Biota
Biologi dan Pendidikan Biologi

http://biota.ac.id/index.php/jb
DOI: http://dx.doi.org/10.20414/jb.v16i1.420

Research Article

Characterization of Potential Perennials as Erosion Retainers in the Brantas River Border Based on Different Environmental Bases in Malang, East Java

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Abstract

Research on the characterization of potential perennials to resist river erosion in the Brantas river border based on different environmental features in Malang, East Java has been carried out. The research aims to know plant species composition, plant diversity, and the dominance of perennials that can prevent erosion. The study used vegetation analysis with cruise methods, exploring perennials on the Brantas river border based on different environmental settings (residential industry, environment, fields). The results of the study found 49 species of plants in 25 families, the diversity of hard plants in the residential environment was high with H' 3.06 while in the industrial and rice fields/fields environment it was moderate with H' 2.67 (Industry) and H' 1.90 (fields). The dominant plants are Gigantochloa apus (Schult. f.) Kurz ex Munro (Industry) species, Calliandra houstoniana (Mill.) Standl. (Settlement) and Pinus merkusii Jungh. & Vriese ex Vriese. (fields) Many perennials in the study area can prevent erosion because these plants meet the criteria of a strong root system and economic value.

Keywords: *Perennials, Erosion, Border, Brantas River.*

1. Introduction

The Brantas River is one of the rivers that play an important role for the people of East Java, especially the people of Malang. The existence of the Brantas river is recognized as very vital by the community because it is the largest supplier of raw water for PDAM Surabaya and Malang (Irawati, 2014). The landscape around the river border consists of different types of land such as swamps, agricultural land, and residential land. Vegetation on riverbanks plays an important role in preventing soil erosion, regulating water flow, and preserving flora, fauna, and water quality. However, the increasing number of people and the rapid pace of development have increased the intensity of pressure on land (Sunarhadi *et al*., 2015). The misuse of these resources if not controlled, in the long term can cause ecological problems and economic losses. Therefore, restoration, rehabilitation, and conservation programs are needed to effectively manage riverbank areas.

The results of the research that has been done show that the diversity of border vegetation with 188 species of plants in 71 families in 61 orders shows good diversity. Border vegetation in terrestrial ecosystems is an important zone for regulating the flow of nutrients and energy movement. The Importance Value Index of border vegetation is more than 10% which is represented by fairly good vegetation phytosociology (Rahardjanto *et al*., 2015). In this regard, the research that has been carried out has not yet identified potential plants as erosion barriers. Thus, this study reveals the types of perennials that have the potential to resist erosion. In addition, an analysis of the hard plant vegetation on the Brantas river border was also carried out based on different environmental hues. This study aims to identify species composition, analyze the level of diversity, and dominance of perennials, and determine potential erosion-retaining perennials in the Brantas river border based on different environmental settings (residential environment, rice fields/fields, and industry) in Malang, East Java.

2. Material and Method

This research was conducted in the Brantas river border area based on different environmental conditions (residential environment, rice fields/fields, and industry) in Malang, East Java, and the Ecology Laboratory of the Department of Biologi, Universitas Negeri Malang from August to September 2021.

