The diversity of tree and open green space (OGS) of hospitals in Banda Aceh

Djufri¹, Hasanuddin¹, M Rusdi², V P Puspa³

¹The Biology Education Department, Faculty of Teacher Training and Education, Syiah Kuala University, Jl. T. Hasan Krueng Kalee, Darussalam, Banda Aceh, 23111, Aceh, Indonesia
²The Department of Soil, Faculty of Agriculture, Syiah Kuala University, Banda Aceh
³The Biology Education Department, Graduate Student Program, Indonesian University of Education, Bandung

*Email: djufri@kip.unsyiah.ac.id

Abstract. This study has been conducted using the quadratic method to find out the species diversity index (H'). Five quadratic plots, with size of 10 m x 10 m (tree strata) were made for each area of samples. The percentage of open green space for each unit samples was measured by the calculation of ratio of the hospital area and the area of open green space for each sample unit. The result of the study was there were 51 species of trees which belongs to 28 families. The importance of each species in all stations was small or relatively homogeneous, but there were eight species of relatively high importance plants. The results of the diversity index analysis (H') showed that the value of H' ranged from 1.484 to 3.082, which placed two hospitals into high H' values including Zainal Abidin Hospital (H' = 3.082) and Kesdam Hospital (H' = 3.015). The other stations had H' medium and low values. Therefore, the OGS data analysis found that 10 out of 12 observation stations had the OGS value more than 50% or the OGS ratio of 11 hospitals in Banda Aceh was > 30% and fulfil the requirements of the law on OGS.

1. Introduction

In Plant diversity is a natural resource that must be maintained in places, including the hospital area. Each plant, especially tree, that is found in the hospital should possess its architect criteria as protection, esthetics, and conservation. In addition, those trees planted must have an ideal ratio area to the hospital area for the Open Green Space (OGS), so that the function of the hospital as a place of treatment must be in a beautiful, comfortable, and soothing condition and provide oxygen for patients and visitors.

OGS is part of open spaces in an urban area filled with plants and vegetation to support the direct and indirect benefits generated by the OGS in the city, such as safety, amenities, welfare and beauty of the urban area [1]. OGS can be found in hospitals, offices, schools, universities and various other places. The more plants and vegetation diversity in an area, the more beauty of it places. The information about the diversity of tree and OGS ratio of the Hospitals in Banda Aceh City is not yet available adequately, therefore it is necessary to conduct research.

This study aimed to find out (a) tree species diversity (H') index and (b) the ratio of open green space of General Hospitals in Banda Aceh City.
2. Method

The tools and materials used in this study were stationery, identification book, digital cameras, meters, GPS, label paper, and herbarium press.

Data on frequency (F) and density (K) of trees were gathered by using a quadratic method (plot) of 5 plots per station with an area of 10 m x 10 m, where the number of plots were adjusted to the area overgrown with trees and the placement was done subjectively. Whereas a gauge was used to calculate the area. Thus, the data of area obtained in the field was used to measure the OGS ratio at each observation station. To obtain comprehensive data, the OGS ratio measurement was carried out in the middle, right and left sides. The parameters observed included the number of species, Absolute Density (AD), Relative Density (RD), Absolute Frequency (AF), and Relative Frequency (RF) values. AD, RD, AF, and RF were calculated using the formula (1), (2), (3), and (4), respectively [2-4].

\[
\text{Absolute Density (AD)} = \frac{\text{The number of individuals of a species}}{\text{Area of sample plots}} \\
\text{Relative Density (RD)} = \frac{\text{The density of a species}}{\text{Total density of all species}} \times 100\% \\
\text{Relative Frequency (RF)} = \frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100\% \\
\]

A formula by [5] was used to calculate the Important Value (IV) of each species which is showed as \( \text{IV} = \text{Relative Frequency (RF)} + \text{Relative Density (RD)} \) [5]. The IV calculation results were then used as a value to find out the Species Diversity Index (\( H' \)). The value of \( H' \) was determined using formula (5) [2,3]:

\[
H' = \sum p_i \ln p_i
\]

With \( p_i = \frac{n_i}{N} \), where \( H' \) is Shannon-Wiener diversity index; \( p_i \) is the proportion of each species in the sample, \( n_i \) is one particular species found, \( N \) is total number of individuals found, and \( \ln \) is natural log. The Shannon-Wiener Species Diversity Index (\( H' \)) value, which range from 0 to 7, are interpreted into the following criteria: \( H \) value \( \leq 1 \), the category is very low; \( H \) value \( \geq 1-2 \), the category is low; \( H \) value \( \geq 2-3 \), the category is medium; \( H \) value \( \geq 3-4 \), the category is high; and \( H \) value \( \geq 4 \), the category is very high [2,6,7].

