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Structure, Composition, and Diversity of Dry Tropical Forest Types in the Sisimeni Sanam Forest Area, Kupang Regency, East Nusa Tenggara Province

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ABSTRACT
Sisimeni Sanam Forest Area is a tropical dry forest area on Timor Island that plays an important role in life, such as maintaining and preserving soil fertility, being the lungs of the world, being a place for living things to live, being a source of biodiversity, regulating water management, and preventing the dangers of flooding and erosion. Data and information regarding the ecology of vegetation in this forest are still limited. This study aims to determine the structure, composition, and diversity of vegetation types in the Sisimeni Sanam Forest Area. The method used is a systematic sampling method using a double rectangular plot with a plot size of 20 x 20 m (trees), 10 x 10 m (poles), 5 x 5 m (sapling), and 2 x 2 m (seedlings and understorey). The results of the study showed that the types of vegetation found were 49 species grouped into 25 families. *Cromolaena odorata* has the highest relative density and frequency values at the seedling and understorey levels, while Tectona grandis (teak) dominates at the sapling, pole, and tree levels. The important value index at each growth level is in the high category with a value range of 200% - 300%. The value of the Species Diversity Index (H') in the Sisimeni Sanam Forest Area shows a number <1, meaning it is included in the low category. Forests with low species diversity values indicate that the forest area has experienced disturbance or forest damage caused by both nature and humans.

Keyword: Composition, Diversity, Dry Tropical Forest, Sisimeni Sanam, Structure

1. Introduction

Forests in Indonesia are renowned for hosting high biodiversity, which is beneficial to providing human needs, such as food, clothing, timber, medicine, oxygen production, and carbon dioxide absorption [1]. In Indonesia, forests generally have three functions, namely conservation, protection, and production, all of which play vital roles in providing economic, social, cultural, and ecological values. Among such functions, conservation and protection are increasingly considered important since biodiversity protection is a crucial issue of the 21st century, requiring diverse conservation approaches adapted to changing local conditions and varying societal priorities [2].

The first step toward forest conservation and protection is understanding the ecology of a forest which can be used as a reference for its management and conservation strategies. An important element in forest ecology activities is the information on the structure, composition, and diversity of the vegetation community [3].

Vegetation structure is a component that makes up the forest and comprises the growth stage of vegetation in the form of trees, poles, saplings, seedlings, and understorey [3]. Forest vegetation structure is generally categorized as upper canopy, middle strata, shrubs, and vegetation canopy near the ground surface [4]. The current state and future dynamic of forest structure can be anticipated by observing the presence, abundance, and dominance of species within the vegetation community [5].

Besides the importance in terms of biodiversity, the existence of vegetation communities in tropical forest ecosystems is important for maintaining the concentration of carbon dioxide and oxygen in the atmosphere, improving the physical, chemical, and biological properties of soil, as well as regulating the groundwater system [6]-[8]. Vegetation is an essential part of the soil and atmosphere systems [9]-[11]. The presence of undisturbed vegetation in a landscape has a positive impact on the balance of the ecosystem [7,8].

The Sisimeni Sanam Forest Area (SSFA) of Forestry Land Register 185 is a dryland ecosystem managed by the Kupang Regency Forest Management Unit (FMU) in Timor Island, East Nusa Tenggara Province, Indonesia. It has an extent of approximately 49,927 ha, with 497.3 ha designated as a special-purpose educational forest. This area is prone to anthropogenic activities because of its proximity to residential areas, accessibility, and limited monitoring resources. Some of the prevalent problems in SSFA include the clearing of forests for fields, felling of trees, and illegal grazing. Anthropogenic activities can affect the existence of forest vegetation, specifically in dryland ecosystems, which has a strategic role in fulfilling society's protection, conservation, sociocultural, and economic functions [4]. Information on biodiversity, specifically vegetation types, is important to support sustainable forest management. A vegetation community with high diversity consists of many species with low dominance of diversity of a few species and a low-diversity vegetation community is characterized by a few dominant species [4,12].

Previous research on composition, forest structure, and vegetation has been carried out in tropical forests [7,8] [13]-[16], but information about the composition, structure, and types of vegetation in the SSFA remains very limited. This limitation hinders the management and development of the area. Research on vegetation diversity is not only essential for assessing the ecological state and ecosystem services in SSFA but also important for identifying endemic biodiversity that has economic and conservation value in Timor Island, such as the *Santalum album* and *Pterocarpus indicus*. Understanding the diversity, structure, and composition of plant species provides valuable information for area managers [17], aiding in ecosystem services assessment [18]. The lack of the latest data on vegetation structure and composition of SSFA underscores the need for further research, specifically as this forest area is a candidate for a special-purpose educational forest designated by the Kupang State Agricultural Polytechnic. Therefore, this research aimed to determine the structure, composition, and diversity of vegetation types in the SSFA. We expected that our comprehensive exploration would be useful for informed management and development planning in the SSFA

2. Method

2.1 Study area and period

This research was carried out in the SSFA of Forestry Land Register 185, which is under the management of the Kupang Regency FMU, covering an area of 497.37 ha from May to November 2023. The location was selected due to the consideration as a candidate for a special-purpose educational forest by the Kupang State Agricultural Polytechnic, and the presence of anthropogenic activities that could affect the existence of vegetation. Two types of soil were present, namely Renzina and District cambisol, with an extent of 77.07 ha (15.5%) and 420.23 ha (84.5%), respectively. The Renzina soil type had a sloping topography in the form of terraces, while district cambisol had a hilly topography, with both having soil solum of <30 cm and >90 cm, respectively. Additionally, rainfall in forest areas ranged from 400 to 2500 mm per year. The forest in the studied area was originally a teak plantation, planted in 1992 through the Industrial Plantation Forest (IPF) program. However, with the end of the IPF program, the people living around the area started to carry out shifting cultivation, which affected the type of vegetation. Nowadays, there is a mix of vegetation existing in the studied area.

