

# Vegetation analysis of 10 urban forests in the city of Banda Aceh, Indonesia

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Manuscript received: 28 May 2022. Revision accepted: 27 July 2022.

**Abstract.** Dharma W, Zakaria R. 2022. *Vegetation analysis of 10 urban forests in the city of Banda Aceh, Indonesia. Biodiversitas* 23: 4131-4137. The vegetation of urban forests is strongly influenced by the composition of trees planted in the forest area. In order to maintain its sustainability, complete vegetation data is needed as a basis for good urban forest management. The purpose of this study was to identify the species diversity of trees in 10 urban forests in the city of Banda Aceh. The study was conducted using the Cruising method with the count of all vegetation species found in urban forests in the city of Banda Aceh. Data analysis was done by the vegetation analysis method through the calculation of diversity index (H'), Relative Frequency (RF), Relative Density (RD), Relative Dominance (RB), and Importance Value Index (IVI). The results showed that the tree component of the area was composed of 50 tree species representing 2218 individuals. The highest IVI value was found in *Samanea saman* with an IVI value of 67.95, and the lowest was in *Tamarindus indica* species with an IVI value of 8.16. The diversity index in the observed urban forests was low, with the highest index in Tibang forest at only 0.37. In order to increase plant diversity in urban forests in the city of Banda Aceh, plant species enrichment is needed. It is expected to increase ecological functions in the surrounding environments.

**Keywords:** Green open space, tree species, urban forest, vegetation

## INTRODUCTION

Forests are important habitats for biodiversity and are beneficial for the provision of various ecosystem services that are essential for human prosperity. There is ample evidence to explain how biodiversity contributes to forest ecosystem function and the provision of ecosystem services (Brockhoff 2017). The role of trees in forest communities is increasingly difficult to maintain (Mohammadi et al. 2014), considering that community pressures on plant groups from time to time continue to increase. Cities and forest communities are an integral part of increasing urban prosperity (Parajuli et al. 2022). Urban forests are an important part of the urban ecosystem (Lin et al. 2022) which are often referred to as the lungs of the city so urban forests are an important part of urban ecosystems. The driving element in the order of biodiversity is vegetation. Vegetation plays an important role as autotrophs and producers in the ecosystem. This not only plays an important role in improving the environmental quality of urban ecosystems (Lee et al. 2016; Lin et al. 2022) but also becomes an influential repository of the carbon cycle of urban ecosystems (Chaudhary and Rathore 2018). Urban ecosystems have become a burden on the biosphere (Rate 2022), so cities need to increase the provision of environmental services to enhance their role as providers of good environmental quality (Weber 2013).

Urban greening provides several other functions that lighten the ecosystem including carbon sequestration, reduction of temperature, and promotion of aesthetic

beauty. Trees improve air pollution by capturing particulate matter on leaves, stems, bark, and trunks (Samson et al. 2017; Chaudhary and Rathore 2018). Furthermore, pollutants in the form of gases are absorbed by plant stomata. Nowak et al. (2018) reported that simulation data in 2010 showed that trees captured 16,500 tonnes of air pollution in 86 Canadian metropolitan cities.

The conversion of forest areas into urban areas has resulted in the fragmentation of isolated forests surrounded by various kinds of development (Pickett et al. 2008). Fragmentation affects the regeneration process of urban forest composition through changes in seed availability, dispersal, and germination formation (Trentanovi et al. 2013). In this isolated part, there is an increase in higher air temperature, increased nitrogen deposition, hydrological changes, and higher atmospheric carbon dioxide levels in rural forests (Savva et al. 2010). The facts also show that plant species that thrive in urban areas have similar characteristics and life histories related to tolerance to forest fragmentation events, changes in biogeochemical cycles, and increasing temperatures in urban areas, being a limiting factor for functional diversity (Johnson and Swan 2014).

Species composition is an integrative response variable for community groups (Dray et al. 2012) that react to local environmental conditions (Johnstone et al. 2016). For example, disposal data are particularly useful in assessing levels of non-native plant species in urban environments (Trentanovi et al. 2013), which have provided important information on the challenges of certain forest species to regenerate in the absence of fire (Hutchinson et al. 2012).