3. Results and Discussions

The results will be discussed in 5 subsections, they are output power, total efficiency, specific fuel consumption, exhaust gas emissions, and diesel replacement ratio.

3.1. Vegetation Composition, Importance Values, Diversity Index and Percentage of Tree Distribution at the Study Site

Based on the results of data collection, the compositions of tree species in 12 observation stations conducted in April-August 2018 at the hospitals in Banda Aceh were 51 species classified into 28 families (Table 1). Based on Table 1, it is known that Arecaceae is the most commonly found families comprising of 8 species and followed by Fabaceae with six species. Ecologically, the two families had the widest distribution and had a better tolerance than other species in the observation stations. The four major species with the highest percentage in the observation stations were *Pterocarpus indicus* (5.8%), *Mangifera indica* (5.19%), *Roystenia regia* (5.19%), and *Tamarindus indicus* (4.54 %). This means that the species were classified as having a relatively high attendance frequency to be found in more than 50% in the study locations.

The tree species found at the study site were 51 species, belonging to 28 families. The importance values (IV) of each species in all stations were relatively small (Table 1). Based on IV, it can be stated that there were 8 species possessing relatively high IVs compared to other species, namely; *Roystonia*...
regia (20.01%), Pterocarpus indicus (16.23%), Polythia longifolia (10.87%), Tamarindus indicus (10.5%), Veitchia merillii (9.12%), Eugenia leina (8.97%), Swietenia mahagoni (8.85%), and Mangifera indica (8.70%). Important values (IV) of species in a community is one parameter that shows the role of species in their community [8]. The presence of species in an area indicates both the adaptation ability in the habitat and broad tolerance to environmental conditions. The higher the IV of a species, the better the control of space to the community is and vice versa. It suggested that IV is an indicator of the control level of species in an area, i.e., the higher IV indicates that it is more likely for the species to survive [7].

The dominance of certain species in a community occurs when the species successfully uses most of the available resources compared to other species [9]. Therefore, the species that had a high IV dominated the study area (Hospital in Banda Aceh). This is due to at least two reasons; they are planted intentionally for different units of land based on available spaces and ability of those species to dominate the community.

Importance values of species classified as low in this study were Averhoa carambola (0.23%), Cananga orodata (0.26%), Bauhenia purpurea (0.26%), and Salacca zalacca (0.26%). The species ecologically had a relatively low level of dominance in the space due to the low adaptability and tolerance including special treatments causing the unnatural development of those species. In addition, different management of the open green space at each hospital had different priority scales to maintain the particular species.