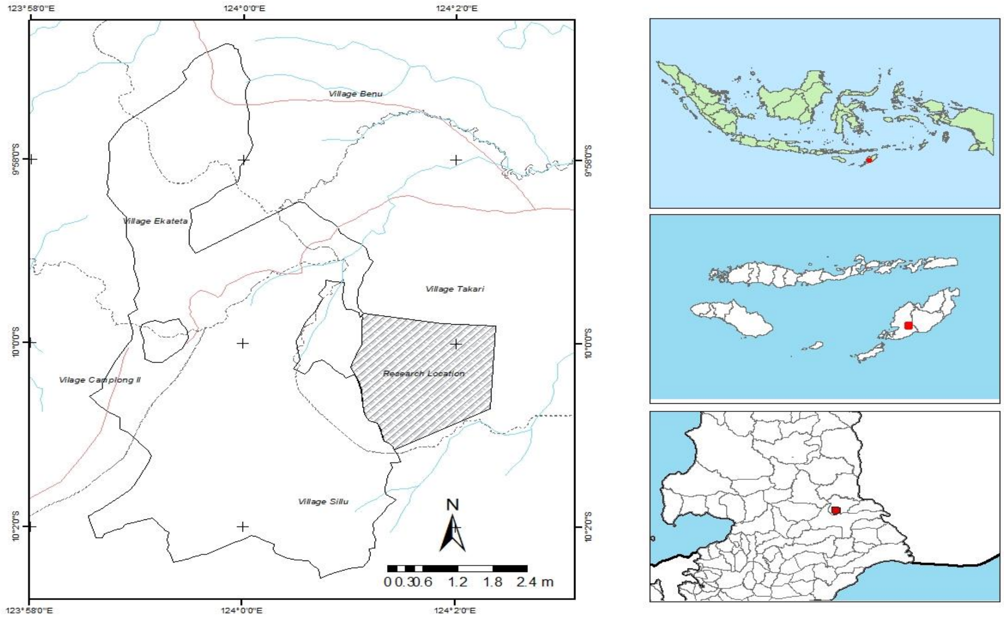

Figure 1. Map of study area in SSFA, Kupang Regency, Timor Island, Indonesia

2.2 Data collection procedure

Data collection was carried out using a systematic sampling method with a double-plot vegetation analysis technique. The sampling intensity used was 1%, resulting in a sampled area of 4.97 hectares with a total of 124 observation plots. This sampling intensity was selected to account for the homogeneity and heterogeneity of vegetation, ensuring a representative sample of the entire forest. The distance between observation plots was 100 meters, and the distance between lanes was 200 meters. The observation plots, designed in a square shape, were established along the transect with 20 x 20 m^2 plots (for tree-level observations) alternating to the left and right of the path. Within the observation plot, smaller plots were nested for different vegetation layers, namely 10 x 10 m2 (pole level), 5 x 5 m2 (sapling level), and 2 x 2 m2 (seedling level) [19]-[22].

Vegetation observations at the pole and tree level include identification of type, number of individuals, height, and diameter at breast height (dbh), while at the seedling & understorey and sapling level, only the type and number of individuals were observed. Specifically, seedlings were defined as tree saplings with a height of less than 1.5 meters. The sapling level was juvenile plants with ≥ 1.5 m in height and < 10 cm in diameter, while the pole level comprised young trees with a diameter ranging from 10–19.9 cm. The tree level was composed of mature trees with a diameter of ≥ 20 cm [1].

2.3 Data analysis

The collected data was subjected to vegetation analysis according to Mueller-Dombois and Ellenberg (1974), on density, frequency, dominance, importance, and index of diversity [7], [21]-[24].

$$\text{Density} = \frac{\text{Number of Individuals}}{\text{Plot area}} \tag{1}$$

$$\text{Relative Density} = \frac{\text{Density of a type}}{\text{Density of all types}} x100\% \tag{2}$$

$$\text{Frequency} = \frac{\text{Number of plots filled with a type}}{\text{Total number of plots}} \tag{3}$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a type}}{\text{Relative frequency of all species}} x100\% \tag{4}$$

$$\text{Dominance} = \frac{\text{Area of the base area in the plot}}{\text{Plot area}} \tag{5}$$

$$\text{Relative Dominance} = \frac{\text{Dominance of a species}}{\text{Dominance of entire species}} x100\% \tag{6}$$

$$\text{Importance Value Index} = \textit{Relative Density} + \textit{Relative Frequency} + \textit{Relative Dominance} \quad (7)$$

$$\text{Important Value Index for seedling and sapling levels} = \textit{Relative Density} + \textit{Relative Frequency} \quad (8)$$

$$\text{Shannon} - \text{Wiener Species Diversity Index (H')} = -\sum \{(\text{ni}/\text{N}) \log (\text{ni}/\text{N})\} \quad (9)$$

where: ni : the importance of each species; N : total important value; The value of the Shannon Wiener Species Diversity Index was categorized as high (H'>3), medium (1≤H'≤3), and low (H'<1) [25]-[28].

