Green space in Ternate: Tree species diversity and physical condition assessment

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Abstract. Greenspace has become an essential element in the built environment. As a crucial living component, trees in the green space need to be maintained to secure their longevity. In Ternate, information on the green space relating to species diversity, tree performance, and other environment variables is still lacking. One of the important green spaces in Ternate is Nukila Park. The purpose of the study was to describe the species diversity and the physical condition of trees in Nukila Park. Data was collected by recording all three species at the research site and observing their physical condition using visual tree assessment (VTA). Results showed that the tree species are dominated by Pterocarpus indicus, Samanea saman, and Swietenia macrophylla. Diversity index (Shannon Wiener, H'), evenness index (E), and Richness index (Margalef, R) were H'=1.92, E=0.69, and R=2.92, respectively. These values indicate that species diversity and evenness were moderate while species richness was low. The tree health showed that most of the trees (81%) were in good condition, while the rest (19%) were damaged caused by pests and diseases. The results could be used to formulate appropriate management of Nukila Park, such as pest and disease control and species enrichment to improve tree health.

1. Introduction

Ternate Island is a volcanic island covering 10,167 ha in North Maluku Province, Indonesia [1]. The existence of the Gamalama volcano on this island makes many areas have steep slopes (slope > 40%), especially the ridges and mountain peaks [2]. Therefore, 2205 hectares of the area is designated as Protected Forest. About 60% of the Ternate Island area is a plantation located on the upper and lower slopes. These forests and plantations make the tree cover on Ternate Island quite dense. Meanwhile, the foot of the mountain is used as a residential area of 2226.73 Ha [3]. In this area, green open space plays a role in enriching tree cover.

Green space is an essential component for urban areas because of its ecological and socio-cultural roles. Its ecological role is to absorb pollution from urban activities, create a comfortable microclimate and provide habitat for various urban wildlife. From the social and cultural perspective, green space functions as recreational facilities and places to interact with other urban communities. Furthermore,
green space is a prerequisite for a city. Act No. 26 of 2007 stipulates that the minimum required green open space is 30% of the total area.

Public green open space in Ternate City currently only covers an area of 2.3 ha, consisting of urban forests, city parks, and green lines. One of them is the 'Taman Nukila' Urban Forest covering 4241 m² or 0.42 Ha [4]. Although the area is small, Nukila Park in the center of Ternate is an important and exciting attraction for the city community. Throughout the day, people come to Nukila Park to play, socialize and enjoy the sea view. The trees that grow thickly in the park provide shade and comfort so that visitors like to spend their time there. Various species of trees in the park are also a habitat for wildlife such as birds and insects.

Many of the plants in Nukila Park are commonly grown in urban areas, such as *angsana* (*Pterocarpus indicus*) and *trembesi* (*Samanea saman*). Unfortunately, studies on plant species in Nukila Park have never been carried out, even though these studies are pretty important to map their species diversity. Visual assessment of trees in Nukila Park is also important to determine their health condition. Information on the diversity of tree species and the current condition of trees can benefit the management of Nukila Park. This information can be used by the Ternate City Government as consideration for the development of Nukila Park for recreational and educational facilities as well as determining appropriate management actions if unhealthy trees are found. For this reason, the study was conducted with the aim of describing the diversity of tree species and their physical conditions in Nukila Park.

2. Methods

2.1 Study site

The study was conducted in Nukila Park, Central Ternate, North Maluku Province, Indonesia (figure 1). Nukila Park is one of the important green spaces in Ternate and is categorized as an urban forest. The area of Nukila Park is 0.4 ha, and its location is towards the east. The study was carried out in June 2021.

![Figure 1. Study site in Nukila Park, Ternate City.](image)

2.2 Procedure

Data collection was carried out by recording the species of all trees in the study location. The unidentified tree species were sampled for their leaves and photographed on the leaves, fruit, trunk, and the whole tree, then the photo was used to identify the species. Identification was carried out in the Bogor Botanical Gardens herbarium. Determination of the value of diversity (diversity, evenness, and species richness index) by counting the number of species and the number of trees and then calculating the diversity index [5]. The physical condition of the tree was observed by visual tree assessment (VTA) [6]. Any symptoms and signs of pest and disease attacks were also recorded.
2.3 Data analysis

Information on tree species in Nukila Park was analyzed to obtain the relative density and diversity of tree species. Relative density refers to the percentage of the number of individuals in a location [7]; the formula is as follows:

\[ \text{RDy} = \frac{n_j}{\sum n_j} \times 100 \]  