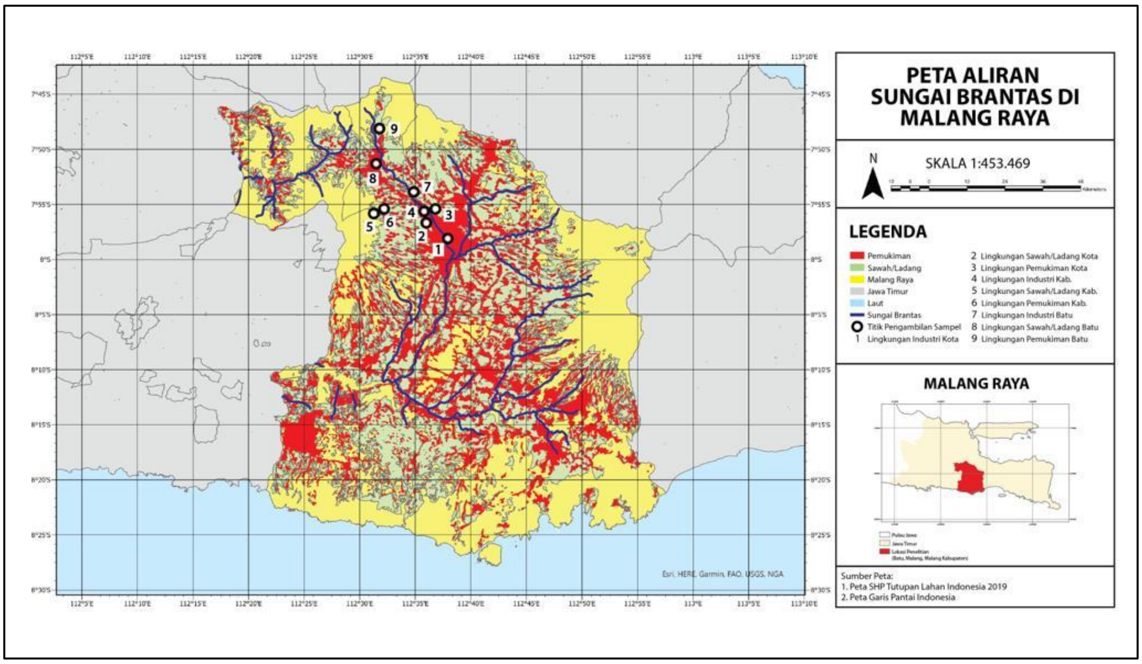

Figure 1. Map of the Brantas River Basin

This study used a descriptive type. exploratory, by exploring perennials as erosion barriers in the Brantas river border area based on different environmental settings (residential environment, rice fields/fields, industry) in Malang, East Java. Primary data retrieval using the cruise method along different environmental zones (housing, paddy fields/fields, and industry) on the Brantas river border and marked in the Garmin Oregon 650 GPS (Global Positioning System), each sampling area is limited to 100x100m^2 (right-left along the river), every plant found was identified and recorded on paper and documented using a Canon 6D DSLR camera. Analysis of plant diversity data using the Shannon-Wiener Diversityndex with the formula: H' = $\sum_{i=1}^{s}(pi)$ (ln pi). The dominance of plants is determined by the Important Value Index (INP) with the formula: INP = KR + FR (Azizah & Utami, 2021). Determination of potential erosion-retaining perennials based on the criteria of having a root system that does not cause severe competition for plants, but has good soil binding properties and does not require a high level of soil fertility, grows fast, produces lots of leaves, and economic value.

3. Result and Discussion

3.1. Result

Plant Composition, Dominance of Perennials, and Diversity of Perennials

The study's overall results found 824 individuals from 49 species belonging to 25 perennial families, based on the analysis of the significance value index (INP) of perennials in different environmental settings, species dominance was found in the industrial and residential environments including high and the industrial environment as well as in the medium fields, based on the results of the analysis of the diversity of perennials in different environmental settings, species diversity was found in residential areas, including high and in industrial areas, as well as in rice fields, including moderate.

Data on the composition of perennials based, the dominance of perennials, and the diversity of perennials on different environmental features found at the study site are presented in Table 1-3 :

Table 1. List of Species, Families, Local Names, Abundance, the dominance of perennials, and diversity of perennials in the Industrial Baseline.

No	Spesies	Family	Local Name	Industrial Environmental Baseline			Total	INP	H'
				Kab. Malang	Batu	Malang city			
1	*Gigantochloa apus* (Schult. f.) Kurz ex Munro	Poaceae	Bambu Apus	9 rumpun	5 rumpun	10 rumpun	24	30,21	2,64
2	*Dendrocalamus as per* (Schult. f.) Backer ex Heyne	Poaceae	Bambu Betung	5 rumpun	-	8 rumpun	13	20,14	
3	*Gigantochloa atter* (Hassk.) Kurz ex Munro	Poaceae	Bambu Jawa	-	3 rumpun	-	3	18,88	
4	*Carica papaya* L.	Caricaceae	Pepaya	3	-	-	3	16,37	