| Table 1. Vegetation Composition, Importance Values, Diversity Index and Percentage of Tree Distribution at the Study Site |
|-----------------------------------------------|
| **Local names** | **Scientific Names** | **Familia** | **IV** | **H’** | **%** |
| Palem raja | _Roystonea regia_ | Arecaceae (1) | 20,019 | 0.1695 | 5.195 |
| Angsana | _Pterocarpus indicus_ | Fabaceae (2) | 16,234 | 0.1434 | 5.844 |
| Glodokan tiang | _Polythia longifolia_ | Annonaceae (3) | 10,862 | 0.1069 | 3.247 |
| Asam Jawa | _Tamarindus indicus_ | Fabaceae (2) | 10,500 | 0.1065 | 4.545 |
| Palem putri | _Veitchia merillii_ | Arecaceae (1) | 9,121 | 0.1055 | 3.896 |
| Pucuk merah | _Eugenia oleina_ | Myrtaceae (4) | 8,974 | 0.0958 | 3.896 |
| Mahoni | _Swietenia mahagoni_ | Meliaceae (5) | 8,855 | 0.1012 | 3.896 |
| Mangga | _Mangifera indica_ | Anacardiaceae (6) | 8,691 | 0.1123 | 5.195 |
| Cemara laut | _Casuarina equisetifolia_ | Casuarinaceae (7) | 6,904 | 0.0499 | 3.896 |
| Palem kuning | _Dypsis lutescens_ | Arecales (1) | 6,721 | 0.0668 | 2.597 |
| Trembesi | _Samanea saman_ | Fabaceae (2) | 6,595 | 0.0848 | 3.896 |
| Palem botol | _Hyophorbe lagenicaulis_ | Arecaceae (1) | 6,304 | 0.0546 | 1.948 |
| Ketapang | _Teminalia cattapa_ | Combretaceae (8) | 5,831 | 0.0579 | 1.948 |
| Kersen | _Muntingia calabura_ | Muntingiaceae (9) | 5,756 | 0.0765 | 3.896 |
| Cemara kipas | _Platycladus orientalis_ | Casuarinaceae (7) | 5,739 | 0.0734 | 1.299 |
| Tanjung | _Minusops elengi_ | Sapotaceae (10) | 5,384 | 0.0731 | 3.247 |
| Dadap Merah | _Erythrina crista-galli_ | Fabaceae (2) | 5,336 | 0.0562 | 2.597 |
| Ketapang | _Terminalia mantaly_ | Combretaceae (8) | 4,846 | 0.0614 | 2.597 |
| Palem merah | _Cytostachys renda_ | Arecaceae (1) | 4,510 | 0.0351 | 1.299 |
| Pulai | _Alstonia scholaris_ | Malvaceae (11) | 3,640 | 0.0476 | 2.597 |
| Bambu kuning | _Bambusa vulgaris_ | Poaceae (12) | 3,505 | 0.0273 | 0.649 |
| Dracaena | _Dracaena marginata_ | Asparagaceae (13) | 3,403 | 0.0422 | 1.948 |
| Waru | _Hibiscus tiliaceus_ | Malvaceae (11) | 2,622 | 0.0243 | 0.649 |
3.2. Species Diversity Index at Research Sites

The results of species diversity index (H') analysis on all observation stations showed that two observation stations had high H' values, six observation stations had medium H' value, and four stations had low H' (Table 2).

In this study, the H' value ranged from 1,484-3,082. This indicates that only two hospitals had high H' values, namely the Zainal Abidin Hospital and Kesdam Hospital. Ecologically, this indicates that those two areas had good environmental conditions, considering H' values related to the dynamics of varied development and phenology of species in the composition of species, flowering and architectural models of trees. Such conditions will provide a more varied aesthetic value for the environment. For instance, within a year there will be different inflorescence periods since January to December from different families, such as Fabaceae, Lauraceae, Myrtaceae, Lamiaceae, Sapotaceae, Annonaceae, Verbenaceae, Moraceae, Sapindaceae, Malvaceae, Mimosaceae, and so on. The phenology will benefit certain fauna that requires food in the area [2] [7] [10]. If throughout the year, the area continues to flower and fertilize, of course, there will also be food sources for certain
animals that live on site throughout the year, so that community dynamics and harmonization will be established leading to the appropriate regeneration of flora and fauna in the area goes. The diversity of tree architectural models will certainly provide certain benefits for the hospital, including protection, aesthetics, shade, and reducing the impact of air pollution and noise.

| Hospital Research Stations | Species Diversity Indices (H') | Categories | Species Number |
|----------------------------|--------------------------------|------------|---------------|
| Zainal Abidin              | 3,082                          | High       | 27            |
| Kesdam                     | 3,015                          | High       | 25            |
| Bhayangkara                | 2,531                          | Medium     | 15            |
| Gigi dan Mulut             | 2,480                          | Medium     | 13            |
| Meuraxa                    | 2,427                          | Medium     | 13            |
| Jiwa Aceh                  | 2,252                          | Medium     | 12            |
| Prince Nayef               | 2,248                          | Medium     | 13            |
| Fakinah                    | 2,117                          | Medium     | 11            |
| Pertamedika                | 1,908                          | Low        | 8             |
| Malahayati                 | 1,699                          | Low        | 6             |
| Meutia                     | 1,530                          | Low        | 5             |
| Ibu dan Anak               | 1,484                          | Low        | 6             |