3. Results and discussions

3.1 Vegetation composition

As shown in Table 1, a total of 49 species were found, with approximately 3380 individuals. These species belong to 25 families, dominated by Fabaceae with 16 species, followed by Arecaceae with five species and Verbenaceae with three species.

Table 1. List of species composing the vegetation in Sisimeni Sanam Forest Area

No	Family	Botanical name	Local name
1	Anacardiaceae	*Spondias pinnata*	Kedondong
2	Anonaceae	*Uvaria rufa* Blume	Lelak
3	Anonaceae	*Annona squamosa* L	Anonak
4	Apocynaceae	*Alstonia scholaris*	Pulai
5	Arecaceae	*Arenga pinnata*	Enau
6	Arecaceae	*Cocos nucifera* L.	Kelapa
7	Arecaceae	*Areca catechu*	Pinang
8	Arecaceae	*Corypha utan* L	Gewang
9	Asteraceae	*Chromolaena odorata* L.	Krinyuh
10	Boraginaceae	*Cordia dichotoma*	Nunak
11	Casuarinaceae	*Casuarina junghuniana*	Kasuari
12	Euphorbiaceae	*Aleurites moluccana* L. Wild	Kemiri
13	Fabaceae	*Cassia siamea* Lamk	Johar
14	Fabaceae	*Sesbania hurbacea*	Turi kuning
15	Fabaceae	*Vachellia leucophloea*	Kabesak hitam
16	Fabaceae	*Gliricidia sepium*	Gamal
17	Fabaceae	*Sesbania grandiflora* L	Turi
18	Fabaceae	*Bauhinia purpurea*	Pohon kupu-kupu
19	Fabaceae	*Mimosa leucophloea* Roxb	Kabesak putih
20	Fabaceae	*Cassia javanica*	Trengguli
21	Fabaceae	*Pterocarpus indicus* Willd	Kayu merah
22	Fabaceae	*Paraserianthes falcataria* L	Sengon
23	Fabaceae	*Tamarindus indica*	Asam
24	Fabaceae	*Leucaena leucocephala*	Lamtoro
25	Lauraceae	*Persea americana*	Alpukat
26	Lauraceae	*Cinnamomum iners* Reinw.ex Bl	Kabun putih
27	Lecythidaceae	*Planchonia valida* (Bi.) BL	Putat
28	Malvaceae	*Hibiscus similis* BI	Waru gunung
29	Malvaceae	*Ceiba pentandra* (L.) Gaertn	Kapuk
30	Meliaceae	*Swietenia macrophylla* King	Mahoni
31	Meliaceae	*Melia azedarach* L	Mindi
32	Moraceae	*Morus alba* L	Kayu mora
33	Myrtaceae	*Psidium guajava* L.	Jambu biji
34	Myrtaceae	*Eucalyptus alba*	Eukaliptus putih
35	Phylanthaceae	*Antidesma bunius*	Buni
36	Poaceae	*Bambusa* sp	Bambu
37	Poacea	*Pennisetum purpupoides*	Rumput kingres
38	Rhamnaceae	*Ziziphus mauritiana*	Bidara
39	Rhamnaceae	*Ziziphus jujuba*	Bidara china

No	Family	Botanical name	Local name
40	Rubiaceae	*Morinda citrifolia* L	Mengkudu
41	Rubiaceae	*Coffea liberica*	Kopi hutan
42	Rutaceae	*Aegle marmelos* L	Dilak
43	Saltaceae	*Santalum album*	Cendana
44	Sapindaceae	*Schleichera oleosa*	Kesambi
45	Sapotaceae	*Mimusops elengi*	Tanjung
46	Sterculiaceae	*Sterculia quadrifida* R. Br	Faloak
47	Verbenaceae	*Lantana camara* L	Tahi ayam
48	Verbenaceae	*Tectona grandis*	Jati
49	Verbenaceae	*Lantana montividensis*	Kasiri

At the seedling and understorey level, 28 species were found, belonging to 16 families with a total number of individuals of 1790. The most common species found was *Chromolaena odorata* with 1180 individuals. This is considered an invasive alien species with a wide distribution from dry or mountainous areas to swamps and wetlands. This growth is a woody shrub that can grow quickly and form clumps that can block the growth of other plants. In addition, this plant is also an aggressive competitor and is thought to have allelopathic effects and can cause fire hazards. Based on the results, it was evenly distributed at 96 observation plots out of 124 observed and was more commonly found under teak stands.

The sapling level consisted of 22 species belonging to 13 families, with a total of 312 individuals. The most common species was teak (*Tectona grandis*), with 77 individuals spread across 26 observation plots. At the pole level, 23 species were found, belonging to 13 families with a total of 289 individuals. The most abundant species found was teak, namely with 167 individuals, which spread across 54 observation plots. Meanwhile, at the tree level, 24 species were found, belonging to 15 families with a total of 989 individuals. The most abundant species found at tree level was teak, with 817 individuals spread across 92 observation plots. This type is very dominant in the SSFA area because it is a former plantation forest managed by Perum Perhutani with the main plant being teak. Despite the dominance across every level, the teak stand faces threats from illegal logging activities and landslides as observed in several measuring plots. In some measurement plots, old and new teak areas were found due to illegal logging carried out by certain community members. If this action is not prevented, it will cause a reduction in teak stands and even threaten extinction.