No	Spesies	Family	Local Name	Industrial Environmental Baseline			Total	INP	H'
				Kab. Malang	Batu	Malang city			
5	*Persea americana* Mill.	Lauraceae	Alpukat	2	-	-	2	10,07	
6	*Mangifera indica* L.	Anacardiaceae	Mangga	3	4	-	7	10,07	
7	*Psidium guajava* L.	Myrtaceae	Jambu biji	1	-	-	1	8,81	
8	*Dimocarpus longan* Lour.	Sapindaceae	Klengkeng	-	7	-	7	8,81	
9	*Artocarpus hetero phyllus* Lam	Moraceae	Nangka	-	5	-	5	8,81	
10	*Muntingia calabura* L.	Muntingiaceae	Kersen	-	-	6	6	8,81	
11	*Hibiscus tiliaceus* L.	Malvaceae	Waru	4	-	3	7	7,55	
12	*Calliandra houstoniana* (Mill.) Standl.	Fabaceae	Kaliandra	7	-	-	7	6,29	
13	*Parkia speciosa* H assk.	Fabaceae	Pete	1	-	-	1	3,78	
14	*Ficus septica* Burm.f.	Moraceae	Awar-awar	9	7	-	16	3,78	
15	*Ficus benjamina* L	Moraceae	Ara	8	-	7	15	2,52	
16	*Toona ciliata* Roem.	Meliaceae	Suren	-	2	-	2	2,52	
17	*Ficus hispida* L.f.	Moraceae	Bisoro	-	-	2	2	2,52	
18	*Leucaena leucocephala* (Lam.) de Wit	Fabaceae	Lamtoro	-	3	5	8	1,26	
19	*Samanea saman* (J acq.) Merr.	Fabaceae	Trembesi	-	-	8	8	1,26	
Total				**38**	**28**	**31**	**137**		

Based on Table 1. It can be explained that the discovery of 97 individuals from 19 species belonging to 10 families of perennials, *Gigantochloa apus (Schult. f.) Kurz ex Munro* plants had the highest number of individuals, 24 clumps. From the data in Table 1. It can be explained that the dominance of the species *Gigantochloa apus (Schult. f.) Kurz ex Munro* reached 30.21, indicating its dominance, while the species *Psidium guajava L.* and *Parkia speciosa Hassk.* showed several 1.26 which indicated a low dominance. Based on Table 1. It can be explained that the hard plant diversity index in the industrial environment is moderate, as shown in the data with the number H' 2.67.

Table 2. List of Species, Families, Local Names, Abundance, the dominance of perennials, and diversity of perennials in the Residential Baselines.

No	Spesies	Family	Local Name	Residential Environmental Baseline			Total	INP	H'
				Kabupaten Malang	Batu	Malang city			
1	*Calliandra houstoniana* (Mill.) Standl.	Fabaceae	Kaliandra	-	11	16	27	22,48	3,06
2	*Gigantochloa apus* (Schult. f.) Kurz ex Munro	Poaceae	Bambu Apus	-	14 rumpun	6 rumpun	20	16,65	
3	*Artocarpus heterophyllus* Lam	Moraceae	Nangka	8	3	7	18	14,99	
4	*Leucaena leucocephala* (Lam.) de Wit	Fabaceae	Lamtoro	4	4	8	16	13,32	
5	*Hibiscus tiliaceus* L.	Malvaceae	Waru	1	2	8	11	9,16	
6	*Terminalia mantaly* H.Perrier	Combretaceae	Ketapang Kencana	-	-	11	11	9,16	
7	*Psidium guajava* L.	Myrtaceae	Jambu Biji	1	5	2	8	6,66	
8	*Dimocarpus longan* Lour.	Sapindaceae	Klengkeng	-	4	3	7	5,83	
9	*Mangifera indica L.*	Anacardiaceae	Mangga	3	2	1	6	5,00	
10	*Ficus septica* Burm.f.	Moraceae	Awar-awar	1	4	-	5	4,16	
11	*Spathodea campanulata* Beauv.	Bignoniaceae	Pohon Hujan	-	-	5	5	4,16	
12	*Coffea arabica* L.	Rubiacea	Kopi Arabika	4	-	-	4	3,33	
13	*Ficus benjamina* L.	Moraceae	Ara	-	-	4	4	3,33	
14	*Muntingia calabura* L.	Muntingiaceae	Kersen	-	-	4	4	3,33	
15	*Annona muricata* L.	Annonaceae	Sirsak	3	-	-	3	2,50	
16	*Ceiba pentandra* (L.) Gaertn.	Malvaceae	Kapuk Randu	3	-	-	3	2,50	
17	*Coffea liberica* W.Bull	Rubiacea	Kopi Liberika	3	-	-	3	2,50	
18	*Dendrocalamus asper* (Schult. f.) Backer ex Heyne	Poaceae	Bambu Betung	-	-	3 rumpun	3	2,50	
19	*Persea americana* Mill.	Lauraceae	Alpukat	2	-	1	3	2,50	
20	*Averrhoa carambola* L	Oxalidaceae	Belimbing	-	-	2	2	1,67	
21	*Erythrina crista-galli* L.	Fabaceae	Dadap Serep	2	-	-	2	1,67	