Urban vegetation is also a valuable food source for wildlife. The regional distribution of vegetation patches in urban environments is a habitat for arthropods (Vergnes et al. 2012), birds (Litteral and Wu 2012), and mammals (Hale et al. 2016), all of which use plants as food and cover. Species respond to relationships and plot sizes differ depending on their functional characteristics (Litteral and Wu 2012). In maintaining the function of the urban forest ecosystem in Banda Aceh, targeted management actions are needed that involve all stakeholders in the area. To support these management efforts, data on species, vegetation structure, density, dominance, frequency, importance index, and species diversity index, as well as ecological data are needed. Based on the description above, it is necessary to conduct research on the analysis of urban forest vegetation in Banda Aceh

Furthermore, it is said that the mastery of a species over another species is determined based on the Importance Value Index (IVI), which is the sum of the relative density, relative dominance, and relative frequency. The index is a value that describes the role of the existence of a species within the community. The greater the IVI, the greater the role of the species in the community. This study aims to identify the diversity of tree species in 10 urban forests in the city of Banda Aceh. The result of this study can be considered basic information for supporting sustainable environmental management of the city of Banda Aceh.

## MATERIALS AND METHODS

### Study area

The study was located at the following 10 locations in Banda Aceh's urban forest: (i) Krueng Cut 1 forest, (ii)

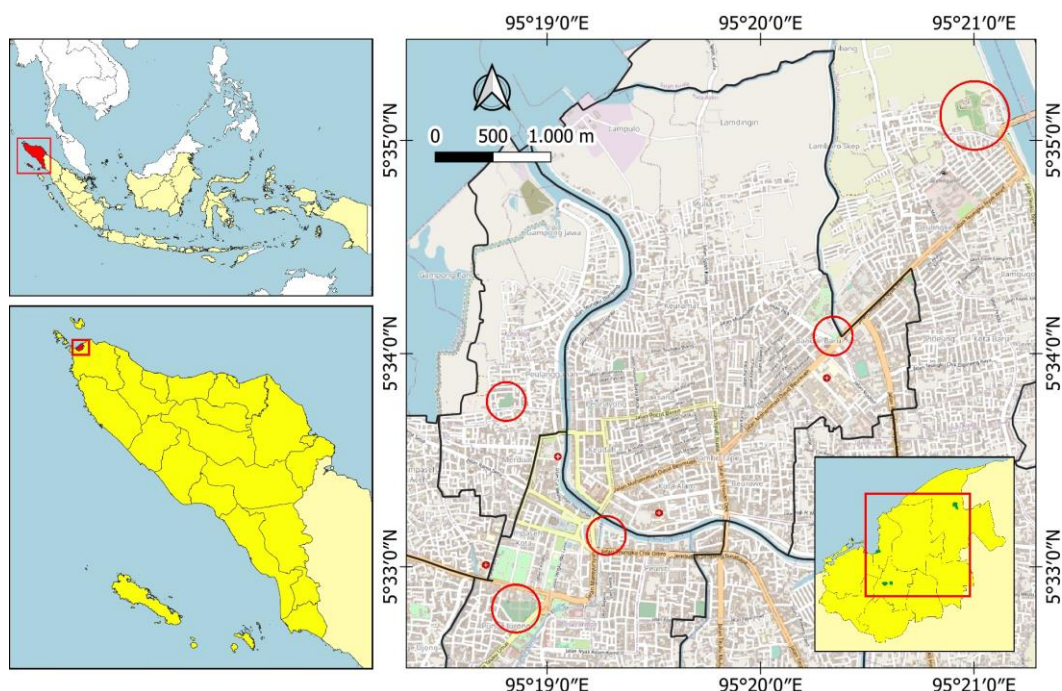
Krueng Cut 2 forest, (iii) the forest in front of the Mesjid Raya, (iv) forests of POM, (v) Kherkhoff forest, (vi) Setui Simpang Tiga forest, (vii) Putroe Phang forest, (viii) Ratu Safiatuddin forest, (ix) Tibang forest, and (x) Trembesi forest. The sizes of each study area are presented in Table 1.

### Data collection

The data collection was done by the Cruising method considering the study area is relatively not too extensive, and given enough time, so that the enumeration can be performed on all the population. Exploration was carried out using the Cruising method at the research site. The types of plants found during the exploration were recorded in field notebooks. In addition to species recording, plant specimen collection activities were also carried out. The research sites of each study area are presented in Figure 1.

