Vegetation analysis of highland tropical rainforest in the conservation area

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Abstract. Nature protection and preservation in Indonesia is carried out by designating certain places as nature reserves. One area that has been chosen as a nature reserve in East Java is the Mount Sigogor Nature Reserve, with the most extensive type of mountain tropical rainforest in the area. The purpose of this study was to determine the composition of species at the level of trees and species dominant in mountain tropical rainforests. Data collection method uses the quadrant method (Point Center Quarter Method). Relationship analysis uses the 2 x 2 Contingency Table method. Based on the results of the study, it founded that the vegetation of Mount Sigogor Nature Reserve consisted of at least 47 tree species including 23 families dominated by couples (Quercus sondaica BL Miq) with INP of 37.93%. The next sequence was Dodonea viscosa with INP of 35.90% followed by Casuarina sp with INP of 28.21%, Litsea glutinosa and Persea odoratissima (Nees) Kosterm with INP of 27.11% and 16.29% respectively. The pair of species that tend to live together is Quercus sondaica with Litsea glutinosa.

1. Introduction

Natural resources, especially forest resources, are one of the most important and potential remedies for human life so that their existence needs to maintain as a buffer function for the living system. Besides, forests have an extensive influence on the condition of land, water sources, human settlements, recreation, animal protection and education [1]. At present, there is more attention in the forest due to their essential role in various aspects of sustainable development. Soil as a necessary part of the forest ecosystem has special conditions in stabilising this ecosystem [2]. Forests formed from various types of plants in which there is an interaction between biotic and abiotic components that form an ecosystem [3]. [4] Trees as the main constituent of forest areas play an important role in water management, germplasm reserves, life support, development resources and state foreign exchange sources. The task of trees in forest communities is increasingly difficult to maintain, given the increasing public pressure on groups of plants.

Indonesia is a country that is known to have a high level of biodiversity with the potential of abundant natural wealth supported by large areas with many islands and in tropical regions. [5] Geographically, Indonesia is between two continents, namely the continent of Asia and the continent of Australia. Besides, Indonesia is also locating around the equator where this condition causes Indonesia to have various types of forests. Tropical rainforests are a feature of natural forests where people grow their plants in climax formation. Another feature of tropical rainforests is the appearance of multi-layered tree canopies and the dominant tree canopy in the upper layers [6]. The cause of forest destruction that is often experienced by tropical forest forests is illegal deforestation which will cause the carrying capacity of the land to decline [7].
Forest vegetation analysis is a study that aims to determine the structure and composition of forests [1], [8], [9] states that the presence of vegetation will have a positive impact on ecosystem balance on a broader scale. For example, in general, the plant will reduce the rate of soil erosion, regulate the balance of carbon dioxide and oxygen in the air, regulate groundwater, improve the physical, chemical and biological properties of the soil. The effect varies depending on the structure and composition of the plants that make up the vegetation formation of the area. [10] The association is one of the forms of interaction that exists between the types of forest vegetation compilers. [11] states that associations divided into positive associations and negative associations. Positive association occurs when a plant species is present simultaneously with other types of plants and will not be forming without the presence of these different types of plants. Negative associations occur when a plant species is not present simultaneously.

Nature protection and preservation in Indonesia is carried out, among others, by appointing certain places as a nature reserve, one of the sites that have designated as a nature reserve in East Java is the Mount Sigogor nature reserve, with the broadest mountainous tropical rainforest ecosystem occupying this area [12].

2. Material and Methods

2.1. Material

This research was carried out in Mount Sigogor Nature Reserve, Ngebel Subdistrict, Ponorogo Regency, East Java Province, while the implementation of the study was in April 2018. The material of this study is all types of trees with breast diameter (dbh) > from 5 cm in the forest area of Mount Sigogor Nature Reserve covering 190.5 ha which is a vast mountain tropical rain forest. While the tools used in this study are: work maps 1: 10,000, compass direction, compass high different, rope off 20 meters, meter length 50 meters, meter 1.5 meters, Altimeter, mobile, calculator, camera and stationery.