No	Spesies	Family	Local Name	Residential Environmental Baseline			Total	INP	H'
				Kabupaten Malang	Batu	Malang city			
22	*Ficus hispida* L.f.	Moraceae	Bisoro	-	-	2	2	1,67	
23	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	Santenan	2	-	-	2	1,67	
24	Neolamarckia cadamba (Roxb.) F. Bosser	Rubiaceae	Jabon	-	-	2	2	1,67	
25	*Pinus merkusii* Jungh. & Vriese ex Vriese	Pinaceae	Pinus	-	-	2	2	1,67	
26	*Spondias dulcis* Parkinson	Anacardiaceae	Kedondong	-	-	2	2	1,67	
27	*Swietenia macrophylla* King.	Meliaceae	Mahoni	2	-	-	2	1,67	
28	*Adenium obesum* (Forssk.) Roem. & Schult.	Apocynaceae	Kamboja Jepang	1	-	-	1	0,83	
29	*Chrysophyllum cainito* L.	Sapotaceae	Kenitu	-	-	1	1	0,83	
30	*Cocos nucifera* L.	Arecaceae	Kelapa	-	-	1	1	0,83	
31	*Pterocarpus indicus* Willd.	Fabaceae	Angsana	1	-	-	1	0,83	
32	*Samanea saman* (Jacq.) Merr.	Fabaceae	Trembesi	-	-	1	1	0,83	
33	*Gigantochloa atter* (Hassk.) Kurz ex Munro	Poaceae	Bambu Jawa	1 rumpun	-	-	1	0,83	
34	*Syzygium aromaticum* (L.) Merr. & L.M.Perry	Myrtaceae	Cengkeh	1	-	-	1	0,83	
35	*Toona ciliata* Roem.	Meliaceae	Suren	1	-	-	1	0,83	
				43	**35**	**83**	**185**		

Based on Table 2. It can be explained that there were 185 individuals from 35 species belonging to 19 families of perennials, *Calliandra houstoniana (Mill.) Standl* plants had the highest number of individuals with 27 individuals. From the data in Table 2. the dominance of the species *Calliandra houstoniana (Mill.) Standl*. reached 22.48 indicating its dominance, while the species *Cocos nucifera L., Chrysophyllum cainito L., Gigantochloa atter (Hassk.) Kurz ex Munro, Syzygium aromaticum (L.) Merr. & L.M. Perry, Toona ciliata Roem., Pterocarpus indicus Willd., Adenium obesum (Forssk.) Roem. & Schult., and Samanea saman (Jacq.) Merr.* shows the number 0.83 which indicates a low dominance. Based on Table 2. It can be explained that the hard plant diversity index in the environmental setting is very abundant, as shown in the data with the number H' 3.06.

Table 3. List of Species, Families, Local Names, Abundance, dominance of perennials, and diversity of perennials in Environmental Baseline of Rice Fields/Fields.

No	Spesies	Family	Nama Lokal	Rice Fields/Fields Environmental Baseline			Total	INP	H'
				Kabupaten Malang	Batu	Malang city			
1	*Pinus merkusii* Jungh. & Vriese ex Vriese	Pinaceae	Pinus	313	1	-	314	68,62	
2	*Persea americana* Mill.	Lauraceae	Alpukat	14	21	-	35	7,65	
3	*Calliandra houstoniana* (Mill.) Standl.	Fabaceae	Kaliandra	-	6	18	24	5,25	
4	*Swietenia macrophylla* King.	Meliaceae	Mahoni	15	-	7	22	4,81	
5	*Gigantochloa apus* (Schult. f.) Kurz ex Munro	Poaceae	Bambu Apus	5 rumpun	6 rumpun	8 rumpun	19	4,15	
6	*Artocarpus heterophyllus* Lam	Moraceae	Nangka	2	5	10	17	3,72	
7	*Samanea saman* (Jacq.) Merr.	Fabaceae	Trembesi	10	-	4	14	3,06	
8	*Psidium guajava* L.	Myrtaceae	Jambu Biji	1	5	6	12	2,62	
9	*Maesopsis eminii* Engl.	Rhamnaceae	Pohon Payung	12	-	-	12	2,62	
10	*Hibiscus tiliaceus* L.	Malvaceae	Waru	-	10	-	10	2,19	1,90
11	*Toona ciliata* Roem.	Meliaceae	Suren	3	5	-	8	1,75	
12	*Citrus maxima* (Burm.) Merr.	Rutaceae	Jeruk	6	-	-	6	1,31	
13	*Syzygium aqueum* (Burm. f.) Alston	Myrtaceae	Jambu Air	-	-	6	6	1,31	
14	*Cocos nucifera* L.	Arecaceae	Kelapa	-	-	5	5	1,09	
15	*Michelia alba* DC.	Magnoliaceae	Cempaka	-	5	-	5	1,09	
16	*Ficus benjamina* L.	Moraceae	Ara	-	-	5	5	1,09	
17	*Mangifera indica* L.	Anacardiaceae	Mangga	-	4	-	4	0,87	
18	*Annona muricata* L.	Annonaceae	Sirsak	3	-	-	3	0,66	
19	*Muntingia calabura* L.	Muntingiaceae	Kersen			3	3	0,66	
20	*Moringa oleifera* Lam.	Moringaceae	Kelor	-	2	1	3	0,66	
21	*Durio zibethinus* Murray	Malvaceae	Durian	-	2	-	2	0,44	