**Table 1.** Research location and area of Banda Aceh urban forest

| No. | Urban forest       | Sub-district | Area (ha) |
|-----|--------------------|--------------|-----------|
| 1   | Krueng Cut-1       | Syiah Kuala  | 3.91      |
| 2   | Krueng Cut-2       | Syiah Kuala  | 1.84      |
| 3   | Mesjid Raya        | Baiturrahman | 0.21      |
| 4   | POM                | Baiturrahman | 0.34      |
| 5   | Kherkhoff Pocut    | Baiturrahman | 4.44      |
| 6   | Simpang Tiga Setui | Banda Raya   | 0.09      |
| 7   | Putroe Phang       | Baiturrahman | 2.42      |
| 8   | Ratu Safiatuddin   | Kuta Alam    | 0.24      |
| 9   | Tibang             | Syiah Kuala  | 6.22      |
| 10  | Trembesi           | Kuta Raja    | 2.50      |



**Figure 1.** Research sites in Banda Aceh's urban forest, Indonesia

## Data analysis

Data were analyzed using descriptive statistics through calculations performed with the formulas and procedures contained in Mueller-Dombois and Ellenberg (1974). The data gathered was analyzed using parameters: population density, frequency, dominance, relative density, relative frequency, relative dominance, and IVI. This kind of analysis provides a better index than density itself regarding the importance or function of a species in its habitat. It also gives rank or order to a particular species within the forest community. The level of diversity of each area was obtained through the determination of the Shannon Wiener diversity index. The data obtained were analyzed using the important value index formula (IVI) by Soerianegara and Indrawan (1988), where the formula is as follows:

$$\text{Density (D)} = \frac{\text{Number of individuals of a type}}{\text{Area of whole plot}}$$

$$\text{Relative Density (RD)} = \frac{\text{Density of a type}}{\text{Density of all types}} \times 100\%$$

$$\text{Frequency (F)} = \frac{\text{Number of plots found of a type}}{\text{Total of plots}}$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of a type}}{\text{Frequency of all types}} \times 100\%$$

$$\text{Dominance (D)} = \frac{\text{Area basal area of a type}}{\text{Area of whole sample plot}}$$

$$\text{Relative Dominance (RDo)} = \frac{\text{Dominance of a kind}}{\text{Dominance of all types}} \times 100\%$$

$$\text{IVI (Important Value Index)} = \text{RF} + \text{RD} + \text{RB}$$

To determine the species diversity, we used the Shannon-Wiener diversity index with the formula:

$$H' = - \sum p_i \cdot \ln p_i$$

Where:

H': Shannon Diversity Index

Pi : (n/N)

Ni: number of individuals to-i

ln : Natural Logaritma

The vegetation data were quantitatively analyzed for density, frequency, and abundance according to the formula given by Curtis and McIntosh (1950). The relative values of density, frequency, and dominance are summarized to obtain the IVI of individual species. The analysis was also done by looking at group closeness in each area using clustering method analysis through Percent Similarity measurement using MVSP (Multi-Variate Statistical Package) 3.22 software.

## RESULTS AND DISCUSSION

The topography of the city of Banda Aceh City ranges 2 m from sea surface level. According to the Master Plan of green open space of the city of Banda Aceh 2009-2029, the

physiography is relatively flat with a slope between 2 and 8%. The city of Banda Aceh and its surroundings are topographically the flood areas of Krueng Aceh, and 70% of its territory is located at an altitude of fewer than 5 meters above sea level. The upstream is narrow and wavy with a height of up to 50 meters above sea level. This area is flanked by steep hills to the west and east at an altitude of more than 500 m, making it similar to a cone with its mouth facing the sea. The topographic and physiographic of the land greatly affect the drainage system.

The absence of complete vegetation data on the diversity index and IVI values in each urban forest in the city of Banda Aceh is the basis for this study. Based on vegetation analysis conducted on 10 sampling sites (urban forest) found 10 tree species with the highest IVI value among 50 tree species in the city of Banda Aceh were shown in Figure 2, i.e., *Samanea saman* (67.95), *Casuaria equisetifolia* (36.53), *Swietenia mahagoni* (17.51), *Mimusops elengi* (17.34), *Delonix regia* (15.01), *Pterocarpus indicus* (14.86), *Terminalia cattapa* (11.90), *Platypodium javanicum* (10.41), *Roytonea regia* (8.89), and *Tamarindus indica* (8.16). In other words, *Samanea saman* is the most dominant species in the 10 urban forest areas. The species is generally a tree planted on urban roads and has proven to be very adaptable to unfavorable urban growth conditions (Ow and Ghosh 2017; Ow and Yusof 2018). Plant species that are successful in urban areas tend to be tolerant in their life history (Johnson and Swan 2014).