2.2. Methods

2.2.1. Sampling

- Establishing the pathway blocked by the Centhong Line as the main route. Then every 250 m the main line is made of branch lines that are made perpendicular to the main line. The first branch path is formed to the left, second to the right, third to the left and so on.
- At each branch line, the measurement points are determined. The distance between the measurement points with one another is 20 m, while the length of the branch path is dependent on the width of the block. So each branch line has not the same measurement point.
- At each measurement point four quadrant lines are determined (in practice this line is only imagined). Then in each quadrant is determined one type of tree that has the closest distance to the measurement point and> 5 cm in diameter. The selected tree then recorded for its kind, measured in diameter at breast height, and the distance of the tree to the measurement point. The recording of tree species is carried out with the help of a local tree identifier, then the name of the botanist is searched in the data and information on the potential of the conservation area.

2.2.2. Data Processing

- Frequency is the distribution of a type which is expressing as a percentage of the presence of the species in the point of measurement of the total number of measurement points.
- Relative Frequency (FR), is the value of the presence of a species divided by the total amount of the frequency of all species multiplied by 100%.
- Relative Density (KR), is the number of individuals of a species divided by the total number of individuals (total individuals) multiplied by 100%.
- Dominance is the mastery of a species in vegetation or community against another species. In this study, dominance determined by calculating the area of the base area of each species.
- Relative Dominance (DR), is the dominance of a species divided by the dominance of all species multiplied by 100%.
- Important Value Index (IVI), is the sum of the Relative Frequency, Relative Density and Relative Dominance \[ [13] [14] [15], [16]\]

Data analysis to determine the association of tree species was made using the 2 x 2 Contingency Table method [17]. In this study, only the main tree species (INP > 12%) included in the analysis. The table contingency form for associations between two types is as follows:

| Species B | Species A | Amount of |
|-----------|-----------|-----------|
| +         | a         | b         | a + b     |
| -         | c         | d         | c + d     |
| Amount of | a + c     | b + d     | a + b + c + d |

**Figure 1.** 2 x 2 Contingency table.

Note:
- \( a \) = Observation of the number of measurement points containing species A and species B
- \( b \) = Observation of the number of measurement points that contain sp B only
- \( c \) = Observation of the number of measurement points that include sp A only
- \( d \) = Observation of the number of measurement points that do not contain species A and species B

While to measure the magnitude of the deviation between the value of the observation with the expectation value is used "Chi-square test", the formula is as below

\[
\text{Chi-square (X}^2\text{) count} = \frac{(ad-bc)^2n}{(a+b)(a+c)(c+d)(b+d)}
\]

This value is compared with the chi-square (\( X^2 \)) table value at a free rate equal to one at the test level of 10% and 5%. Based on these two chi-square values, a conclusion:

- If the chi-square value is calculated to be higher than the chi-square table value, then the two associated types hold real associations at the test level.
- If the chi-square value counts smaller than the chi-square table value, then the two types associated with holding unrealistic associations at the test level.

Determination of the level of association is used by the Association Coefficient [17] with the following conditions:

- If \( ad \geq bc \),
  Then \( C = (ad-bc) / ((a + d) (b + d)) \)
- If \( bc > ad \) and \( d \geq a \),
  Then \( C = (ad-bc) / ((a + d) (b + d)) \)
- If \( bc > ad \) and \( a > d \),
  Then \( C = (ad-bc) / ((b + d) (c + d)) \)

Whereas \( C \) is the level of association between types.

3. Result and Discussion

3.1. The condition of the Observation Area

The Mount Sigogor nature reserve designated as a nature reserve based on SK: Gb No 23 Stbl. 471, 4 September 1936 with an area of 190.5 ha. The Mount Sigogor nature reserve located in Pupus Village, Ngebel District, Ponorogo Regency. The length of the 19.71 Km area boundary line and has been realised as long as 19.71 Km during the reconstruction of the region in 1986. The number of borders
is 364 pal limit. The geographical location of the Mount Sigogor CA is 07°00'48" - 07°00'50" LS and 111°36' - 111°38' BT.