3.2 Vegetation structure

3.2.1 Density and relative density

At SSFA, some species regenerated naturally, including *Leucaena leucocephala, Tectona grandis, Cassia siamea, Vachellia leucophloea, Mimosa leucophloea, Ziziphus mauritiana, Cordia dichotoma* and *Bauhinia purpurea*. In this context, regeneration is a natural biological process that increases forest resources in ecosystem dynamics, allowing forests to self-replenish and preserve genetic identity [29]-[31]. The number of individual trees that grow naturally decreases as the growth size increases. These conditions contribute to the formation of complex structures and diverse assemblages of species in communities, including trees, poles, saplings, and seedlings, as well as other understory plants that create multi-layered structures [32]. Natural regeneration of forests is very important for the substitution of old trees with juvenile ones for the advancement of forest succession [33]. This regeneration is influenced by local environmental factors, the intensity of previous land use, as well as the spread of seeds and sprouts [34,35].

The rejuvenation rate of seedlings and understorey in 124 observation plots showed that *Chromolaena odorata* had the highest relative density (65.92%), while the lowest (0.82%) was observed in *Sterculia quadrifida, Morinda citrifolia, Uvaria rufa, Lantana camara, Casuarina junghuniana*, and *Planconia valida* of 28 species belonging to 16 families (Table 3). At the sapling level, teak had the highest relative density of 25.83% while the lowest (0.336%) was recorded in *Bauhinia purpurea, Coffea liberica, Psidium guajava, Persea americana*, and *Morus alba* of 22 species belonging to 13 families. At pole level, *Tectona grandis* had the highest relative density (60.28%), and the lowest (0.66%) was found in *Morinda citrifolia*, *Gliricidia sepium, Coffea liberica, Psidium guajava, Cassia javanica*, and *Ceiba pentandra* of 23 species belonging to 13 families and. At the tree level, teak had the highest relative density (82.61%), and the lowest (0.1%) was recorded in *Leucaena leucocephala, Schleichera oleosa, Cocos nucifera, Cassia javanica, Aegle marmelos, Aleurites moluccana, Mimusops elengi,* and *Alstonia scholaris* of 24 species belonging to 15 families.

Teak had the highest density from sapling to tree level, showing favorable growing conditions and minimal disturbance. This high density also correlates with effective light penetration to the soil surface. Disturbance plays a significant or complex role in species density. According to the Environmental Quality Standard value based on Minister of Environment Decree No. 02/1988, species density classification is as follows: very low (≤ 20 individuals/ha), low (21–50 individuals/ha), moderate (51–100 individuals/ha), high (101–200 individuals/ha), and very high (≥ 200 individuals/ha). Based on the results, the density value at the tree level was 198,795 individuals per ha, falling within the high-density category. Although the density of each species at the pole level was very low, the total density was classified as very high (233,065 individuals/ha), primarily due to the large number of species. The total density for the sapling rate was in the very high category with 1006,452 individuals/ha. Approximately 50% of seedling density for the understorey was categorized as very high, while 31.03% was in the low category. At the tree level, the density value for each species was very low, even though the total density was relatively high. The high total density value was caused by a large number of species.

Table 2. Density (D) and relative density (RD) of each species in varying growth stage