Furthermore, Arrijani (2006) stated that the presence of a certain tree species in a certain area shows the ability of the tree to adapt to the local environment so that species that dominate an area can be expressed as a species that has wide adaptability and tolerance to environmental conditions.

Figure 2 shows the composition and structure of plants whose value varies on each species because of the differences in the character of each tree. According to Kimmins (1987), variations in the structure and composition of plants in a community are influenced, among others, by plant phenology, dispersal, and natality. The success of becoming a new individual is influenced by the different vertices and fecundity of each species so that there are differences in the structure and composition of each species. According to Sundarapandian and Swamy (2000), the Important Value Index is one of the parameters that shows the role of species in the community or at the study site. The presence of the *Samanea saman* in the urban forest of Banda Aceh is an effort made by the city government to plant the tree. Furthermore, Turner (2010) says that ecologists are increasingly aware of the widespread impact of human activities on the diversity, structure, and function of vegetative communities, and their role as providers of ecosystem services (Utarasakul 2017). In Bangkok, *Samanea saman* is one of the flagship species selected by policymakers and governments to be planted in many city parks for various reasons. Humans have a direct role in regulating urban vegetation (Faeth et al. 2011). Another important constituent of changes in biodiversity associated with urbanization is changes in species

composition. There are often radical changes in community composition, even when overall species richness is comparable to or sometimes higher than that of communities in the wild (Faeth et al. 2011; Bang et al. 2012).

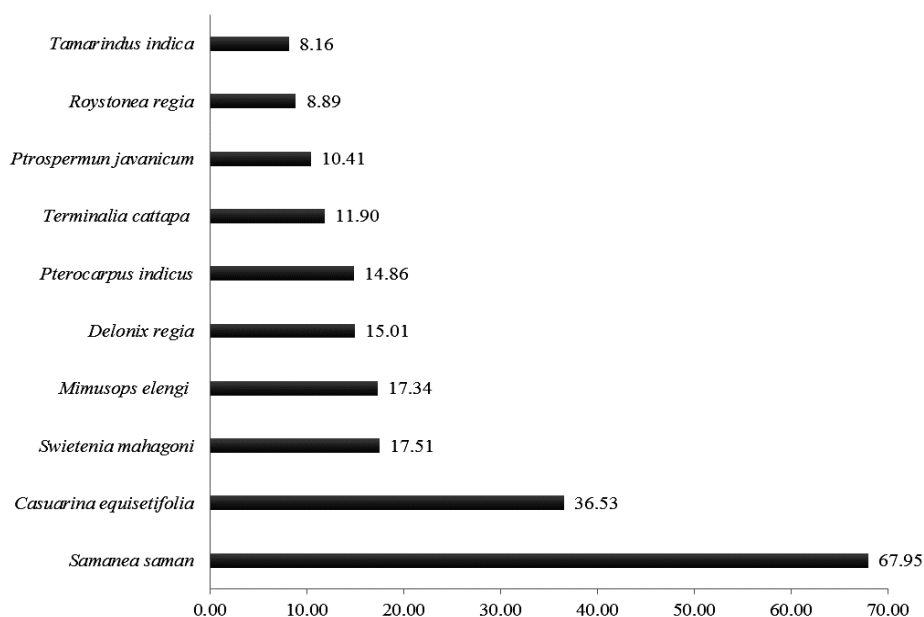
The results of relative density, relative frequency, relative dominance, and IVI are presented in Table 2. *Samanea saman* had the highest IVI compared to other species. The species has great benefits, especially its role in addressing environmental problems. It is a fast-growing tree and is distributed in tropical and sub-tropical countries (Heyne 1987). The tree has a wide canopy exceeding the size of its vertical height and resembles an umbrella. It is often used by people as a protective tree. As stated by Bashri et al. (2018), the thick and circular canopy form of *Samanea saman* allows it to be used as a protective ornamental plant.

According to Lubis (2013), *Samanea saman* may reach a maximum height of 15–25 m with a diameter may reach 1–2 m, and the canopy may reach a diameter of 30 m. *Samanea saman* forms an umbrella-shaped canopy, with a horizontal spread of the canopy that is larger than the height of the tree when planted in an open space. In conditions of denser planting, the height of *Samanea saman* may reach 40 m, and the diameter of the canopy is smaller. This plant is very tolerant of extreme conditions. Therefore, the tree can grow everywhere. It may grow in shallow poor soils and is tolerant to acidic soils. Staples et al. (2006) stated that this plant grows on soil with a wide range of pHs, from acid to alkaline soils, and with little nutrient content. In the concept of dominance, this species has the highest IVI value, and high tolerance and can compete with other species growing together in the area. This is in line with the opinion of Murti et al. (1986) who stated that an index of important values is needed to determine the level of mastery of tree species in stands. The higher the index of important values of a species, the higher the mastery of that species in the community where it grows.

