16.30. Anemometers were placed at distances of 0m, 10m, 20m, and 30m as shown in Figure 2. Each data at each observation points standardized with International wind velocity scale, Beaufort Scale [5], Comfortable Wind Velocity Range [6] and Criteria for Wind Comfort and Danger.[7]

![Figure 2. Anemometer placement point](image)

3. Results

3.1 General Condition

The beach area was a recreation area that dominates the entire TIJA recreation area. Elok Beach was a beach that has a long embankment and a 500-meter jogging track. This beach was not intended for swimming because the sea was steep, but there were still recreational activities, such as a picnic and walking along the beach. There were also children’s playgrounds, such as swing games, slide, and ladder games.

3.2 Vegetation Analysis

Vegetation analysis measurements are carried out on plots that use vegetation as a barrier. The parameters measured include the type name, the number of individuals of each type, diameter, and height. Vegetation analysis results obtained from 11 species with a total of 229 trees spread across three barriers, as presented in Table 1.

| Table 1. Vegetation plot database |
|----------------------------------|
| **Barrier Type** | **No** | **Local Name** | **Species Name** | **Amount (trees)** |
| Homogeneous |   1   | Kelapa | Cocos nucifera | 41     |
|             |   2   | WaruLaut | Hibiscus tiliaceus | 1     |
|             |       | Total |                   | 42     |
| Heterogeneous |   1   | Palembismark | Bismarckianobilis | 2     |
|             |   2   | Kelapa | Cocos nucifera | 35    |
|             |   3   | Flamboyan | Delonix regia | 13    |
|             |   4   | Beringin | Ficus benjamina | 20    |
|             |   5   | Beringinemas | Ficus microcarpa 'Golden' | 4     |
|             |   6   | Warulaut | Hibiscus tiliaceus | 31    |
|             |   7   | Glodoganbulat | Polyalthia fragrans | 13    |
|             |   8   | Polongan | Pongamia pinnata | 5     |
|             |   9   | Jati | Tectonia grandis | 2     |
|             |  10   | Ketapang | Terminalia catappa | 2     |
|             |       | Total |                   | 127    |
| Heterogeneous |   1   | Lontar | Barassus flabellifer | 1     |
|             |   2   | Kelapa | Cocos nucifera | 36    |
|             |   3   | Beringin | Ficus benjamina | 3     |
|             |   4   | Warulaut | Hibiscus tiliaceus | 20    |
|             |       | Total |                   | 60     |
a. Relative abundance
Abundance values provide information about how the distribution and its patterns of a species. In homogeneous type, the highest relative abundance was in the Cocos nucifera species, with a relative abundance of almost 100%. This means that almost all of the sites filled by Cocos nucifera. In heterogeneous plot 1, the highest abundance is Cocos nucifera, then in Hibiscus tillaceus. The lowest abundance found in Bismarckanobilis. In heterogeneous plot 2, the highest abundance found in Cocos nucifera species with the lowest abundance is Barassusflabellifer. Overall, the highest abundance in the wind barrier in the three observation plots was the Cocos nucifera species.

b. Relative Frequency
Calculation results show that Cocos nucifera and Hibiscus tillaceus have the highest relative frequency compared to other species. It is because of the two species found in the three observation plots, which means, the two species were scattered almost throughout the wind barrier experiment.

c. Relative dominance
Dominance concerns the area of land occupied by the part of the plant that appears from above. Dominance means mastery of one type of other types. The relative dominance value of each species varies from the lowest, Barassusflabellifer by 0.1% to the highest, Cocos nucifera by 40.8%. These values indicate the area of coverage of each species to the observation plot.

d. Important Value Index
The critical value index is the result of the sum of the relative values of the three parameters (abundance, frequency, and density) whose values range from 0-300 [8]. The index of the plant species importance is one of the parameters that show the role of these species in the community. The greater the INP value of a species, the higher the level of control over the community and vice versa [9]. The measurement results (Fig. 3) show that Cocos nucifera has the highest INP of 86.8, and the lowest is Barassus flabellifer with an INP score of 6.6. The critical value of Cocos nucifera was higher than other types because this species was quite dominant in the three barriers and has a large tree diameter so that it causes a high dominance value.