No	Spesies	Family	Nama Lokal	Rice Fields/Fields Environmental Baseline			Total	INP	H'
				Kabupaten Malang	Batu	Malang city			
22	*Coffea arabica* L.	Rubiacea	Kopi Arabika	-	2	-	2	0,44	
23	*Dypsis lutescens* (H.Wendl.) Beentje & J.Dransf.	Arecaceae	Palem Kuning	-	2	-	2	0,44	
24	*Casuarina equisetifolia* L.	Casuarinaceae	Cemara	-	2	-	2	0,44	
25	*Rhaphiolepis bibas* (Lour.) Galasso & Banfi	Rosaceae	Biwa/Loquat	-	2	-	2	0,44	
26	*Ceiba pentandra* (L.) Gaertn.	Malvaceae	Kapuk Randu	-	-	2	2	0,44	
27	*Dimocarpus longan* Lour.	Sapindaceae	Klengkeng	-	1	-	1	0,22	
28	*Artocarpus altilis* (Parkinson) Fosberg	Moraceae	Sukun	-	-	1	1	0,22	
29	*Roystonea regia* (Kunth) O.F.Cook	Arecaceae	Palem Raja	-	-	1	1	0,22	
Total				**379**	**75**	**69**	**542**		

Based on Table 3 that there were 542 individuals from 29 species belonging to 20 families of perennials, *Pinus merkusii Jungh. & Vriese ex Vriese* has the highest number of individuals with 314 individuals. From the data in Table 3. the dominance of Pinus merkusii Jungh. & Vriese ex Vriese reached 68.62 indicating its dominance, while the species *Artocarpus altilis (Parkinson) Fosberg* and *Roystonea regia (Kunth) O.F.Cook* showed 0.22 which indicated low dominance. Based on Table 3. It can be explained that the hard plant diversity index on the environmental hue of the rice fields/fields is moderate as shown in the data with the number H' 1.90.

Erosion Retaining Potential Plants

From the results of the study, it can be seen that 39 species out of a total of 49 plant species were found as a barrier to river erosion, indicating that hard plants in the Brantas river border are based on different environmental conditions (residential environments, rice fields/fields, and industries) in Malang, East Java, including high.

Table 4. List of Species, Families and Local Names of Erosion Retaining Perennials found.

No	Species	Family	Local Name
1	*Annona muricata* L.	Annonaceae	Sirsak
2	*Artocarpus altilis* (Parkinson) Fosberg	Moraceae	Sukun
3	*Artocarpus heterophyllus* Lam	Moraceae	Nangka
4	*Averrhoa carambola* L	Oxalidaceae	Belimbing