No	Botanical Name	Seedling and understorey		Sapling		Pole		Tree	
		Density	Relative Density (%)	Density	Relative Density (%)	Density	Relative Density (%)	Density	Relative Density (%)
1	*Leucaena leucocephala*	2,318.55	6.42	112.90	11.74	5.64	2.52	0.2	0.1
2	*Tectona grandis Linn.* F	2,258.07	6.25	248.38	25.83	134.67	60.28	164.7	82.61
3	*Cassia siamea* Lamk	705.65	1.95	109.67	11.40	12.90	5.77	4.44	2.22
4	*Annona squamosa* L	645.16	1.78	183.87	19.12	-	-	-	-
5	*Chromolaena odorata* L.	23,790.32	65.92	-	-	-	-	-	-
6	*Sesbania hurbacea*	262.09	0.72	32.25	3.35	1.61	0.72	-	-
7	*Bambusa* sp	1,451.61	4.02	-	-	-	-	-	-
8	*Vachellia leucophloea*	725.80	2.01	32.25	3.35	4.83	2.16	4.84	2.43
9	*Corypha utan* L	806.45	2.23	9.67	1.00	-	-	-	-
10	*Schleichera oleosa*	40.32	0.11	9.67	1.00	-	-	0.2	0.1
11	*Mimosa leucophloae* Roxb	282.25	0.78	32.25	3.35	4.03	1.80	5.24	2.63
12	*Arenga pinnata*	100.80	0.27	-	-	-	-	-	-
13	*Cocos nucifera* L	201.61	0.55	-	-	-	-	0.2	0.1
14	*Areca catechu*	322.58	0.89	-	-	-	-	-	-
15	*Sterculia quadrifida* R. Br	20.16	0.05	-	-	-	-	-	-
16	*Morinda citrifolia* L	20.16	0.05	-	-	0.80	0.36	-	-
17	*Uvaria rufa* Blume	20.16	0.05	-	-	-	-	-	-
18	*Ziziphus mauritiana*	80.64	0.22	25.80	2.68	4.03	1.80	1.81	0.91
19	*Lantana montividensis*	40.32	0.11	-	-	-	-	-	-
20	*Gliricidia sepium*	504.03	1.39	19.35	2.01	0.80	0.36	-	-
21	*Lantana camara* L	20.16	0.05	-	-	-	-	-	-
22	*Pennisetum purpupoides*	766.12	2.12	-	-	-	-	-	-
23	*Swietenia macrophylla King*	322.58	0.89	-	-	3.22	1.44	5.44	2.73
24	*Sesbania grandiflora* L	80.64	0.22	38.71	4.02	3.22	1.44	-	-
25	*Casuarina junghuniana*	20.16	0.05	-	-	-	-	-	-
26	*Cordia dichotoma*	60.48	0.16	32.25	3.35	23.38	10.46	3.02	1.52
27	*Bauhinia purpurea*	40.32	0.11	3.22	0.33	4.83	2.16	1.41	0.71
28	*Planconia valida* (Bi.) BL	20.16	0.05	-	-	-	-	-	-
29	*Ziziphus jujuba*	-	-	38.71	4.02	5.64	2.52	-	-
30	*Cinnamomum iners* Reinw.ex Bl.	-	-	22.58	2.34	-	-	-	-
31	*Coffea liberica*	-	-	3.22	0.33	0.80	0.36	-	-
32	*Psidium guajava* L	-	-	3.22	0.33	0.80	0.36	-	-
33	*Persea americana*	-	-	3.22	0.33	-	-	-	-
34	*Melia azedarach* L	-	-	16.12	1.67	-	-	0.4	0.2
35	*Morus alba* L	-	-	3.22	0.33	-	-	-	-
36	*Cassia javanica*	-	-	6.45	0.67	0.80	0.36	0.2	0.1
37	*Pterocarpus indicus* Willd	-	-	-	-	2.41	1.08	1.21	0.61
38	*Ceiba pentandra* (L.) Gaertn	-	-	-	-	0.80	0.36	1.21	0.61

39	*Aegle marmelos* L	-	-	-	-	1.61	0.72	0.2	0.1
40	*Antidesma bunius*	-	-	-	-	1.61	0.72	-	-
41	*Santalum album*	-	-	-	-	3.22	1.44	-	-
42	*Paraserianthes falcataria* L	-	-	-	-	-	-	0.4	0.2
43	*Aleurites moluccana* L.Wild	-	-	-	-	-	-	0.2	0.1
44	*Mimusops elengi*	-	-	-	-	-	-	0.2	0.1
45	*Eucalyptus alba*	-	-	-	-	-	-	1.21	0.61
46	*Hibiscus similis* BI	-	-	-	-	-	-	0.6	0.3
47	*Tamarindus indica*	-	-	-	-	-	-	0.6	0.3
48	*Spondias Pinnata*	-	-	-	-	-	-	0.6	0.3
49	*Alstonia scholaris*	-	-	-	-	-	-	0.2	0.1
		36,088.71	100	961.29	100	223,38	100	198.79	100

3.2.2 Frequency and relative frequency

At the seeding level, the highest relative frequency (43.63%) across 124 observation plots was recorded in *Chromolaena odorata*, and the lowest (0.445%) was found in 14 species. At the sapling level, teak had the highest frequency (25.49%), and the lowest was (0.980%) found in 11 species. At the pole level, the highest frequency (46.95%), was recorded in teak, while the lowest (0.870%) was found in 11 species. At the tree level, teak had the highest frequency (50.54%), and the lowest (0.54%) was identified in 11 species (Table 4).

Frequency classification consists of five classes, namely class A (1-20% in the very low category), B (21–40% in the low category), C (41-60% in the medium category), D (61–80% in the high category), and E (81–100% in the very high category) [36]. At the tree growth level, teak had the highest distribution rate (50%), while *Mimosa leucophloea* (9.78%), *Vachellia leucophloea* (7.60%), *Cassia siamea*, *Cordia dichotoma* (5.43%), as well as *Ziziphus mauritiana* (3.26%) had the lowest. In general, the distribution for each species at the tree level was classified as very low, primarily due to a relative frequency value of 21%. This very low distribution may be attributed to the planting of various species with each species gathered in specific locations.

Species frequency describes the distribution within the habitat, and in general, relatively high frequency positively correlates with the population density occupying the available physical space. Species with the highest relative frequency include *Chromolaena odorata* (seedling level) and teak (sapling, pole, and tree level). These plants tend to have a large number of individuals, enabling widespread growth within the community. The population in each location was strongly influenced by anthropogenic (human) and naturogenic (natural phenomena) disturbance factors. Anthropogenic disturbances including harvesting leaves, stems and fruit as well as other human actions, pose a threat to the existence of vegetation in area [37,38]. Naturogenic disturbances including landslides, prolonged drought, land and forest fires, as well as climate change, also often occur in SSFA and cause damage to forest structures. Damage to forest structure tends to affect the ability to provide ecosystem services and functions such as biodiversity and carbon absorption [39].