The species diversity index (H') of trees at the hospitals in Banda Aceh was in the medium (medium) and low (low) category. This condition is ecologically unfavoured, so it is necessary to introduce different species to increase H'. The higher value of H' will have the higher the diversity of species and productivity of the ecosystem, the decreasing pressure on ecosystems and increasing stability of the ecosystem [8]. This is related to resilience as an ecosystem's ability to recover after being disturbed. The faster the condition of the ecosystem is recovered; the better resilience of the ecosystem will be [11]. Resilience is the nature of an ecosystem to increase the possibility of the ecosystem recovering back to its original balance after being disturbed [11]. One of the strategies to achieve the intended resilience is by increasing the value of H' in the natural as well as the artificial community, including the hospital area which should require open green space in accordance with regulations. This is in line with the statement that one of the focuses of attention on environmental ethics is how humans must act and how humans should behave towards the environment [12].

Ecosystems have regularity as an embodiment of the ability of ecosystems to nurture, regulate, and re-balance themselves [13]. The ecosystem balance is referred to as homeostasis, i.e., the ability of the ecosystem to resist various changes in the system as a whole [3]. In addition to maintaining high diversity, communities require regular and random disruptions. In a stable regionally extensive homogeneous community, species diversity is lower than mosaic-shaped forest or regionally disturbed forest at certain times by fire, wind, floods, diseases, and human intervention. After the disturbance, there will usually be an increase in species diversity to a dominance point with only a few species that live for long periods of time and are large in size, thus reversing the tendency for diversity to decrease [4]. In this study site, it did not occur because hospital park managers tended to plant their open green space with the same selected species so that they did not improve the condition of the species diversity index (H').

It suggested that the value of H' ranges from 0-7. If H' ≤ 1 category is very low, if H' ≥ 1-2, it is a low category, if H' ≥ 2-3 it is a medium category, if H' ≥ 3-4 it is high (high), and if H' ≥ 4 the category is very high [2] [6] [10]. The results of data collection at 12 observation stations revealed that two
stations had high 'H' which were the Zainal Abidin Hospital (H' = 3,082) with 27 species and Kesdam Hospital (H' = 3,015) with 25 species. Furthermore, six observation stations had H' values ranging from 2.117 to 2.531 (medium category), and the other four stations had H' values ranging from 1.484 to 1.908 (low category).

Based on the H' value (Table 2), there was a large number of species did not always generate a high species diversity index, although in some research results it shows otherwise. For example, in the Mental Hospital, it was found 12 species with diversity index (H = 2.252), while at R.S. Prince Nayef, it was found 13 species with species diversity index (H' = 2,248). Species diversity index is more determined by variations in the importance values indicated by each species in each sampling unit [4]. The species diversity index (H') can be considered as information about the community [2]. The more varied the composition of the quantitative variables is calculated, the more difficult it is to estimate the unit of each sample even though it is generally accepted that many species tend to produce a high species diversity index.

The existence of plants is essential to reduce the rate of erosion. In other words, the presence of open green space plays a vital role in land and water conservation. The trees with the same architectural model, namely the Rauh model might have different ability to conserve water and soil [14]. Schima wallichii had higher erosion value than Altingia excelsa plant plots. This difference might be caused by a discrepancy in the morphology of the stem of both plants in which the texture of the bark of A. excelsa grooved to the side, while the S. wallichii stem had a straight down skin forming a canal. Additionally, there were also differences in the stem diameter, i.e., S. wallichii had a greater diameter than A. excelsa, so that the water flowing on the S. wallichii stem would be more intense and quickly fall to the ground.

When associated with the existence of tree architecture in the research location, there were several species that need to be maintained because their functions in controlling the flow of rainwater for the surrounding area, and at the same time maintaining the aesthetic values of a hospital area. These species included Pterocarpus indicus, Terminalia catappa, Swietenia mahagophoni, and Delonix regia. However, there were some species (Roystenia regia, Cocos nucifera, Musa pradisiaca, and Pandanus Sp.) that are not too relevant to maintain because ecologically it is less favorable both regarding its functional aspects and beauty.