Topography Mount Sigogor Nature Reserve is hilly (located on the western slope of Mount Wilis) with moderate to steep slopes in an altitude of 1,000 - 1,700 masl. The highest peaks include the southern part (Patok Banteng and Batu Blandar areas) and the eastern part (Cenger area). Sigogor CA has young volcanic rock geological formations with soil types that enter the Mediterranean complex, lithosol soil type. The climate type in the region categorised as C with a Q value of 57%. The average rainfall is 2,582 mm / year with the number of rainy days 142 days, the average temperature is 15-20°C at night and 30 - 35°C during the day. [18].

3.2. Composition of Vegetation

Based on the results of research in the location of mountain tropical rainforest, Mount Sigogor Nature Reserve found 47 species of trees included in 32 genera and 23 tribes. The number of trees per hectare is 504 stems, with the total area of the base area per hectare is 92,053.6 m².

Based on the results of medicinal plant exploration [18] found 12 types of medicinal plants. The difference in the number of species compositions is due to the different functions of the surveyed plants. The above discrepancies also caused by the determination of the minimum diameter of trees and the differences in sampling of forested areas surveyed.

A large number of species found at the study site showed that the composition of the forest vegetation composition was quite diverse. With this type of diversity, the stability of the ecosystem will be maintained, as stated by [19] [12] that the existence of species diversity will improve the stability of existing ecosystems because natural pest deterrence can be prevented. Whereas seen from the composition of mountain tropical rainforests Mount Sigogor Nature Reserve is a mixed forest with several species of plants more dominant than others.

3.3. Relative Frequency

The value of the relative frequency of a species indicates the spread of the species in its habitat. Broadly spread species will have a relatively high presence value, and vice versa, the species with a narrow range will have a relatively low presence value.

The distribution of the relative frequency of the tree species that comprise the Mount Sigogor nature reserve which has a corresponding frequency of more than 4% as in the figure below.

![Figure 2. Types of trees composing vegetations that have more than 4% relative frequency value.](image)

In Figure 2, it can seen that *Dodonea viscosa*, *Litsea glutinosa* and *Quercus sondaica* have a high spread compared to others, with a relative attendance value of 11.31%; 10.12% and 8.93%. The widespread of this type is thought to be because this type has a broad tolerance for differences in existing soil moisture and other environmental factors. For plants that have a general understanding, they will be distributed very widely so that the value of their relative presence will be higher than others, such as...
what was stated by [20] opinion that the spread of plant species in the community is a reaction (response ) which are different from these types of microhabitat differences. Among environmental factors that influence the range of plants, soil moisture (water content) is the most influential factor.

3.4. Relative Density

The relative density value calculated as the percentage of a species density for all types. Types of vegetation constituent trees that have a relative density value of more than 4% as shown in Figure 3.

![Figure 3](image1.png)

**Figure 3.** Types of vegetation composers that have relative density value more than 4%.

Figure 3 we can see the types of *Dodonea viscosa*, *Quercus sonaica* and *Litsea glutinosa* having a relatively high-density value compared to others, with a relative density value of 11.70%; 11.17%; 10.64%. Sizeable relative density values of these types because this type is the types of winners in competition and has a broad tolerance so that the unity of the area will find in more significant individuals. - species of trees that have a sizeable Relative Attendance value will tend to have a considerable Relative Density value as well.

3.5. Relative Dominance (DR)

Dominance is a characteristic of the community that states the influence of the control of a species in the community on other species so that the population of other species will relatively reduce in the amount of power of life [21].

