

Short Communication:

Species composition and diversity of vegetation in dryland agricultural landscape

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Abstract. *Ardiyaningrum I, Budiastuti MTS, Komariah. 2021. Short Communication: Species composition and diversity of vegetation in dryland agricultural landscape. Biodiversitas 22: 65-71.* Drylands are a part of the terrestrial ecosystems with a relatively larger area compared to wetlands. Selo has dryland with steep slopes and high rainfall, resulting in relatively high soil erosion. The land use in this sub-district is dominated by plantations and agriculture, with conditions that have not been fully balanced by trees as a means of controlling erosion and supporting vegetation diversity. Therefore, studies on biodiversity are important as an indicator of dryland sustainability, especially in terms of soil and water conservations. This research aimed to study the species composition and diversity of vegetation in the dryland agricultural landscape in Selo Sub-district, Boyolali District, Central Java Province, Indonesia. Vegetation analysis was performed by using the quadratic sampling technique for tree category, pole category, sapling category, and seedling categories. The results indicated that Fabaceae had the highest number of species. Tree species with the highest Importance Value Index were *Toona sureni*, *Artocarpus heterophyllus*, and *Casuarina junghuhniana*, respectively. The Shanon-Wiener Diversity Index showed that the vegetation at tree, pole, and sapling stages had a moderate diversity, and seedling-stage vegetation had a low diversity.

Keywords: Conservation, erosion, dryland, Selo Sub-district, *Toona sureni*, vegetation analysis

INTRODUCTION

Drylands are a part of the terrestrial ecosystem with a relatively larger area compared to wetlands. There are various limiting factors of dryland use, including soil erosion, topography, and water availability. The use of drylands for agriculture regardless of conservation principles will lead to erosion and decrease soil fertility. Continuing land degradation will cause the lands to be critical and disturb their ecosystem balance. According to Akinyemi and Kgomo (2019), degraded drylands will have low diversity and species richness. Vegetation diversity is the key to the stability of dryland ecosystems. High vegetation diversity can increase the ability of an ecosystem to maintain stability under climate fluctuations (Geng et al. 2019)

Selo is a mountainous area on the slopes between Mount Merapi and Mount Merbabu. The valley between the two mountains is an area that is widely used as agricultural land (Nurhadi et al. 2019). Selo has tiled to steep slopes. The slopes in Selo Sub-district are twice as steep as those in Mojosoongo Sub-district and Boyolali Sub-district of Boyolali District, Indonesia. Selo has a wet climate as it has a high annual rainfall up to 2.801 mm/year in 2018 (BPS 2019). Steep slope conditions and a high rainfall cause a high level of erosion hazard. A steeper slope results in a greater surface runoff strength which has the potential to cause erosion (Zhang et al. 2018).

Dryland in Selo is used as a dry fields/ gardens (1,926.3 ha), state forest (1,350.6 ha), yard/ building (999.3 ha), pastureland (800 ha), and others (496.2 ha) (BPS 2019). Land use in agricultural landscapes is dominated by plantations and dry fields. Land use in the form of dry fields with a slope of 31% in Jeruk Village, Selo, has a high erosion of 284.75 tons/ha/year (Syahidah et al. 2016) Land cover affects the amount of soil erosion. Areas with a smaller land cover have a higher risk of soil erosion than those with greater land cover (Wijitkosum 2012). Areas protected by green vegetation have a low risk of soil erosion, even with steep slopes and a high annual rainfall (Ochoa et al. 2016) Erosion will also increase in monoculture farming systems (Donia et al. 2019)

Vegetation plays an important role in controlling soil erosion (Zhao et al. 2015). Vegetation controls soil erosion with canopies, roots, and litter, but erosion affects vegetation in terms of composition, structure, and growth patterns of plant communities (Gyssels et al. 2005). The erosion rate will decrease depending on the structure and composition of plants in the area. The morphology and structure of vegetation become the priority in controlling erosion (Miri et al. 2017). Higher species richness can reduce annual soil erosion rates (Song et al. 2019)

The land use in Selo is dominated by plantations and agriculture, with conditions that have not been fully balanced by trees as a means of controlling erosion and supporting vegetation diversity. Therefore, studies on

biodiversity are important. This analysis of vegetation in this study was conducted to investigate the species composition and diversity of vegetation in the dryland agricultural landscape in Selo Sub-district, Boyolali District, Central Java Province, Indonesia.