Table 2 shows *Artocarpus communis*, *Cyrtostachys laca*, *Filicium decipiens*, *Murraya koenigii*, *Morinda citrifolia*, *Moringa oleifera*, *Pithecelobium dulce*, *Syzygium aqueum*, and *Syzygium cumini* had the lowest species index values found in the green open space of urban forests in the city of Banda Aceh. They were very rarely found in the 10 study areas.

The density values of each species listed in Table 2 show that there are striking variations in the density of 48 species found in the study areas. The total number of individuals of the 48 tree species was 2159, with the lowest relative density value (RD) found in *Artocarpus communis* (0.05%), *Cyrtostachys renda* (0.05%), *Filicium decipiens* (0.05%), *Murraya koenigii* (0.05%), *Morinda citrifolia* (0.05%), *Moringa oleifera* (0.05%), *Pithecelobium dulce* (0.05%), *Syzygium aqueum* (0.05%), and *Syzygium cumini* (0.05%), and the highest RD value was in *Samanea saman* (25.20%). This study showed that there were nine tree species having the lowest value of RD. This is caused by the number of individuals rarely found in the sampling areas. *Samanea saman* had the highest RD value due to its high number of individuals found in almost every study area. The density of a species shows the number of individuals within a certain area unit. The density value cannot provide an idea of how the species were distributed and the distribution patterns. The description of the distribution of individuals of a particular species can be seen from its frequency value, while the patterns of distribution can be determined by comparing the mean values of certain species with the overall population variance (Arrijani et al. 2006).

The density value of a species indicates the number of individuals concerned in a certain unit area, thus it is an overview of the number of species in the forest area in the city of Banda Aceh. Nevertheless, the density value has not been able to provide a description of the distribution and pattern of the spread of the plants in the study areas.