(1)

RDy : Relative density

nj : Number of individual species j

The value of plant diversity was obtained by analyzing the value of the species diversity index (Shannon-Wiener), the species richness index (Margalef), and the Evenness Index [5]. The formula used is as follows:

2.3.1 Shannon-Wiener index

\[ H' = -\sum_{i=1}^{S} (p_i \ln p_i) \]  

(2)

pi : \( \sum n_i / N \)

H' : Shannon Wiener Index

ni : The number of individuals of species i

N : Total number of individuals

The Shannon Wiener index classified into three categories: \( H' > 3 \) (high species diversity), \( H' = 1-3 \) (moderate species diversity), and \( H' < 1 \) (low species diversity) [8].

2.3.2 Margalef index

\[ R = \frac{S-1}{\ln N} \]  

(3)

R : Margalef Index (Species richness index)

S : Number of species observed

N : Total number of individuals

The value of \( R < 3.5 \) indicates that species richness is low if \( R = 3.5-5.0 \) indicates moderate species richness and if \( R > 5.0 \), then species richness is high [5].

2.3.3 Evenness Index

\[ E = \frac{H'}{\ln S} \]  

(4)

E : Evenness Index

H' : Shannon Wiener Index

S : Number of species observed

The evenness index value ranges from 0 - 1, with a value close to 0 if the number of plant species between plots has only a few types of the same, while the value will be close to 1 if the number of species found is almost the same between plots with other plots.

3. Results and Discussion

3.1 Tree species in Nukila Park

One of the important green spaces in Ternate is Nukila Park. The number of trees found in Nukila Park was 169 trees from 16 species, eight families (figure 2). The most dominant species found were *Pterocarpus indicus* and *Samana saman*. *P. indicus* can accumulate heavy metal Pb in its leaves from the combustion of motor vehicles. Therefore, this species is widely grown in green spaces in Indonesia. Planting this species in an urban area is expected to reduce city air pollution and provide shade for green space [9, 10].

*Samanea saman* is also commonly planted in urban landscapes since it provides many environmental services, social, and economic benefits to the community. This species has excellent protective shade,
and its wood is widely used as commercial lumber. In addition, *S. saman* has an excellent ability to absorb CO$_2$ and store groundwater [12, 13].

**Figure 2.** Relative density (RD) of each tree species in Nukila Park.

From the result of tree species composition, it appears that the Moraceae family (*Ficus* spp.) has the most significant number of species, six species (figure 2 and figure 3). *Ficus* has a unique inflorescence (syconium or fig fruit), and it is food for wildlife, especially birds, to spread to a broader area. The fig species also has the advantage of growing in many different habits: shrubs, climbers, epiphytes, trees, and hemi-epiphytes. Hemi-epiphytes are also called "strangler figs" because they germinate as epiphytes on trees, develop long aerial roots, which eventually reach the forest floor, and then kill the host tree slowly by "strangling" the host with its roots [14].

*Ficus* is a key resource species often found in the tropics because it can bear fruit throughout the year. Therefore, there are many types of *Ficus* spp., which are a source of food and a source of habitat for various types of animals. In addition, the roots of *Ficus* spp. can adapt to dry, open, rocky, and hard areas making it a pioneer plant in forest ecosystems [15].

**Figure 3.** The number of species in each family in Nukila Park.
In addition to trees, Pandan (Pandanus tectorius) and coconut plants (Cocos nucifera) also grow in the eastern part of the park facing the. These plants provide shade for the dock of the park as well as protect the trees in the center of the park from the direct impact of the coastal breeze. Both of these plants are plant species that are commonly found in coastal areas.

Nukila Park can be an ex-situ conservation area for coastal ecosystem species diversity and improve the ecological function of the surrounding urban area. Barringtonia asiatica, Calophyllum inophyllum and Hibiscus tiliaceus in Nukila Park are characteristic vegetation in coastal ecosystems. Barringtonia asiatica and Calophyllum inophyllum have high adaptability [16] and can withstand ocean waves [17], so both have an important ecological role in the sustainability of Nukila Park. Hibiscus tiliaceus also has a high ecological role because it can break the wind, resist high salinity and be an ornamental plant [18]. The beautiful and large Hibiscus tiliaceus flower can attract pollinators, provide food, and form balance urban park ecosystems for urban animals. Pterocarpus indicus has the highest relative density in Nukila Park (41.42%), apparently it has an IUCN Redlist conservation status of Endangered [19].