MATERIALS AND METHODS

Study area

This study was carried out in the dryland agricultural landscape in Selo Sub-district, Boyolali District, Central Java Province, Indonesia (Figure 1). The location is on the slopes between Mount Merapi and Merbabu with an altitude of 1200-1500 m asl. The study was conducted from January to February 2020.

Procedure

The sampling location was determined purposively based on land use of dry fields/gardens. There were 12 sampling stations or locations with a total area of 1.4 hectares. At each location, 3 replications were carried out, resulting in 36 plots for each type of vegetation. Vegetation analysis was performed by using quadratic sampling technique with a size of 20 m x 20 m for the tree category, 10 m x 10 m for the pole category, 5 m x 5 m for the

sapling category, and 2 m x 2 m for the seedlings category (Kusmana 2017).

Data analysis

The vegetation data were analyzed quantitatively. The importance of a plant species and its role in the community was obtained by calculating the Importance Value Index (IVI). IVI is the sum of Relative Density (RD), Relative Frequency (RF), and Relative Dominance (RDo) (Curtis and McIntosh, 1951). IVI for seedling is the sum of RD and RF (Soerianegara and Indrawan 2002). The equation used follows that of Soerianegara and Indrawan (2002).

$$\text{Density (D)} = \frac{\text{Total number of individuals}}{\text{Total plot area}}$$

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

$$\text{Frequency (F)} = \frac{\text{Number of plots where a species is found}}{\text{Number of total plots}}$$

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

$$\text{Dominance (Do)} = \frac{\text{Basal area of a species}}{\text{Total plot area}}$$