Table 3. Frequency (F) and relative frequency (RF) of each species in varying growth stage

No	Botanical Name	Seedling & understorey		Sapling		Pole		Tree	
		F	RF (%)	F	RF (%)	F	RF (%)	F	RF (%)
1	*Leucaena leucocephala*	0.16	9.09	0.09	11.76	0.04	5.21	0.008	0.54
2	*Tectona grandis Linn.* F	0.25	14.09	0.21	25.49	0.435	46.95	0.74	50.54
3	*Cassia siamea* Lamk	0.08	5.00	0.10	12.74	0.04	4.34	0.08	5.49
4	*Annona squamosa* L	0.05	3.18	0.10	12.74	-	-	-	-
5	*Chromolaena odorata* L.	0.77	43.63	-	-	-	-	-	-
6	*Sesbania hurbacea*	0.01	0.90	0.04	4.90	0.01	1.73	-	-
7	*Bambusa* sp	0.07	4.09	-	-	-	-	-	-
8	*Vachellia leucophloea*	0.07	4.09	0.04	4.90	0.04	5.21	0.11	7.69
9	*Corypha utan* L	0.04	2.27	0.008	0.98	-	-	-	-
10	*Schleichera oleosa*	0.01	0.90	0.008	0.98	-	-	0.008	0.54
11	*Mimosa leucophloae* Roxb	0.008	0.45	0.01	1.96	0.04	4.34	0.14	9.89
12	*Arenga pinnata*	0.008	0.45	-	-	-	-	-	-
13	*Cocos nucifera* L	0.008	0.45	-	-	-	-	0.008	0.54
14	*Areca catechu*	0.008	0.45	-	-	-	-	-	-
15	*Sterculia quadrifida* R. Br	0.008	0.45	-	-	-	-	-	-

No	Botanical Name	Seedling & understorey		Sapling		Pole		Tree	
		F	RF (%)	F	RF (%)	F	RF (%)	F	RF (%)
16	*Morinda citrifolia* L	0.008	0.45	-	-	0.008	0.87	-	-
17	*Uvaria rufa* Blume	0.008	0.45	-	-	-	-	-	-
18	*Ziziphus mauritiana*	0.008	0.45	0.02	2.94	0.008	0.87	0.04	3.29
19	*Lantana montividensis*	0.008	0.45	-	-	-	-	-	-
20	*Gliricidia sepium*	0.04	2.27	0.02	2.94	0.008	0.87	-	-
21	*Lantana camara* L	0.008	0.45	-	-	-	-	-	-
22	*Pennisetum purpupoides*	0.04	2.72	-	-	-	-	-	-
23	*Swietenia macrophylla King*	0.02	1.36	-	-	0.008	0.87	0.02	1.64
24	*Sesbania grandiflora* L	0.024	1.36	0.04	4.90	0.01	1.73	-	-
25	*Casuarina junghuniana*	0.008	0.45	-	-	-	-	-	-
26	*Cordia dichotoma*	0.008	0.45	0.008	0.98	0.13	14.78	0.08	5.49
27	*Bauhinia purpurea*	0.008	0.45	0.008	0.98	0.04	5.21	0.03	2.19
28	*Planconia valida* (Bi.) BL	0.008	0.45	-	-	-	-	-	-
29	*Ziziphus jujuba*	-	-	0.03	3.92	0.02	2.60	-	-
30	*Cinnamomum iners* Reinw.ex BI	-	-	0.008	0.98	-	-	-	-
31	*Coffea liberica*	-	-	0.008	0.98	0.008	0.87	-	-
32	*Psidium guajava* L	-	-	0.008	0.98	0.008	0.87	-	-
33	*Persea americana*	-	-	0.008	0.98	-	-	-	-
34	*Melia azedarach* L	-	-	0.008	0.98	-	-	0.008	0.54
35	*Morus alba* L	-	-	0.008	0.98	-	-	-	-
36	*Cassia javanica*	-	-	0.008	0.98	0.008	0.87	0.008	0.54
37	*Pterocarpus indicus* Willd	-	-	-	-	0.024	2.60	0.04	2.74
38	*Ceiba pentandra* (L.) Gaertn	-	-	-	-	0.008	0.87	0.03	2.19
39	*Aegle marmelos* L	-	-	-	-	0.008	0.87	0.008	0.54
40	*Antidesma bunius*	-	-	-	-	0.008	0.87	-	-
41	*Santalum album*	-	-	-	-	0.008	0.87	-	-
42	*Paraserianthes falcataria* L	-	-	-	-	-	-	0.01	1.09
43	*Aleurites moluccana* L.Wild	-	-	-	-	-	-	0.008	0.54
44	*Mimusops elengi*	-	-	-	-	-	-	0.008	0.54
45	*Eucalyptus alba*	-	-	-	-	-	-	0.008	0.54
46	*Hibiscus similis* BI	-	-	-	-	-	-	0.01	1.09
47	*Tamarindus indica*	-	-	-	-	-	-	0.008	0.54
48	*Spondias Pinnata*	-	-	-	-	-	-	0.008	0.54
49	*Alstonia scholaris*	-	-	-	-	0.016	1.739	0.008	0.54
		1.83	100	0.82	100	0.92	100	1.46	100

3.2.3 Dominance and relative dominance

Dominance shows the proportion of space covered by plant species to the total area of habitat and was applied to pole and tree levels. Meanwhile, relative dominance refers to the proportion of a species' coverage area to the total cover. At the pole level, *Vachellia leucophloea* had the highest dominance (53.80%), and the lowest (0.09%) was found in *Gliricidia sepium*. Meanwhile, at the tree level, teak had the highest dominance (79.7%) and the lowest (0.05%) was recorded in *Schleicera oleosa*. This suggested that teak occupied the largest habitat area, while Schleicera oleosa had the smallest.