![Figure 3. Graph of importance index of species](image)

Legend
1: Barassusflabellifer 7: Hibiscustillaceus
2: Bismarckanobilis 8: Polgalthiafragrans
3: Cocos nucifera 9: Pongamiapinata
4: Delonixregia 10: Tectoniagrandis
5: Ficusbenjamin 11: Terminalia catappa
6: Ficusmicrocarpa ‘Golden’

e. Diversity index
A species diversity index value can be used to determine the stability of a transect in an community [10]. Calculation results show heterogeneous type 1 has the highest species diversity compared to the two observed plots. This high value influenced by the number of species and more diverse individuals, which consists of 10 species. The lowest species diversity value found in a homogeneous type, found from the low number of species.
Figure 4. Diversity index at each barrier

3.3 Leaf Area Index (LAI)

The results of Leaf Area Index (LAI) measurements on each wind barrier get different values on each type. Heterogeneous wind barrier type 1 has the highest value of canopy density compared to the other two barriers of 1.3378. The value of vegetation canopy density on homogeneous type wind barriers is 1.0276, and the LAI value on heterogeneous type wind barrier 2 is equal to 1.3179. While the control plot does not have an LAI value because it does not have tree vegetation.

| Barrier Type        | LAI Value |
|---------------------|-----------|
| Homogeneous         | 1.0276    |
| Heterogeneous 1     | 1.3378    |
| Heterogeneous 2     | 1.3179    |

3.4 Calculation of Wind Protection Coverage

a. Wind velocity at each barrier

The wind moves from low pressure to high-pressure areas. The coastline, causing wind circulation in this area is very typical compared to other regions because it affected by sea and land winds. The observations show there are differences in wind velocity that occur in the four observation plots at each observation distance. The direction of the wind during observation moves to the southwest.

As it gets noon, the intensity of the solar radiation received by the land increases, so the temperature differences between land and sea expand. Also, the pressure difference arises even greater and cause higher wind velocities. HSU in Ullva [11], states that the wind is getting stronger at 15.00 when the temperature difference between land and sea has reached its maximum value. At this hour, there is an opportunity for cumulus clouds to make rain on land at 16:00 to 17:00 to a radius of 30-40 km from the coastline.

Observation on the control variable(Fig. 5) shown at the 0m point, the wind gusts move on gentlebreeze(96% data) and strengthens at 15.00 (4% is moderate breeze). The wind strengthened again at 15.35 at the observation point of 10m distance (moderate breeze 4% data). At the 20m point, there is a decrease in wind velocity, 83% of data is on a gentle breeze scale with the rest on a light breeze scale. At the 30m point, a gentle breeze scale blowing occurs as much as 63%, with the rest occurring on a light breeze scale (38%).

In wind barrier with homogeneous vegetation structure (Fig.6), the wind velocity that occurs is on a scale of moderate to light breeze. The wind velocity at the 0m point rises at 14.55 to 15.40, with the moderate breeze blowing of 75% of the data, and 25% data at gentle breeze scale. The 10m point shows that wind velocity as much as 96% of the data occurred on a gentle breeze scale, and the rest on a light breeze scale. At the 20m measurement point, there is an equal amount of data on both scales, i.e., gentle breeze and light breeze 50% each. At the distance point of 30 wind velocities are still on a light breeze scale of about 92% of the data and...
the rest on a gentle breeze scale. The velocity not too decreased because it caused by the type of vegetation fitting this wind barrier, the *Cocos nucifera* species which has high enough of lowest crown distance.

![Figure 5. Wind velocity at control plot](image)

![Figure 6. Wind velocity at homogenous plot](image)

The third observation plot is a wind barrier plot with a heterogeneous type 1 vegetation structure. In this observation plot, there are differences in wind velocity that occur at each distance of the measurement point. The 0m point is on gentle breeze scale (46% of data) and light breeze scale of 50%, and light air scale of 4%. The wind velocity at point 10 consists of a range of scales with light breeze (88%) and light air (13%). The 20m measurement point is at calm scale (13% data), light air (46% data), and light breeze (42% data). At measurement point 30m, the wind velocity on light breeze scale is 8% of the data, at light air scale is 67%, and calm scale as much as 25%. This type of wind barrier shows a significant difference between the wind velocities that occur at each distance of the measurement point. This difference shows that the range of protection against wind velocities carried out by wind barrier type heterogeneous 1 is higher than the other types.