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

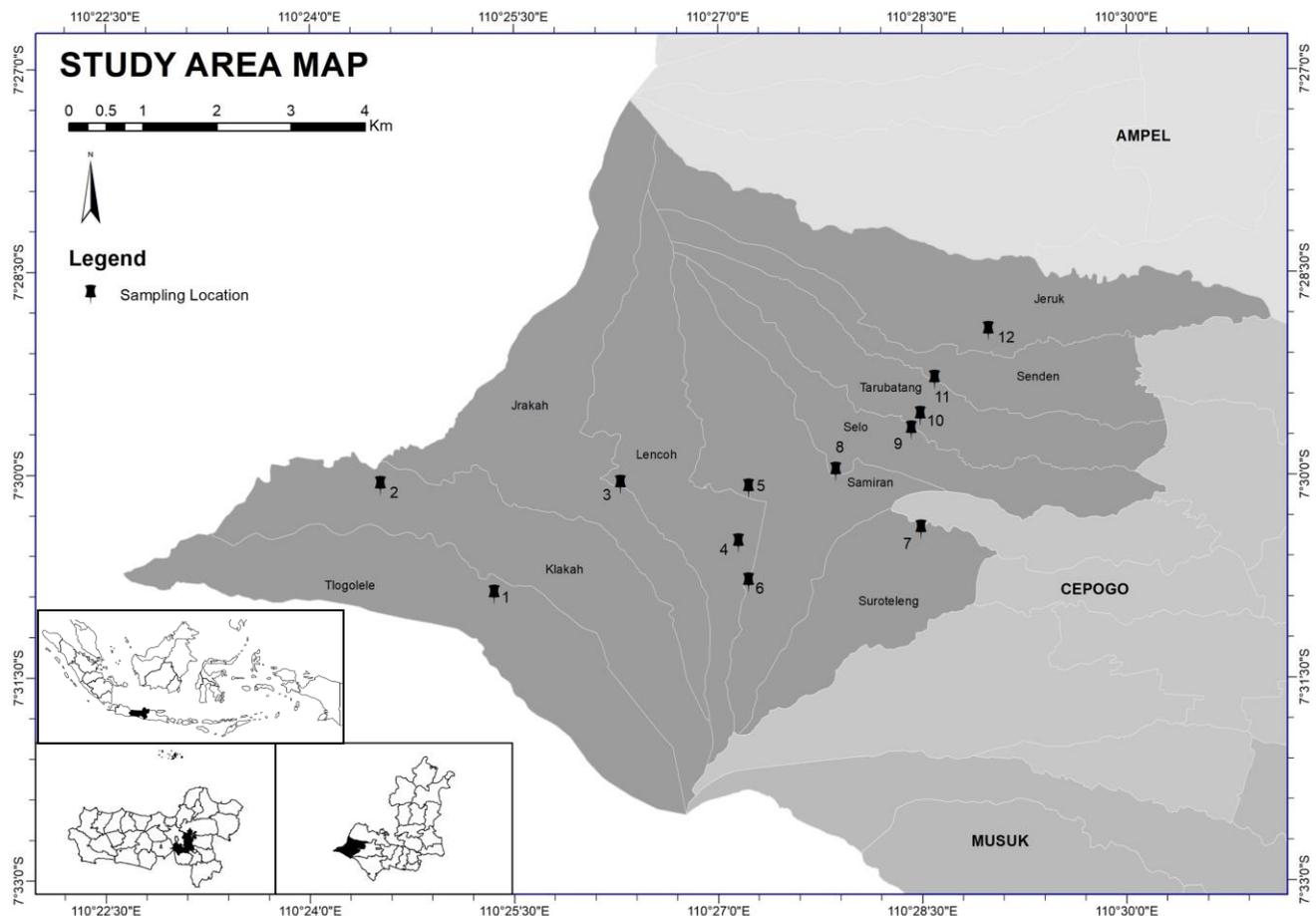


Figure 1. The study area map in Selo Sub-district, Boyolali District, Central Java Province, Indonesia

The vegetation diversity index was calculated by using the Shannon-Wiener Diversity Index formula:

$$H' = - \sum_{i=1}^n \left[\left(\frac{n_i}{N} \right) \ln \left(\frac{n_i}{N} \right) \right]$$

Where:

H' : Diversity index

n_i : Number of individuals of each species

N : Total number of individuals

The dominance index was calculated by using the Simpson dominance index formula.

$$D = \sum \left(\frac{n_i}{N} \right)^2$$

Where:

D : Dominance index

n_i : Number of individuals of each species

N : Total number of individuals

RESULTS AND DISCUSSION

Species composition

Table 1 shows the composition of plant species at 12 sampling locations. There were 19 species of plants from 11 families consisting of growth stages of trees, poles, saplings, and seedlings. The families with the highest number of species included Fabaceae (5 species). Species from the Fabaceae family are widely used by the surrounding community for greening. Meanwhile, those with the fewest species included Casuarinaceae, Euphorbiaceae, Lauraceae, Malvaceae, Myrtaceae, and Pinaceae (1 species each).

The species of the Fabaceae family dominated with a total of 59 individuals, which was followed by 49 individuals of Rubiaceae, and 33 individuals of Meliaceae. *Coffea arabica* had the highest number of individuals i.e. 36, which was followed by *Paraserianthes lophantha* and *Toona sureni* of 29 each. *Glochidion rubrum*, *Samanea saman*, *Cinnamomum verum*, *Ficus racemosa*, and *Syzygium myrtifolium* were the rarest species.

Figure 2 shows that the sapling stage obtained the highest density of 955.56 individuals ha⁻¹, which was followed by seedling stage of 694.44 individuals ha⁻¹, pole stage of 147.27 individuals ha⁻¹, and the lowest density at the tree stage of 37.5 individuals ha⁻¹. Based on the density of each stage, vegetation in the dryland agricultural landscapes had a poor regeneration characterized by a lower density of seedlings than the sapling stage. Seedlings are an important indicator of the continuation of regeneration (Susilowati et al. 2020). The regeneration status is good if the seedling density > the sapling stage density > mature tree stage density (Shankar 2001; Saikia and Khan 2016).

Tree stage

The total density for the tree stage was 37.5 individuals ha⁻¹. *T. sureni* had the highest relative density of 29.63% followed by *Artocarpus heterophyllus* of 18.52% and *Acacia decurens* of 16.67% (Tabel 2). Meanwhile, *Albizia chinensis*, *Hibiscus macrophyllus*, *Melia azedarach*, and *P. lophantha* had the lowest relative density of 3.70% each. The tree stage density was low compared to other regions such as those in Sigi District, Central Sulawesi, Indonesia with a density of 572.67 individuals ha⁻¹ (Lestari et al. 2018).

Toona sureni had the highest IVI (71.49) at the tree stage, followed by *A. heterophyllus* (60.6) and *Casuarina junghuhniana* (50.85), while *M. azedarach* had the lowest IVI (9.59). *T. sureni* is a type of tree planted by people in Selo. It has a diameter of up to 100 cm (Latifah et al. 2018) and produces good quality woods with a high economic value (Latifah et al. 2019).