![Figure 4](image2.png)

**Figure 4.** Types of tree making vegetation that has a relative dominance value of more than 4%.
Figure 4 shows that the type *Casuarina sp; Quercus sondaica* and *Dodonea viscosa* has a relatively high dominance value, each 18.66%; 18.34% and 12.89%. This high value is thought to be because these types can compete with other species in obtaining sunlight and nutrients in the soil. This is through the opinion of [22] [12] the mastery of a type against another type has to do with the growth of these types. The species that can grow strong and fast will get more light so that it will become thicker and can flow food well and be able to grow roots quickly. This condition causes a greater food supply, deeper penetration and spread more full than the roots so that these types will get better sources of life (water, light and nutrients) than their competitors.

3.6. Important Value Index (IVI)

A vital value index of a species in a plant community shows the level of importance or role of the species in the community. Species that have a significant (dominant) position in the community will have high IVI. IVI obtained by adding up the value of Relative Presence, Relative Density and Relative Dominance. Because the IVI determined by these three relative values, it ranges from 0 to 300 [13].

![Figure 5. Types of trees composing vegetation that has an important value index (IVI) more than 12%.](image)

Figure 5 shows the type of *Quercus sondaica* having the greatest IVI when compared to other species, meaning that this type has the most prominent role when compared to others. Figure 1; 2; 3 and 4 also show that using only one relative value cannot be used to determine whether the role of a species is higher than the others. So the dominance based on an important value index (IVI) provides more information when compared to the dominance that only uses one relative value. This is following what stated by [13], that the use of one relative parameter only provides limited information.

3.7. Species associations

Associations between species were tested using the 2 x 2 Contingency table method, where the types proved had INP ≥ 12%, while the results were presented in table 1 for the chi-square table with a free degree of 1 (one) at level 10 % and 5% respectively were 2.71 and 3.84. It can be seeing that four types of combinations have a positive coefficient, namely *Quercus sondaica* and *Litsea glutinosa*, *Quercus sondaica* with *Casuarina sp, Dodonea viscosa* with *Persea odoratissima* and *Dodonea viscosa* with *Litsea glutinosa* (Table 1). This means that between these types tend to live together, while other types of combinations have negative coefficient values, which means that there are no tendencies to live together. This is following the opinion of [22] who say, that certain types of plants usually grow together and some do not have the tendency to do so.
Table 1. Results of association calculations between tree species that have INP ≥ 12%.

| No. | Species Combination                      | C     | X^2     |
|-----|----------------------------------------|-------|---------|
| 1   | *Quercus sondaica* Vs *Dodonea viscosa*| -0.0771 | 0.2912  |
| 2   | *Quercus sondaica* Vs *Casuarina sp*    | 0.1162 | 1.4512  |
| 3   | *Quercus sondaica* Vs *Litsea glutinosa*| 0.3816 | 6.8433**|
| 4   | *Quercus sondaica* Vs *Persea odoratissima*| -0.2853 | 2.3397  |
| 5   | *Dodonea viscosa* Vs *Casuarina sp*     | -0.1988 | 1.2174  |
| 6   | *Dodonea viscosa* Vs *Litsea glutinosa* | 0.0617 | 0.1956  |
| 7   | *Dodonea viscosa* Vs *Persea odoratissima*| 0.1160 | 0.3113  |
| 8   | *Casuarina sp* Vs *Litsea glutinosa*    | -0.0958 | 0.7215  |
| 9   | *Casuarina sp* Vs *Persea odoratissima* | -0.0622 | 0.2340  |
| 10  | *Litsea glutinosa* Vs *Persea odoratissima*| -0.0253 | 0.0227  |

Data Source: Data processing

Table 1 shows that the combination of *Quercus sondaica* and *Litsea glutinosa* has a specific association at the 5% level. That shows that the joint occurrence between the pair of species is higher than expected [23]. Another possibility is that this pair does not negate one another, or that the type pair has the same reaction to environmental differences[20]. Besides, the tendency to not issue each other between the two types is allegedly causing by the absence of competition between the two species. The lack of this competition is due to the species of life that have the same life needs while the sources that support life's needs themselves fulfilled.