In terms of habitat area, *Vachellia leucophloea* had the most extensive coverage at the pole level, with a relative dominance value of 53.09%, followed by teak at 31.43%, while other types had a relative dominance of <5%. Dominant species reflect the cover area relative to the total area of habitat, forming a complex and highly variable relationship with the functional diversity of vegetation and the soil substratum.

Table 4. Dominance (D) and relative dominance (RD) of each species in varying growth stage

No	Botanical Name	Seedling & understorey		Sapling		Pole		Tree	
		D	RD (%)	D	RD (%)	D	RD (%)	D	RD (%)
1	*Leucaena leucocephala*	-	-	-	-	0.10	1.12	0.02	0.1
2	*Tectona grandis Linn.* F	-	-	-	-	2.91	31.85	12.61	79.7
3	*Cassia siamea* Lamk	-	-	-	-	0.22	2.39	0.26	1.66
4	*Annona squamosa* L	-	-	-	-	-	-	-	-
5	*Chromolaena odorata* L.	-	-	-	-	-	-	-	-
6	*Sesbania hurbacea*	-	-	-	-	0.03	0.32	-	-
7	*Bambusa* sp	-	-	-	-	-	-	-	-
8	*Vachellia leucophloea*	-	-	-	-	4.91	53.80	0.5	3.14
9	*Corypha utan* L	-	-	-	-	-	-	-	-
10	*Schleichera oleosa*	-	-	-	-	-	-	0.01	0.05
11	*Mimosa leucophloae* Roxb	-	-	-	-	0.09	1.01	0.76	4.81
12	*Arenga pinnata*	-	-	-	-	-	-	-	-
13	*Cocos nucifera* L	-	-	-	-	-	-	0.02	0.13
14	*Areca catechu*	-	-	-	-	-	-	-	-
15	*Sterculia quadrifida* R. Br	-	-	-	-	-	-	-	-
16	*Morinda citrifolia* L	-	-	-	-	0.01	0.12	-	-
17	*Uvaria rufa* Blume	-	-	-	-	-	-	-	-
18	*Ziziphus mauritiana*	-	-	-	-	0.09	1.02	0.08	0.51
19	*Lantana montividensis*	-	-	-	-	-	-	-	-
20	*Gliricidia sepium*	-	-	-	-	0.01	0.09	-	-
21	*Lantana camara* L	-	-	-	-	-	-	-	-
22	*Pennisetum purpupoides*	-	-	-	-	-	-	-	-
23	*Swietenia macrophylla King*	-	-	-	-	0.04	0.41	0.48	3.05
24	*Sesbania grandiflora* L	-	-	-	-	0.03	0.34	-	-
25	*Casuarina junghuniana*	-	-	-	-	-	-	-	-
26	*Cordia dichotoma*	-	-	-	-	0.31	3.41	0.31	1.97
27	*Bauhinia purpurea*	-	-	-	-	0.10	1.09	0.13	0.8
28	*Planconia valida* (Bi.) BL	-	-	-	-	-	-	-	-
29	*Ziziphus jujuba*	-	-	-	-	0.05	0.60	-	-
30	*Cinnamomum iners* Reinw.ex BI	-	-	-	-	-	-	-	-
31	*Coffea liberica*	-	-	-	-	0.02	0.20	-	-
32	*Psidium guajava* L	-	-	-	-	0.01	0.10	-	-
33	*Persea americana*	-	-	-	-	-	-	-	-
34	*Melia azedarach* L	-	-	-	-	-	-	0.04	0.22
35	*Morus alba* L	-	-	-	-	-	-	-	-
36	*Cassia javanica*	-	-	-	-	0.02	0.27	0.01	0.08
37	*Pterocarpus indicus* Willd	-	-	-	-	0.05	0.54	0.1	0.66
38	*Ceiba pentandra* (L.) Gaertn	-	-	-	-	0.02	0.25	0.12	0.77
39	*Aegle marmelos* L	-	-	-	-	0.02	0.17	0.01	0.08
40	*Antidesma bunius*	-	-	-	-	0.04	0.46	-	-
41	*Santalum album*	-	-	-	-	0.03	0.28	-	-
42	*Paraserianthes falcataria* L	-	-	-	-	-	-	0.02	0.15
43	*Aleurites moluccana* L.Wild	-	-	-	-	-	-	0.02	0.1
44	*Mimusops elengi*	-	-	-	-	-	-	0.01	0.06
45	*Eucalyptus alba*	-	-	-	-	-	-	0.07	0.47
46	*Hibiscus similis* BI	-	-	-	-	-	-	0.05	0.29
47	*Tamarindus indica*	-	-	-	-	-	-	0.15	0.97
48	*Spondias Pinnata*	-	-	-	-	-	-	0.03	0.18
49	*Alstonia scholaris*	-	-	-	-	-	-	0.01	0.07
						9.13	100	15.82	100