**Figure 2.** Plant species with the highest important value index (IVI) from 10 urban forests in Banda Aceh, Indonesia

**Table 2.** IVI values of tree species found from 10 urban forests in Banda Aceh, Indonesia

| Species                                  | Family         | Local Name       | RF (%) | RD (%) | RDo (%) | IVI   | H'    |
|------------------------------------------|----------------|------------------|--------|--------|---------|-------|-------|
| <i>Samanea saman</i> Jacq.               | Fabaceae       | Trembesi         | 7.21   | 25.2   | 35.54   | 67.95 | 0.35  |
| <i>Casuarina equisetifolia</i> L.        | Casuarinaceae  | Cemara laut      | 6.31   | 12.88  | 17.35   | 36.53 | 0.26  |
| <i>Swietenia mahagoni</i> L.             | Meliaceae      | Mahoni           | 5.41   | 6.81   | 5.29    | 17.51 | 0.18  |
| <i>Mimusops elengi</i> L.                | Sapotaceae     | Bunga Tanjung    | 2.7    | 8.57   | 6.07    | 17.34 | 0.21  |
| <i>Delonix regia</i> L.                  | Fabaceae       | Flamboyen        | 4.5    | 3.89   | 6.62    | 15.01 | 0.13  |
| <i>Pterocarpus indicus</i> Willd.        | Fabaceae       | Angsana          | 5.41   | 7.27   | 2.19    | 14.86 | 0.19  |
| <i>Terminalia cattapa</i> L.             | Combretaceae   | Ketapang         | 5.41   | 4.96   | 1.54    | 11.9  | 0.15  |
| <i>Pterospermum javanicum</i> Jungh.     | Malvaceae      | Bayur            | 2.7    | 0.69   | 7.02    | 10.41 | 0.03  |
| <i>Roystonea regia</i> (Kunth) O.F.Cook. | Arecaceae      | Palem Raja       | 2.7    | 1.99   | 4.19    | 8.89  | 0.08  |
| <i>Tamarindus indica</i> L.              | Fabaceae       | Asam jawa        | 3.6    | 2.55   | 2       | 8.16  | 0.09  |
| <i>Alstonia scholaris</i> L.             | Apocynaceae    | Pulai            | 2.7    | 2.13   | 2.43    | 7.26  | 0.08  |
| <i>Acacia mangium</i> Willd.             | Fabaceae       | Tongke Hutan     | 5.41   | 1.02   | 0.8     | 7.23  | 0.05  |
| <i>Sterculia foetida</i> L.              | Malvaceae      | Kepuh            | 1.8    | 3.57   | 1.27    | 6.64  | 0.12  |
| <i>Polyalthia longifolia</i>             | Annonaceae     | Asoka            | 1.8    | 3.29   | 0.91    | 6     | 0.11  |
| <i>Azadirachta indica</i> A.             | Meliaceae      | Imba             | 2.7    | 1.85   | 0.6     | 5.16  | 0.07  |
| <i>Senna siamea</i> Lam.                 | Fabaceae       | Johar            | 2.7    | 1.57   | 0.66    | 4.93  | 0.07  |
| <i>Ficus benjamina</i> L.                | Moraceae       | Beringin         | 2.7    | 0.93   | 1.18    | 4.81  | 0.04  |
| <i>Paraserianthes falcataria</i> L.      | Fabaceae       | Sengon           | 2.7    | 1.16   | 0.64    | 4.5   | 0.05  |
| <i>Lannea grandis</i> Engl.              | Anacardiaceae  | Kayu Jawa        | 1.8    | 1.39   | 0.53    | 3.72  | 0.06  |
| <i>Vitex pubescens</i> Vahl.             | Lamiaceae      | Laban            | 1.8    | 1.11   | 0.54    | 3.45  | 0.05  |
| <i>Sesbania grandiflora</i> L.           | Fabaceae       | Turi             | 0.9    | 0.93   | 0.41    | 2.23  | 0.04  |
| <i>Hibiscus tiliaceus</i> L.             | Malvaceae      | Siron            | 0.9    | 0.93   | 0.33    | 2.16  | 0.04  |
| <i>Tectona grandis</i> L.F               | Verbenaceae    | Jati             | 1.8    | 0.28   | 0.06    | 2.14  | 0.02  |
| <i>Areca catechu</i> L.                  | Arecaceae      | Pinang           | 0.9    | 0.93   | 0.31    | 2.13  | 0.04  |
| <i>Bauhinia purpurea</i> L.              | Fabaceae       | bunga kupu-kupu  | 1.8    | 0.23   | 0.06    | 2.09  | 0.01  |
| <i>Cocos nucifera</i> L.                 | Arecaceae      | Kelapa           | 1.8    | 0.09   | 0.04    | 1.93  | 0.01  |
| <i>Hura crepitans</i> L.                 | Euphorbiaceae  | Buah roda        | 0.9    | 0.51   | 0.26    | 1.67  | 0.03  |
| <i>Flacourtia rukam</i> Zoll.            | Flacourtiaceae | Rukam            | 0.9    | 0.51   | 0.15    | 1.56  | 0.03  |
| <i>Mangifera indica</i> L.               | Anacardiaceae  | Mangga           | 0.9    | 0.32   | 0.33    | 1.55  | 0.02  |
| <i>Terminalia mantaly</i> H.Pirier       | Combretaceae   | Ketapang kencana | 0.9    | 0.42   | 0.11    | 1.43  | 0.02  |
| <i>Barringtonia asiatica</i> L.          | Lecythidaceae  | Keben            | 0.9    | 0.37   | 0.06    | 1.33  | 0.02  |
| <i>Aleurites moluccana</i> L.            | Euphorbiaceae  | Kemiri           | 0.9    | 0.28   | 0.06    | 1.24  | 0.02  |
| <i>Cananga odorata</i> Lam.              | Annonaceae     | Kenanga          | 0.9    | 0.19   | 0.05    | 1.13  | 0.01  |
| <i>Spathodea campanulata</i> Beauv.      | Bignoniaceae   | Tulib            | 0.9    | 0.19   | 0.05    | 1.13  | 0.01  |
| <i>Muntingia calabura</i> L.             | Muntingiaceae  | Seri             | 0.9    | 0.19   | 0.01    | 1.1   | 0.01  |
| <i>Azadirachta excelsa</i> Jack.         | Meliaceae      | Mimba            | 0.9    | 0.14   | 0.02    | 1.06  | 0.01  |
| <i>Acacia auriculiformis</i> A.Cunn.     | Fabaceae       | Akasia           | 0.9    | 0.09   | 0.06    | 1.05  | 0.01  |
| <i>Morinda citrifolia</i> L.             | Rubiaceae      | Mengkudu         | 0.9    | 0.05   | 0.1     | 1.05  | 0.001 |
| <i>Erythrina cristagalli</i> L.          | Fabaceae       | Dadap            | 0.9    | 0.09   | 0.03    | 1.02  | 0.01  |
| <i>Calophyllum inophyllum</i> L.         | Calophyllaceae | Nyamplung        | 0.9    | 0.09   | 0.02    | 1.01  | 0.01  |
| <i>Syzygium cumini</i> L.                | Myrtaceae      | Jamblang         | 0.9    | 0.05   | 0.04    | 0.98  | 0.001 |
| <i>Artocarpus communis</i> Forst.        | Moraceae       | Sukun            | 0.9    | 0.05   | 0.02    | 0.96  | 0.001 |
| <i>Cyrtostachys renda</i> Blume.         | Arecaceae      | Pinang Merah     | 0.9    | 0.05   | 0.01    | 0.96  | 0.001 |
| <i>Murraya koenigii</i> L.               | Rutaceae       | Daun Salam       | 0.9    | 0.05   | 0.01    | 0.96  | 0.001 |
| <i>Moringa oleifera</i> L.               | Moringaceae    | Kelor            | 0.9    | 0.05   | 0.01    | 0.96  | 0.001 |
| <i>Pithecellobium dulce</i> Benth.       | Fabaceae       | Asam belanda     | 0.9    | 0.05   | 0.02    | 0.96  | 0.001 |
| <i>Syzygium aqueum</i> Burm.             | Myrtaceae      | Jambu Air        | 0.9    | 0.05   | 0.01    | 0.96  | 0.001 |
| <i>Filicium decipiens</i> Wight & Arn.   | Sapindaceae    | Ki Payung        | 0.9    | 0.05   | 0.01    | 0.95  | 0.001 |