In Table 1 it can be seen that various associative coefficient values are ranging from 0.3816 to -0.2853. The difference in the association coefficient value is caused by:

- Differences in the silvicultural properties of each type of plant, creating gaps in responses to variations in environmental factors.
- Differences in the distribution patterns of each type.
- Difference between soil layers in each placed.
- The difference in the area of land occupied by each type.

4. Conclusion

The constituent vegetation of the mountain tropical rainforest area of the Sigogor Mountain Nature Reserve consists of at least 47 tree species, 32 genera and 23 tribes. Based on the value of the Value Index, the importance is that *Quercus sondaica* is the type that plays the most role in the community with INP equal to 38.44%. Other species that are dominant are *Dodonea viscosa*; *Casuarina sp*; *Litsea glutinosa* and *Persea odoratissima* (Nees) Kosterm with INP 35.90; 28.21; 27.11 and 16.29. The type of couple who has a tendency to live together is *Quercus sondaica* with *Litsea glutinosa*.

References

[1] T. Cahyanto, D. Chairunnisa, and T. Sudjarwo, “Analisis Vegetasi Pohon Hutan Alam Gunung Manglayang Kabupaten Bandung,” *Istek*, vol. VIII, no. 2, pp. 145–160, 2014.
[2] H. Rezaei, A. A. Jafarzadeh, A. Alijanpour, F. Shahbazi, and K. V. Kamran, “Effect of Slope Position on Soil Properties and Types Along an Elevation Gradient of Arasbaran Forest , Iran,” *International J. Adv. Sci. Eng. Inf. Technology*, vol. 5, no. 6, pp. 449–456, 2015.
[3] Zulkarnain, L. O. Alimuddin, and A. Razak, “Analisis Vegetasi Dan Visualisasi Profil Vegetasi Hutan Di Ekosistem Hutan Tahura Nipa-Nipa Di Kelurahan Mangga Dua Kota Kendari,” *Ecogreen*, vol. I, no. 1, pp. 43–54, 2015.
[4] Mariana, F. Wardani, and Warso, “Analisis Komposisi Dan Struktur Vegetasi Untuk Menentukan Indeks Keanekekaraganam Di Kawasan Hutan Kota Pekanbaru;” *J. Pendidik. Biol.*, vol. 3, no. 2, pp. 90–96, 2016.
[5] A. N. Samin, Chairul, and E. Mukhtar, “Analisis Vegetasi Tumbuhan Pantai Pada Kawasan Wisata Pasir Jambak, Kota Padang,” *Biocelebes*, vol. 10, no. 2, pp. 32–42, 2016.
[6] B. Dendang and W. Handayani, “Struktur dan komposisi tegakan hutan di Taman Nasional Gunung Gede Pangrango, Jawa Barat,” in Prosiding Seminar Nasional Masyarakat Biodiversity Indonesia, 2015, vol. 1, no. 4, pp. 691–695.

[7] A. and A. K. Amrizal Saidi, “Prediction of Erosion Rate at Several Land Units in Upper Watershed of Batang Mangau, West Sumatera,” LIASEIT, vol. 3, no. 1, pp. 93–98, 2013.

[8] A. Kusumo, A. Nur Bambang, and M. Izzati, “Struktur Vegetasi Kawasan Hutan Alam dan Hutan Rerdegradasi di Taman Nasional Tesso Nilo,” J. Ilmu Lingk., vol. 14, no. 1, pp. 19–26, 2016.

[9] Arrijani, D. Setiadi, E. Guhardja, and I. Qayim, “Analisis Vegetasi Hutan Alami di Taman Nasional Gunung Gede-Pangrango,” BIODIVERSITAS, vol. 7, no. 2, pp. 147–153, 2006.