Pole stage

The total density for the pole stage was 147.44 individuals ha⁻¹. *P. lophantha* contributed the highest relative density of 18.87% which was followed by *T. sureni* of 16.98% and *Cinchona pubescens* of 15.09%, while *Cinnamomum verum*, *F. racemosa*, *G. rubrum*, *Leucaena leucocephala*, *Pinus merkusii*, and *Syzygium myrtifolium* had the lowest relative density of 1.89% each (Tabel 3). *P. lophantha* is an annual plant useable as a building material and shade plant (Hakim et al. 2019).

Paraserianthes lophantha had the highest IVI (50.61) at the pole stage, followed by *T. sureni* (48.65) and *Acacia decurens* (43.21), while *Syzygium myrtifolium* and *M. azedarach* had the lowest IVI of 5.13 each. Several exotic species were found, but some plants could become invasive species (Ismail et al. 2019). *Acacia decurens* is an invasive plant species in Mount Merapi National Park (Sunardi et al. 2017). It is one type of species that grows fast, spreads, and is dominant (Suryawan et al. 2015).

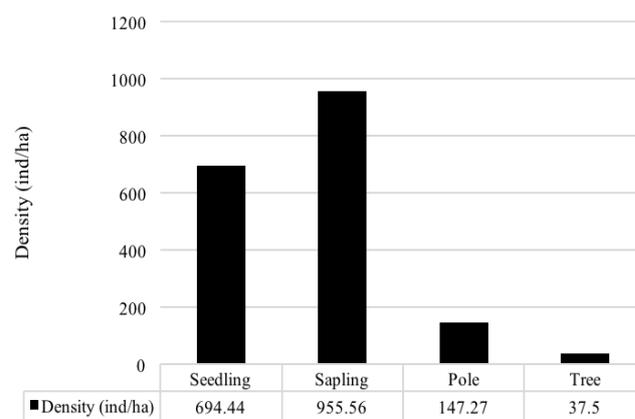


Figure 2. The density of vegetation in dryland agricultural landscape

Table 1. Species composition in dryland agricultural landscape

Family	Plant species	Number of individuals	Total number of individual
Casuarinaceae	<i>Casuarina junghuhniana</i> Miq.	26	26
Euphorbiaceae	<i>Glochidion rubrum</i> Bl	1	1
Fabaceae	<i>Albizia chinensis</i> (Osbeck) Merr	2	59
	<i>Acacia decurrens</i> (Wendl. f.) Wild.	25	
	<i>Paraserianthes lophantha</i> (Wild.) I.C. Nielsen	29	
	<i>Leucaena leucocephala</i> (Lam.) de Wit	2	
	<i>Samanea saman</i> (Jacq.) Merr.	1	
Lauraceae	<i>Cinnamomum verum</i> J.S. Presl.	1	1
Malvaceae	<i>Hibiscus macrophyllus</i> Roxb. Ex Hornem.	7	7
Meliaceae	<i>Melia azedarach</i> L.	4	33
	<i>Toona sureni</i> (Blume) Merr.	29	
Moraceae	<i>Artocarpus heterophyllus</i> Lam	14	15
	<i>Ficus racemosa</i> L.	1	
Myrtaceae	<i>Syzygium myrtifolium</i> Walp.	1	1
Pinaceae	<i>Pinus merkusii</i> Jungh. & Vriese ex Vriese	4	4
Rubiaceae	<i>Cinchona pubescens</i> Vahl	13	49
	<i>Coffea arabica</i> L.	36	
Theaceae	<i>Schima wallichii</i> (DC.) Korth.	4	7
	<i>Camellia sinensis</i> (L.) Kuntze	3	

Table 2. Vegetation analysis of tree stage

Plant species	RD	RF	RDo	IVI
<i>Acacia decurrens</i> (Wendl. f.) Wild.	16.67	13.33	7.79	37.79
<i>Albizia chinensis</i> (Osbeck) Merr	3.70	6.67	1.86	12.23
<i>Artocarpus heterophyllus</i> Lam	18.52	20.00	22.08	60.60
<i>Casuarina junghuhniana</i> Miq.	9.26	6.67	34.92	50.85
<i>Cinchona pubescens</i> Vahl	5.56	10.00	2.89	18.45
<i>Hibiscus macrophyllus</i> Roxb. Ex Hornem.	3.70	6.67	1.72	12.09
<i>Melia azedarach</i> L.	3.70	3.33	2.55	9.59
<i>Paraserianthes lophantha</i> (Wild.) I.C. Nielsen	3.70	3.33	4.48	11.52
<i>Pinus merkusii</i> Jungh. & Vriese ex Vriese	5.56	6.67	3.18	15.40
<i>Toona sureni</i> (Blume) Merr.	29.63	23.33	18.53	71.49