The fourth observation made in a heterogeneous type 2 wind barrier plot (Figure 8). In heterogeneous type 2 wind barriers, there is a difference between the wind velocity at the 0m measurement point and the wind velocity at the 30m point. At point 0, the scale of the wind velocity that occurs in this type area, 75% is gentle breeze, the rest is light breeze. At the 10m point, wind velocity occurred on a light breeze (38%); gentle breeze was 63%. At the 20m point, all wind velocities occur on a light breeze at a point of 30m, 92% of the data occurs on light breeze and calm (8%).
Figure 7. Wind velocity at heterogenous plot type 1

Figure 8. Wind velocity at heterogenous plot type 2

b. Wind Protection Capability
The function of vegetation as a wind barrier includes blocking the wind, deflecting the wind, reducing the strength of the wind, and modifying the micro-climate conditions that are less comfortable.[12] In the form of a percentage, the highest reduction in wind velocity owned by a type 1 heterogeneous wind barrier and the lowest in the control observation plot (Figure 7). In the heterogeneous type of wind barrier 1, the percentage reduction in wind velocity that occurs from the 0m observation point to the 30m observation point occurs at 81.77%, affected by the diversity value and the substantial LAI value on this type of wind barrier. In the control observation plot, there was a reduction in wind velocity of 29.42%. In a homogeneous type of wind barrier, a reduction in wind velocity occurs by 35.43%. The percentage value of the reduction in wind velocity that occurs in wind barrier type heterogeneous 2 is 45.09%.
3.5 Relationship of Wind Protection Coverage to Other Variables

The relationship between the percentage of ability to reach wind protection as a dependent variable with other independent variables. The relationship was analyzed used simple linear regression analysis to found how the correlation between variables works. The following table is a summary of the outputs from the analysis.

| Variable              | Multiple R | R Square | Correlation |
|-----------------------|------------|----------|-------------|
| LAI value             | 0.7031352  | 49.44%   | +           |
| Average barrier height| 0.8436082  | 71.17%   | -           |
| Temperature           | 0.143791   | 2.07%    | -           |
| Species diversity     | 0.9680324  | 93.71%   | +           |

The results of the analysis show multiple R values > 0.6 indicate a robust relationship between the variables analyzed. Based on the analysis results, there are three of the four variables that show multiple R values > 0.6. It shows that the LAI value, the average height of the wind barrier, and the level of species diversity have a strong relationship with the ability of wind protection carried out by the wind barrier. R square > 50% indicates that the independent variables influence variations in the range of wind protection by the wind barrier. Based on table 3, there are an average height of the wind barrier and the level of species diversity affects > 50% variation in wind barrier in controlling wind velocity. While the LAI value and temperature magnitude affect the remaining amount of variation of the range of wind protection. Correlation values consist of two types, positive/+ and negative/- . The analysis shows that the three variables have a + correlation, shows that the greater the value of canopy shade, and the higher the level of species diversity in a wind barrier, the higher the percentage of wind protection will be resulted.
4. Conclusions and Suggestion

4.1. Conclusions

Wind protection (velocity reduction) is one of the vegetation functions in the landscape. A good wind barrier composition consists of diverse species with thick canopy. The more diverse and denser is the vegetation that makes up a wind barrier, the better the ability of wind barriers in controlling wind velocity. At this research, we found wind barrier that can reduce wind velocity up to 81.77%. The structure contains high diversity index rate with value of 1.89 and high level shade rate with value of 1.3378. All activities on the standard comfort wind velocity can be carried out in the coastal area of Taman Impian Jaya Ancol. The three wind barrier plots show an excellent function in controlling wind velocity and provide good comfort for activities to sit, stand, and walk-in coastal areas.

4.2 Suggestion

Based on the results of this study, further research needs to be done to find out various types of wind barriers composed of other vegetation and the aspects of the thermal comfort of a tourist area concerning wind velocity.

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