3.3 Important Value Index (IVI) and Diversity Index (H')

In SSFA, calcareous soils dominate, encouraging the dominance of teak plants throughout the observation plots. At the seedling and understorey levels, *Chromolaena odorata* had the highest Importance Value Index

(IVI) of 109.558%, while the lowest of 0.510% was recorded in *Sterculia quadrifida* and five other species. At the sapling level, teak had the highest IVI (51.329%), and the lowest (1.316%) was found in *Bauhinia purpurea* and four other species. Similarly, at the pole level, teak had the highest IVI (139.09%), and the lowest (1.32%) was found in *Gliricidia sepium*. At the tree level, teak had the highest IVI (213.109%), while the lowest (0.705%) was recorded in *Schleichera oleosa*. The higher the IVI of a species indicates the greater the level of control over the community and vice versa. High IVI in several species at various growth stages indicates the ability of the species to adapt effectively to habitats and broad tolerance to growing environments. Generally, species with high IVI can grow and develop in areas with high soil temperatures and soil acidity levels [40]. Species with higher IVI have greater control over the community, indicating success in accessing resources compared to other species [41]. The important value index of a species provides an indication that the existence of the species is increasingly stable or has the potential to maintain the growth and sustainability of the species [42].

In general, the species diversity index at the tree level is included in the low category (H' = 0.388). Likewise, the species diversity at the pole level is included in the low category (H' = 0.73). The species diversity at the sapling level is included in the moderate category (H' = 1.022). At the seedling and understorey levels, there was an increase in the number of species, but the species diversity at this level is included in the low category with a value of H' <1 (H' = 0.66). The low diversity index is primarily because the research area was a former industrial plantation forest project managed by the State Forest Company (Perum Perhutani), which aims to reforest critical land on Timor Island with the main vegetation type being teak. Forests with low species diversity values indicate that the forest area has experienced forest disturbance or damage [42]. Other factors that can affect the diversity of plant species in an area are soil organic matter, soil moisture, soil pH, temperature, and light intensity. Plants have a certain level of tolerance to environmental conditions in order to survive and thrive. If environmental conditions change beyond the tolerance level, it will cause the extinction of plants from that habitat [42].

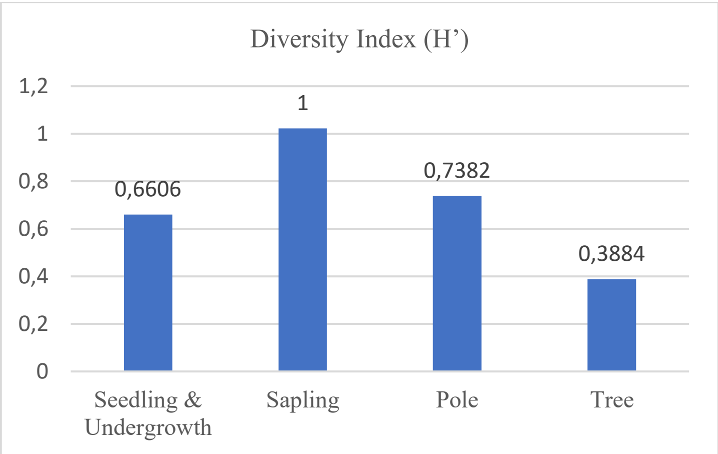

Figure 2. Diversity Index (H') in the SSFA

The H' value serves as a diversity index that determines the richness of species within a given area. The diversity index is vegetation parameter that plays a crucial role in comparing communities, particularly for analyzing the various impacts of environmental or abiotic factor disturbances as well as understanding the state of succession and stability [43]. The older or more stable the condition of the community, the higher the diversity of plant species. In contrast, when the H' is small, the community is only dominated by one or a few types. A high level of diversity also shows that each type is distributed evenly in different areas. High diversity shows that a community has high complexity or is composed of various species. The success of forest area management from an ecological perspective is often evaluated by species diversity as well as carbon stocks above the surface, and soil carbon [44].

If the forest area has various types of plants in abundance, it will make it easier to manage the forest area. If the species diversity (H') is low in the forest area, the first step that will be taken is to conduct a comprehensive evaluation to identify the causes, such as habitat damage, climate change, or invasive species. After that, the management will implement appropriate habitat management strategies, including habitat restoration, invasive species control, and habitat quality improvement. Species conservation actions will also be carried out, such as captive breeding programs and poaching control. Long-term monitoring and further research will be carried out to track changes and the effectiveness of actions. Local community involvement is also an important part of conservation efforts through education and empowerment programs. With these steps, SSFA managers strive to restore and improve the diversity of species, structure, and composition of species in the forest area.

4. Conclusion

The study found that the vegetation community in SSFA consisted of 49 species from 25 families, with teak being the most dominant across all growth levels. At the seedling and understorey level, *Chromolaena odorata* had the highest relative density and frequency, while teak dominated at the sapling, pole, and tree levels. At the pole level, *Vachellia leucophloea* was more predominant, and Tectona grandis dominated the tree level. Furthermore, each growth level showed a distinct Important Value Index. Species diversity in SSFA was included in the low category due to the dominance of certain species as well as the presence of anthropogenic and natural pressure. This underscores the importance of careful and effective management including the enrichment of various species through planting or facilitating natural regeneration to improve the diversity of vegetation in SSFA.

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