[10] S. H. Purnomo, A. A. Bratawinata, B. Simarangkir, P. Matius, and Rahmawati, “Asosiasi Jenis-Jenis Pohon Dominan Utama pada Hutan Bekas Terbakar Berat Tahun 1997/1998 Di Bukit Soeharto Kalimantan Timur,” Forestsaints, vol. 11, no. 2, pp. 92–98, 2014.

[11] A. Kurniawan, N. K. E. Undaharta, and I. M. R. Pendit, “Asosiasi Jenis-jenis Pohon Dominan di Hutan Dataran Rendah Cagar Alam Tangkoko, Bitung, Sulawesi Utara,” BIODIVERSITAS, vol. 9, no. 3, pp. 199–203, 2008.

[12] D. S. Martono, “Analisis Vegetasi Dan Asosiasi Antara Jenis-Jenis Pohon Utama Penyusun Hutan Tropis Dataran Rendah Di Taman Nasional Gunung Rinjani Nusa Tenggara Barat,” Agri-tek, vol. 13, no. 2, pp. 18–27, 2012.

[13] D. E. H. Mueller-Dombois, Aim & Methods of Vegetation Ecology. New York: John Wiley and Sons, 1974.

[14] Onrizal, C. Kusmana, B. H. Saharjo, lin P. Handayani, and T. Kato, “Analisis Vegetasi Hutan Hujan Tropika Dataran Rendah Sekunder di Taman Nasional Danau Sentarum, Kalimantan Barat,” Biology, vol. 4, no. 6, pp. 359–372, 2005.

[15] B. Saharjo Hero and A. D. Nurhayati, “Domination and Composition Structure Change at Hemic Peat Natural Regeneration Following Burning; A Case Study in Pelalawan, Riau Province,” Biodiversitas, J. Biol. Divers., vol. 7, no. 2, pp. 154–158, 2006.

[16] S. Iwao, “Analysis Of Spatial Association Between Two Species Based On The Interspecies Mean Crowding,” 1977.

[17] K. Floriana and M. Warpur, “Struktur, Komposisi Jenis Pohon dan Nilai Ekologi Vegetasi Kawasan Hutan di Kampung Sewan Distrik Sarmi, Kabupaten Sarmi,” J. Biol. PAPUA, vol. 1, no. 2, pp. 72–80, 2009.

[18] S. Titek, “Pemanfaatan Pohon Berkhasiat Obat Di Cagar Alam Gunung Picis Dan Gunung Sigogor, Kabupaten Ponorogo, Jawa Timur,” Penelit. Hutan dan Konserv. Lahan, vol. VII, no. 2, pp. 177–192, 2010.

[19] J. C. Krebs, Ecology. The Experimental Analysis of Distribution and Abundance Sixth Edition, Sixth Edit. United States of America: Pearson Education Limited, 2014.

[20] O. W. Van Auken, D. L. Taylor, C. Shen, and J. K. Bush, “Structure of Isolated Acer grandidentatum (Bigtooth Maple) Communities and Potential Population Changes,” Am. J. Plant Sci., vol. 8, pp. 1368–1387, 2017.

[21] D. H.A. Hilm. and iSim, Technical forestry education Design and implementation. Rome: FOOD AGRICULTURE ORGANIZATION UNITED NATIONS, 1984.

[22] S. Wawan, “Jenis Tanaman, Kerapatan, dan Stratifikasi Tajuk pada Hutan Kemasyarakatan Kelompok Tani Rukun Makmur 1 di Register 30 Gunung Tanggamus, Lampung,” Universitas Lampung, 2016.

[23] F. Dapadeda, E. A. M. Zuhud, and A. Hikmat, “Asosiasi Species Pohon Penyimpan Mayat di Taman Nasional Laiwangi Wanggameti, Nusa Tenggara Timur (Species Association of Corpse Storage Trees in Laiwangi Wanggameti National Park, East Nusa Tenggara),” Media Konser., vol. 22, no. 3, pp. 220–229, 2017.

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