3.3. Open Green Space (OGS)

The ratio and physiognomy of open green space in the study locations are presented in Table 3 and Figure 1. The results of data analysis show that ten out of 12 research stations had OGS ratio in accordance with the Law on Regional Spatial Ratios. Open green space is part of open space in an urban area that contains plants that are intentionally or unintentionally planted to support direct or indirect benefits of the space. Plants are oxygen producers for all living things on earth, therefore the presence of open green spaces is urgently required. The Law on Spatial Planning stipulates that Article 26 of 2007 states ideally OGS is present in 30% of total area in the region. This provision is a government policy to reforest the city as a natural conservation program. The open green space in a hospital, for example, should fulfill the requirements determined by the law. The study showed that 90% of all observation stations had ideal OGS categories in accordance with the Spatial Law. Only 20% of the hospitals had OGS <30%, i.e., Pertamedika Hospital and Malahayati Hospital. Hospitals in the city of Banda Aceh with thousands of people who inhabit the unit every day as patients or visitors, therefore the ideal area of open green space ratio is expected to be able to produce enough oxygen for all people who interact with the hospitals.

Based on the data in Table 3, most of the open green space of the hospitals (Meutia, Jiwa, Meuraxa, and Zainal Abidin with OGS ratio ≥ 50%) in this study were classified as a good ratio, except Pertamedika which was classified as a poor category. In theory, there are three essential functions of open green space, namely as aesthetic, social and ecological means. As an aesthetic facility, OGS is providing a green landscape in the midst of concrete buildings that look arid; as a social facility, green space provides an air conditioning atmosphere in the midst of urban air heat; and as an ecological
function, OGS contributes significantly to maintaining the balance of the ecosystem. Leaves from trees can neutralize pollution levels. Aside from being a provider of oxygen, OGS also plays a role in absorbing water so that making groundwater safe for consumption. The physiognomy of green space in the research location is presented in Figure 1.

Figure 1. Physiognomy of OGS at the study site of hospitals: (A) Zainal Abidin, (B) Gigi dan Mulut, (C) Meutia, (D) Prince Nayef, (E) Pertamedika, (F) Kesdam, (G) Ibu dan Anak, (H) Fakinah, (I) Meuraxa, (J) Bhayangkara, (K) Jiwa Aceh, (L) Malahayati

The existence of OGS as the lungs of the city, catchment area, and water catchment is crucial for the environmental balance so that there is an urgency for OGS development and conservation programs in each city. The 1992 First Earth Summit in Rio de Janeiro Brazil and the second in Johannesburg agreed that a city should ideally have a balance of built-in space and OGS with 70:30
percent of the total area. The OGS under this study fulfilled for ratio and should be maintained in the future.

In addition to deforestation and desertification, land for OGS gradually decreases in urban areas due to land conversion. Ideally, increasing the combustion of fossil fuels must be balanced with a green program so that more green plants can absorb and offset the increase in CO₂ emissions. In reality, however, environmental programs are often defeated by industrialization programs. The lands which should have been preserved as OGS have been converted into modern business centers which are more profitable in terms of the economy. The number of OGS is decreasing because of the influence of development that is less concerned about the environment and health [15]. The hospital OGSs in Banda Aceh are generally located in the city center, so they are less effective for future development for a long period, although the data in Table 3 shows that the current condition is still in the good OGS ratio category. However, the provincial government of Aceh must anticipate the OGS needs related to the development of hospitals in the future.

| Hospitals           | OGS (%) |
|---------------------|---------|
| Bayangkara          | 51      |
| Fakinah             | 42      |
| Gigi dan Mulut      | 52      |
| Ibu dan Anak        | 41      |
| Jiwa Aceh           | 61      |
| Kesdam              | 45      |
| Malahayati          | 15      |
| Meutia              | 62      |
| Pertamedika         | 9       |
| Prince Nayef        | 48      |
| Zainal Abidin       | 54      |
| Meuraxa             | 60      |

In addition to deforestation and desertification, land for OGS gradually decreases in urban areas due to land conversion. Ideally, increasing the combustion of fossil fuels must be balanced with a green program so that more green plants can absorb and offset the increase in CO₂ emissions. In reality, however, environmental programs are often defeated by industrialization programs. The lands which should have been preserved as OGS have been converted into modern business centers which are more profitable in terms of the economy. The number of OGS is decreasing because of the influence of development that is less concerned about the environment and health [15]. The hospital OGSs in Banda Aceh are generally located in the city center, so they are less effective for future development for a long period, although the data in Table 3 shows that the current condition is still in the good OGS ratio category. However, the provincial government of Aceh must anticipate the OGS needs related to the development of hospitals in the future.