3.2 Diversity, evenness, and species richness
Species diversity is a community-level characteristic based on its biological organization, which can indicate community structure. Species diversity can be used to measure community stability which means the ability of a community to keep itself stable even though there are attacks to its components [20]. Diversity has two basic components: richness (the number of species in the study area) and evenness (how much relative abundance or biomass is distributed among species). The high and low diversity index of a plant community depends on the number of species and the number of individuals of each species (species richness). The individual richness and abundance of each species will reflect the vegetation's level of heterogeneity or stability [21].

The species diversity index often used in monitoring biodiversity and ecology is the Shannon Wiener index (H') [22]. Results showed that the Shanon Wiener index (H') obtained in the study site was 1.92, indicated that the species diversity was moderate. Species diversity in younger forest communities such as planted forests tends to be lower than in older communities [8]. Most of the trees in Nukila Park come from planting so that the tree species are quite uniform, and made the population of certain species such as S. saman and P. indicus much higher than others. Similar results were also shown by the species composition in green space in Banda Aceh [23]. Planting trees and other plants need to be carried out in Nukila Park to increase biodiversity. The plants found are generally intentionally planted, and several species may have grown early, so it needs to be enriched with native plant species such as Myristica fragrans [24] and Canarium indicum [25].

The evenness index in Nukila Park was 0.69, in a moderate range. This index shows how evenly the individuals of each species are distributed in the community [26]. The evenness index will be maximized if all species have the same number of individuals in each location. This condition is very rarely found in nature because each species has a special ability to adapt and tolerate environmental conditions in nature which are very complex. Thus, this means that the distribution of the population of each tree species in the study location is not evenly distributed, as can be seen from several species that have a more significant number of individuals than other species.

Species richness refers to the number of species within a defined region, indicated by the Margalef index (R). The results showed that the margalef index was R=2.92. This value indicates that the species richness in Nukila Park is low. The species richness in Nukila Park can be increased by plant enrichment. Increasing species richness will also increase the diversity of ecological functions, which in turn will increase ecological stability.

The plant criteria for planting in Nukila Park are various plants with large crowns, beautiful crowns, and thick leaves to break the wind, balancing microclimate, and be ornamental plants. The coolness maintained and the beautiful scenery of Nukila Park can increase the comfort of the city community in their activities. Examples of suitable plant species around the coastal include Terminalia catappa, Casuarina equisetifolia, and Pongamia pinnata [17].
3.3 Tree physical condition
As many as 81% of the trees in Nukila Park are in healthy condition, while the rest appear to be damaged (table 1). The damaged parts of the tree are in the roots, leaves, stems, and branches, but most commonly found in the branches (table 1, table 2). Almost all physical damage to trees is caused by park maintenance activities, especially the pruning of tree branches. Unfortunately, the remaining cuttings from pruning often do not recover properly and make them vulnerable to pests and diseases. The remains of pieces in some trees were also found to form cavities.

Table 1. Trees' physical condition in Nukila Park.

| No | Species            | Healthy | Damaged | Total |
|----|--------------------|---------|---------|-------|
|    |                    | Roots   | Trunk   | Branches | Leaves |
| 1  | Ficus variegata    | 1       |         |         |        |
| 2  | Ficus virens       | 1       |         |         |        |
| 3  | Ficus rumpfii      | 2       |         |         |        |
| 4  | Ficus subulata     | 1       |         |         |        |
| 5  | Tabebuia aurea     | 2       |         |         |        |
| 6  | Mimusops elengi    | 3       |         |         |        |
| 7  | Inocarpus fagiferus| 3       |         |         |        |
| 8  | Swietenia mahagoni | 4       |         |         |        |
| 9  | Barringtonia asiatica| 3 | 2 | 2 | 5 |
| 10 | Hibiscus tiliaceus | 5       |         |         |        |
| 11 | Ficus sudaica      | 7       |         |         |        |
| 12 | Calophyllum inophyllum | 6 | 1 | 1 | 7 |
| 13 | Ficus benjamina    | 8       |         |         |        |
| 14 | Swietenia macrophylla | 9 | | | |
| 15 | Samanea saman      | 33      | 3       | 4       | 7      | 40    |
| 16 | Pterocarpus indicus| 49      | 13      | 5       | 4      | 22    | 71    |
|    | Grand Total        | 137     | 3       | 17      | 7      | 5     | 32    | 169   |

The tree species that suffered the most damage was the S. saman tree (table 1), and this is also related to the large population of this species (figure 2) and its position in Nukila Park. S. saman tree is planted at the front of the park to the pedestrian. The location is at the front of the park and directly adjacent to the main road. Because of its position, it is most often pruned to prevent tree branches from blocking the road.