Note: RD: Relative Density (%), FR: Relative Frequency (%), RDo: Relative Dominance (%), IVI: Important Value Index

Table 3. Vegetation analysis of pole stage

Plant species	RD	RF	RDo	IVI
<i>Acacia decurrens</i> (Wendl. f.) Wild.	11.32	13.95	17.94	43.21
<i>Artocarpus heterophyllus</i> Lam	3.77	4.65	3.63	12.05
<i>Casuarina junghuhniana</i> Miq.	11.32	6.98	13.16	31.46
<i>Cinchona pubescens</i> Vahl	15.09	11.63	14.39	41.12
<i>Cinnamomum verum</i> J.S. Presl.	1.89	2.33	1.81	6.02
<i>Ficus racemosa</i> L.	1.89	2.33	2.06	6.27
<i>Glochidion rubrum</i> Bl	1.89	2.33	1.81	6.02
<i>Hibiscus macrophyllus</i> Roxb. Ex Hornem.	5.66	6.98	8.31	20.95
<i>Leucaena leucocephala</i> (Lam.) de Wit	1.89	2.33	1.29	5.51
<i>Melia azedarach</i> L.	1.89	2.33	0.92	5.13
<i>Paraserianthes lophantha</i> (Wild.) I.C. Nielsen	18.87	20.93	10.81	50.61
<i>Pinus merkusii</i> Jungh. & Vriese ex Vriese	1.89	2.33	1.10	5.31
<i>Schima wallichii</i> (DC.) Korth.	3.77	4.65	4.13	12.56
<i>Syzygium myrtifolium</i> Walp.	1.89	2.33	0.92	5.13
<i>Toona sureni</i> (Blume) Merr.	16.98	13.95	17.71	48.65

Table 4. Vegetation analysis of sapling stage

Plant species	RD	RF	RDo	IVI
<i>Acacia decurens</i> (Wendl. f.) Wild.	11.63	11.76	11.03	34.42
<i>Artocarpus heterophyllus</i> Lam	2.33	2.94	5.31	10.57
<i>Casuarina junghuhniana</i> Miq.	17.44	11.76	24.25	53.46
<i>Cinchona pubescens</i> Vahl	2.33	5.88	0.99	9.20
<i>Coffea arabica</i> L.	34.88	20.59	26.45	81.92
<i>Hibiscus macrophyllus</i> Roxb. Ex Hornem.	2.33	2.94	3.55	8.81
<i>Leucaena leucocephala</i> (Lam.) de Wit	1.16	2.94	1.28	5.38
<i>Melia azedarach</i> L.	1.16	2.94	2.23	6.33
<i>Paraserianthes lophantha</i> (Wild.) I.C. Nielsen	18.60	17.65	11.77	48.02
<i>Samanea saman</i> (Jacq.) Merr.	1.16	2.94	0.53	4.63
<i>Schima wallichii</i> (DC.) Korth.	2.33	5.88	2.31	10.52
<i>Toona sureni</i> (Blume) Merr.	4.65	11.76	10.31	26.73

Sapling stage

The total density for the sapling stage was 955.56 individuals ha⁻¹. *Coffea arabica* contributed the highest relative density of 34.88%, which was followed by *P. lophantha* of 18.6% and *Casuarina junghuhniana* of 17.44%, while *L. leucocephala*, *M. azedarach*, and *S. saman* had the lowest relative density of 1.16% each (Table 4).

Coffea arabica had the highest IVI (81.92) at the sapling stage, followed by *C. junghuhniana* (53.46) and *P. lophantha* (48.02). Meanwhile, *S. saman* had the lowest IVI (4.63). *C. arabica* is a commodity developed in the agroforestry system in Selo. Some agroforestry systems can be found in agricultural landscapes dominated by vegetable gardens. Sepulveda and Carrillo (2015) stated that coffee agroforestry systems have been proven to reduce erosion and are effective in terms of soil conservation in tropical highlands.