Note: RD: relative density; RF: relative frequency; RDo: relative dominance; IVI: important value index; STD: Standard Deviation; (H'): Diversity Index; AVR: Average

The description of the distribution of individuals of a species can be seen from the value of relative frequency (RF). The highest relative frequency was found in *Samanea saman* (7.21%), and the lowest value was 0.90%, found in *Artocarpus communis*, *Cyrtostachys renda*, *Filicium decipiens*, *Murraya koenigii*, *Morinda citrifolia*, *Moringa oleifera*, *Pithecellobium dulce*, *Syzygium aqueum*, *Syzygium cumini*, *Acacia auriculiformis*, *Calophyllum inophyllum*, *Erythrina cristagalli*, *Azadirachta excelsa*, *Cananga*

*odorata*, *Muntingia calabura*, *Spathodea campanulata*, *Aleurites moluccana*, *Mangifera indica*, *Barringtonia asiatica*, *Terminalia mantaly*, *Flacourtia rukam*, *Hura crepitans*, *Areca catechu*, *Hibiscus tiliaceus*, and *Sesbania grandiflora*. The variation of FR values is in line with Greig-Smith (1983) who stated that the frequency value of a species is directly influenced by the density and the distribution pattern.

The relative dominance value (RDo) of each species also varied from the highest (35.54%) for *Samanea saman*, and the lowest (0.01%) for *Muraya koenigii*, *Muntingia calabura*, *Moringa oleifera*, *Cyrtostachys renda*, *Syzygium aqueum*, and *Filicium decipiens*. The RDo of each species is calculated based on the diameter at breast height (dbh) of the stem so that the value of dominance is also influenced by the density of the species and the average size of the stem diameter of each tree of the same species.

The Important Value Index of all species further becomes the basis for computing Shannon-Wiener's diversity ( $H'$ ) index. The results of the calculations indicate that the highest diversity index in all study areas is Tibang forest ( $H'$  0.37), followed by Trembesi forest (0.32), Putroe Phang forest (0.27), Kherkhoff forest (0.20), Krueng Cut-2 forest (0.18), POM forest (0.17), Mesjid Raya forest (0.10), Safiatuddin forest (0.09), Krueng Cut-1 forest (0.08), and Simpang Tiga Setui forest (0.06) (Figure 3). Magurran (1988) pointed out that the value of the diversity index ( $H'$ ) is related to the species richness in a particular area, but also influenced by the distribution of species abundance. This study found 37 tree species and 799 individuals with an  $H'$  value of 0.37 in the Tibang forest. Indriyanto (2006) stated that a community has a high species diversity if it consists of many species. Conversely, a community has a low species diversity if it is composed of a few species and only a few dominant species exist.