Many OGSs are used as the city’s physical buildings for various purposes. OGS has a vital role in the midst of the hustle and bustle of the city community. Jakarta, for example, with a total area of 66,155 ha, from a total of 1.5 million square meters of green parks in 2000, the number of switching functions reached around 300,000 square meters, most of them turned into business centers. The area of OGS in the field also continued to decrease from 32,110.30 ha (49.40%) in 1972 shrinking to 30,990.32 ha (47.67%) in 1976, shrinking to 27,014.23 ha (41.56%) in in 1979, shrinking to 23,551.35 ha (36.23%) in 1985, shrinking again to 7,246.64 ha (11.14%) in 1999, and remaining to 6,900 ha
(9.12%) in 2004. Based on these data, in the period 1965 to 2004, tens of thousands of hectares of OGS have been ransacked, and hundreds of thousands of trees were cut down [15].

The development of the mobility level of modern society involves users of transportation facilities in the form of motorized vehicles, trains, airplanes, and ships. All types of transportation facilities are driven by machines that burn fossil fuels. The transportation sector needs oxygen for a motorized vehicle engine combustion. This sector coupled with the industrial sector requires large amounts of oxygen if it reaches ten times greater than what human need. Increasing traffic density in urban areas is certainly proportional to the increasing consumption of fuel. As a result, oxygen levels diminish because there is no balance between oxygen contained in the atmosphere from photosynthesis and oxygen demand to support human activities. This phenomenon occurred in Banda Aceh which massively built facilities in all institutions including hospitals leading to the declining green space ratio.

Depreciation of the number of tropical forests and OGS and the expansion of barren and critical areas will have a severe impact on the oxygen supplies in the atmosphere. Increased demand that is not balanced with supply, even a decline in supply due to reduced oxygen producer plants, can cause scarcity of oxygen in the atmosphere. The number of oxygens from time to time will decrease with the narrowing of the green area of agriculture, plantations, forests, landscapes, and grassy sports fields. In addition to experiencing the withdrawal and destruction, the conversion of these lands into industrial estates, airports, highways, business areas, hospitals, offices, campuses, schools, and other concrete buildings causes a reduction in oxygen supplies on the earth. In fact, OGS in the form of urban forests with an area of 25 ha in one year can produce one ton of oxygen to the environment. In order to prevent this from happening in Banda Aceh, initial and further research providing information and data related to OGS are encouraged to conduct to maintain the ideal OGS ratio.

Green plants have an important role in controlling atmospheric CO₂ levels. Decreasing number of green plants also means shrinking the amount of CO₂ that can be absorbed by the green plants leading to high levels of CO₂ in the atmosphere. Every hour, one hectare of leaves of green plants can absorb eight kilograms of CO₂ contained in the atmosphere. This amount is equivalent to CO₂ exhaled through breathing by approximately 200 people at the same time. The leaves in the trees act as air filters to maintain the air quality. The green areas have an important role in supporting life on earth. Therefore, the number of OGS areas must be added along with the increasing population and industrialization in various sectors [15].

4. Conclusions
Based on the results of the study concluded that; (a) 51 species of trees were found belonging to 28 families. The four species had the highest percentage of frequency, namely *Pterocarpus indicus* (5.8%), *Rosystenia regia* (5.19%), *Mangifera indica* (5.19), and *Tamarindus indica* (4.54%). The importance of each species in all stations was relatively small, so the condition of the vegetation in the study area was relatively homogeneous, but there were eight species that had relatively high importance value, namely *Rosystenia regia* (20.01%), *Pterocarpus indicus* (16.23%), *Polyathia longifolia* (10.87%), *Tamarindus indicus* (10.5%), *Veitchia merillii* (9.12%), *Eugenis oleina* (8.97%), *Swietenia mahagoni* (8.85%), and *Mangifera indica* (8.70%). (b) The high category Species Diversity (H’) index was found in the R.S. Zainal Abidin (H’ = 3.082) with 27 species followed by R.S. Kesdam (H’ = 3.015) with 25 species. (c) Generally, OGS at the hospitals in Banda Aceh meets the ratio requirements of the Act.
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