Seedling stage

The total density for the seedling stage was 694.44 individuals ha⁻¹. *C. arabica* had the highest relative density of 60%, which was followed by *Camellia sinensis* of 30% and *P. lophantha* of 10% (Table 5). *C. arabica* also had the highest IVI (93.33) at the seedling stage, followed by *C. sinensis* (80), while *P. lophantha* has the lowest IVI (26.67). There was a decrease in density and number of species at the seedling stage because the level of community participation in conservation was low. Fitriana and Banowati (2018) stated that the low level of community participation in Tlogolele Village, Selo Sub-district, was due to the fact that many plants were not planted, which made the agroforestry program not run efficiently.

Vegetation diversity

The Shannon-Wiener Diversity Index showed that the diversity of trees, poles, and saplings in Selo was in the moderate category with the values of 2.00 for tree stage, 2.33 for pole stage, 1.88 for sapling stage (Table 6). This indicates that the ecosystem is quite balanced. Odum (1971) stated that the diversity value $1 \leq H' \leq 3$ indicates moderate diversity, distribution, and community stability of a region. High species diversity in an ecosystem is more likely to increase the stability of the plant community, and

vice versa (Boeck et al. 2018).

The diversity of seedling stage was in the low category with the value of 0.87. Only three species were found in the seedling stage, affecting the low diversity index. Yudaputra and Rahardjo (2020) stated that the high or low value of the diversity index is influenced by the number of species and individuals found. The lower value of the diversity index of a region reflects the instability of the community.

No vegetation with a high diversity index was found on the dryland agricultural landscape. This is because the community, especially farmers, are more concerned with high yields on their agricultural land. They think that planting a large number of trees will reduce land productivity; they do not consider the sustainability of the land in the future. Intensification of agricultural land is the main reason for the decline in biodiversity and the provision of ecosystem services (Tarigan 2019; Hall et al. 2020). Also, farmers only rely on tree seedlings from the government without conducting independent seedlings.

The Simpson dominance index ranged from 0.17 to 0.46. Seedling vegetation had the highest dominance index while pole vegetation has the lowest. The dominance index affects species diversity (Yam and Tripathi 2016). A high dominance index indicates a low diversity. The higher the value of the dominance index is, the lower the diversity index will be (Ulfah et al. 2019).

Table 5. Vegetation analysis of seedling stage

Plant species	RD	RF	IVI
<i>Camellia sinensis</i> (L.) Kuntze	30.00	50.00	80.00
<i>Coffea arabica</i> L.	60.00	33.33	93.33
<i>Paraserianthes lophantha</i> (Wild.) I.C. Nielsen	10.00	16.67	26.67

Table 6. Vegetation diversity and dominance index in all growth stage

Growth stage	Diversity index (H')	Dominance index (D)
Tree	2.00	0.17
Pole	2.33	0.13
Sapling	1.88	0.20
Seedling	0.87	0.46

The condition of vegetation in Selo, including composition and diversity, can be used as an indicator of the sustainability of dry land, especially in terms of soil and water conservation. This study found that tree diversity was in the medium category. Trees play an important role in agricultural landscapes with steep slopes. Vegetation affects the ability of the soil to retain water to prevent erosion and landslides (Wang et al. 2013).

Vegetation types and cover play an important role in controlling runoff (Blinkova and Lavrov 2017). According to Kazemi et al. (2018), high biodiversity can reduce the risk of soil erosion. Allen et al. (2016) found that vegetation diversity could significantly reduce erosion rates by 23%. Vegetation diversity reduces erosion rates indirectly through positive effects on roots. The species-rich and diverse vegetation community have a larger root morphology so that it can control erosion (Ford et al. 2016). The results of the study by Chang et al. (2019) also showed that the development of vegetation roots could significantly reduce the total amount of runoff.

Vegetation can control soil erosion through canopy, litter, and roots. Vegetation canopy can block raindrops and reduce their kinetic energy as they fall to the ground, thereby reducing the risk of soil damage and erosion rate. The litter layer produced by trees can also reduce surface runoff and increase infiltration (Maridi et al. 2014)

In conclusion, there are 19 vegetation species from 11 families with Fabaceae having the highest number of species. Tree species with the highest IVI are *Toona sureni* (71.49), *Artocarpus heterophyllus* (60.60), and *Casuarina junghuhniana* (50.85), respectively. The Shannon-Wiener Diversity Index shows that the vegetation at tree, pole, and sapling has a moderate diversity, while seedling-stage vegetation has a low diversity.

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