Figure 3 shows that Tibang forest had a diversity index of 0.37 and was included in the category of low level of diversity. According to Wilhm and Dorris (1968), the value of  $H' \leq 1$ , is categorized as low diversity, and a value of  $1 \leq H' \leq 3$ , as medium-sized. According to Barbour et al. (1987), the species diversity index is important information about a community. In Tibang and other forests, the value of the diversity index was low because of the absence of replanting (no interference) after the tsunami in 2004. Low diversity index values are generally found in a stable community. To maintain high diversity, the community needs disturbance regularly. Usually, after the disturbance passes, there will be an increase in species diversity to a point where the community reaches climax.

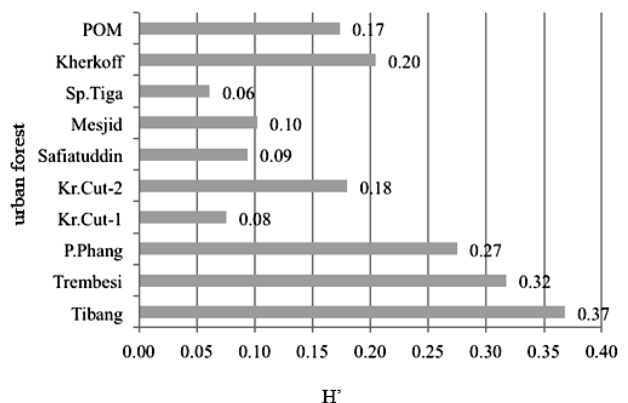
Since calculated in the determination of this diversity index is only in the species of tree habitat, the value of species diversity in the study areas is actually higher than the results reported in this study. Therefore, the level of vegetation biodiversity in the study area is actually very high.

The result of the Nearest Neighbors Cluster Analysis of the 10 study areas is shown in Figure 4. The grouping was performed using Percent Similarity. The position of each area on the dendrogram illustrates the similarity among each location. Study areas with adjacent positions linked to connecting lines indicate that the distance between the two areas is closer than that of the other areas. Likewise, study areas that are far apart and linked to a longer line (higher Percent Similarity value) indicate that the species has a longer distance than other species.

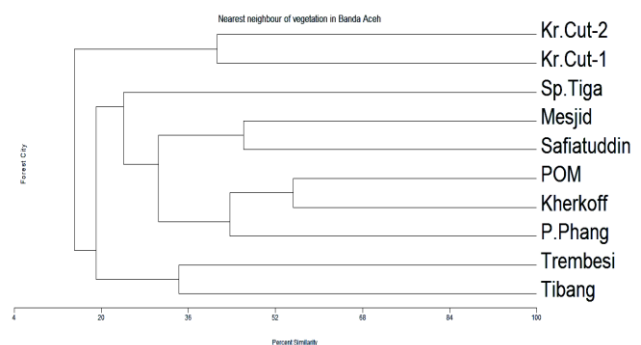
The dendrogram in Figure 4 showed that there is a tendency for separation of each area. Cluster analysis of the 10 observation areas showed that the level of vegetation

similarity among species was relatively low, the highest percentage of similarity was Kherkhoff forest and POM forest with 55.31%, and the lowest was Mesjid forest and Krueng Cut 1 forest, Mesjid forest and Krueng Cut 2, Simpang Tiga Setui and Mesjid forest, with each of 0.0%. The smaller the percent similarity for each combination of observed areas, the lower the similarity level. In general, the level of evenness of vegetation types in each of the forest areas illustrates that there are certain types of vegetation that are very dominating so that other types of vegetation are uneven. This is very clearly shown in the Kherkhoff forest and POM forest. The evenness value of vegetation type is determined by the distribution of each type of vegetation in each study area. The more evenly distributed type of vegetation in all study areas, the higher the value of evenness of the species.

In conclusion, the level of vegetation diversity in the urban forests of Banda Aceh is considered low. The composition of tree species in the study area comprised 48 tree species with 2159 individuals, the highest IVI was found in *Samanea saman* and the lowest was *Tamarindus indica*. In order to increase plant diversity in urban forests in the city of Banda Aceh, plant species enrichment is needed. It is expected to increase ecological functions in the surrounding environments.



**Figure 3.** Diversity index ( $H'$ ) of tree species from 10 urban forests in Banda Aceh, Indonesia



**Figure 4.** The Nearest Neighbor Cluster from 10 urban forests in Banda Aceh, Indonesia

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