Table 2. Symptoms that appear on damaged trees in Nukila Park.

| Tree Parts | Cavities | Chlorosis | Cancer and gall | Rotten | Stem borer | Fungi |
|------------|----------|-----------|-----------------|--------|------------|-------|
| Roots      | 2        | 1         |                 |        |            |       |
| Trunk      | 8        | 3         |                 |        |            |       |
| Branches   | 4        | 3         |                 |        |            |       |
| Leaves     | 4        | 4         |                 |        |            | 1     |
| Grand Total| 14       | 4         | 4               | 3      | 6          | 1     |

Some individual trees are also affected by cancer and gall caused by pathogens such as fungi and bacteria (table 2). Pathogens generally infect their hosts through the secretion of chemical substances that can affect the host's metabolic mechanisms. This causes the pathogens to enter plants easily, absorb nutrients and neutralize the plant's defense reactions [27]. Indications of this pathogen attack can be seen from the gall on the trunk. It occurs because the pathogen stimulates the multiplication of plant tissue so that cell enlargement occurs (symptoms of hyperplasia). Treatment of trees affected by cancer and gall can be done by cleaning the infected parts and then applying pesticides to kill the pathogens. Further damage can be treated by pruning the infected area or cutting down the tree if the severity is very high.
Pruning and felling can prevent the spread of disease to other trees [28], improves light interception, and helps control the growth of branches and shoots [29].

![Image of damaged tree in Nukila park: Trunk of P. indicus tree attacked by stem borer (left); the roots of S. saman were cut to control the spread of the roots (right).](image)

**Figure 4.** Damaged tree in Nukila park: Trunk of *P. indicus* tree attacked by stem borer (left); the roots of *S. saman* were cut to control the spread of the roots (right).

The Nukila park floors are mostly made with paving blocks which apparently interfere with the growth of tree roots. Some parts of the floor that have been paved even lifted due to the continued growth of roots (figure 4). Management action is taken to reduce the influence of roots on the road by cutting the roots. Unfortunately, this action seems to have a negative effect on the tree, such as the roots becoming crooked. By avoiding paving the forest floor around the roots, there will be sufficient growing space for tree roots. In addition, the paved forest floor can be protected from damage caused by root growth so that the frequency of tree root cutting activities can be reduced.

As many as three individual trees were found rotting on some of the branches, especially the upper branches of the canopy (table 2). The leaves were almost gone, and even the tops of the crowns were also starting to rot. Severely damaged trees can harm other trees around them because they can transmit pests and diseases they suffer. These trees are prone to falling and damaging other trees, as well as being dangerous to park visitors. Severely damaged trees can be cut down and then replanted with other suitable species. This action can prevent the spread of pests and diseases, as well as increase the diversity of plant species in the location. Diverse plant species can also support the resistance of trees to pests and diseases [30].

Although physical damage was found in several individual trees, the overall physical condition of the trees in Nukila Park was considered healthy. Maintenance efforts such as tree pruning are actually only carried out on branches that interfere with the mobility of park visitors or pedestrians so that physical damage to trees is minimal. However, additional maintenance is needed to increase the protection of the trees. Several maintenance activities can be carried out, such as fertilizing young plants, applying pesticides to plants infected with pests and diseases, pruning damaged branches or considered dangerous for visitors, felling heavily damaged trees, and enriching tree species. In addition, it is necessary to assess the health condition of the trees on a regular basis in order to determine appropriate maintenance actions and prevent further tree damage.

4. Conclusion

Nukila Park is one of the green open spaces in the type of urban forest in Ternate City. A total of 16 tree species from 8 families grow in this park, the most species being *P. indicus* and *S. saman*. The diversity of tree species is seen based on the Diversity index (Shannon Wiener, \( H \)), evenness index (\( E \)), and Richness index (Margalef, \( R \)); the values are \( H=1.92 \), \( E=0.69 \), and \( R=2.92 \), respectively. These values indicate that species diversity and evenness were moderate while species richness was low. In general,
the trees in Nukila Park are in good physical condition, as many as 81% are healthy, and the rest are damaged in the roots, stems, branches, and leaves.

5. References

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