No	Species	Family	Local Name
5	*Calliandra houstoniana* (Mill.) Standl.	Fabaceae	Kaliandra
6	*Casuarina equisetifolia* L.	Casuarinaceae	Cemara
7	*Chrysophyllum cainito* L.	Sapotaceae	Kenitu
8	*Coffea arabica* L.	Rubiacea	Kopi Arabika
9	*Coffea liberica* W.Bull	Rubiacea	Kopi Liberika
10	*Dendrocalamus asper* (Schult. f.) Backer ex Heyne	Poaceae	Bambu Betung
11	*Dimocarpus longan* Lour.	Sapindaceae	Klengkeng
12	*Durio zibethinus* Murray	Malvaceae	Durian
13	*Ficus hispida* L.f.	Moraceae	Bisoro
14	*Ficus septica* Burm.f.	Moraceae	Awar-awar
15	*Ficus benjamina* L.	Moraceae	Ara
16	*Ficus elastica* Roxb. ex Hornem	Moraceae	Karet Kebo
17	*Gigantochloa atter* (Hassk.) Kurz ex Munro	Poaceae	Bambu Jawa
18	*Gigantochloa apus* (Schult. f.) Kurz ex Munro	Poaceae	Bambu Apus
19	*Hibiscus tiliaceus* L.	Malvaceae	Waru
20	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	Santenan
21	*Leucaena leucocephala* (Lam.) de Wit	Fabaceae	Lamtoro
22	*Maesopsis eminii* Engl.	Rhamnaceae	Pohon Payung
23	*Mangifera indica* L.	Anacardiaceae	Mangga
24	*Michelia alba* DC.	Magnoliaceae	Cempaka
25	*Muntingia calabura* L.	Muntingiaceae	Kersen
26	Neolamarckia cadamba (Roxb.) F. Bosser	Rubiaceae	Jabon
27	*Parkia speciosa* Hassk.	Fabaceae	Pete
28	*Persea americana* Mill.	Lauraceae	Alpukat
29	*Pinus merkusii* Jungh. & Vriese ex Vriese	Pinaceae	Pinus
30	*Psidium guajava* L.	Myrtaceae	Jambu Biji
31	*Pterocarpus indicus* Willd.	Fabaceae	Angsana
32	*Samanea saman* (Jacq.) Merr.	Fabaceae	Trembesi
33	*Spathodea campanulata* Beauv.	Bignoniaceae	Pohon Hujan
34	*Spondias dulcis* Parkinson	Anacardiaceae	Kedondong
35	*Swietenia macrophylla* King.	Meliaceae	Mahoni
36	*Syzygium aromaticum* (L.) Merr. & L.M.Perry	Myrtaceae	Cengkeh

No	Species	Family	Local Name
37	*Syzygium aqueum* (Burm. f.) Alston	Myrtaceae	Jambu Air
38	*Terminalia mantaly* H.Perrier	Combretaceae	Ketapang Kencana
39	*Toona ciliata* Roem.	Meliaceae	Suren

From Table 10. It can be seen that 39 species belonging to 20 families were found. Plants or plants that are suitable for use in erosion prevention and use in crop rotation systems must meet the requirements of having a root system that does not cause severe competition for plants, but has good soil binding properties and does not require a high level of soil fertility, grows fast. and produce a lot of leaves.

Figure 2. Plant data collection process (a), and border vegetation (b)

3.2.Discussion

From research conducted on the industrial environment, it was found that 97 individuals of 19 species belong to 10 families. In the residential environment found 185 individuals of 35 species belonging to 19 Families. In the rice field environment, 542 individuals from 29 species were found in 20 families. Based on these data, the paddy field/field environment and residential environment have an abundant composition of plant species marked by the number of species and families of 29 species in the rice field/field environment and 35 species in the residential environment. This is due to the environmental function used by the community by planting various types of plants. From the results of the research that has been carried out, research shows that the diversity of the Brantas river border vegetation found 188 species from 71 families belonging to 61 orders showing good diversity. Riparian vegetation in terrestrial ecosystems is an important zone for regulating the flow of nutrients and energy movement. The Importance Value Index of riparian vegetation of more than 10% is represented as fairly good vegetation phytosociology (Rahardjanto et al., 2015).

Species diversity aims to determine the structure and stability of a community. A stable community is able to maintain the stability of the community from various disturbances to its components, species diversity is a characteristic of the community level and is also used to express community structure. Ecologically, a community with a diversity index and evenness index has a high value, it can be said that the species community has the same or nearly the same species abundance, the species diversity index can also be used to assess human pressures (Wahyuningsih *et al.*, 2019). Tree diversity is biodiversity that shows the overall form of genes, species, and ecosystems in an area. Two factors cause biodiversity, namely genetic factors and external factors. Genetic factors have a relatively constant or stable effect on the morphology of an organism. On the other hand, external factors have a relatively stable effect on the morphology of living organisms. This is caused by biodiversity or species diversity of the same species. Environmental or external factors such as food, temperature, sunlight, humidity, rainfall, and other factors.

Based on the analysis of the hard plant diversity index in the industrial environment, the results obtained H' = 2.67, which indicates that the diversity of plants in the environment is moderate. In residential areas, the result is H' = 3.06, which indicates that the diversity in the environment is high. Meanwhile, in the rice field environment, the result is H' = 1.90, which means that the diversity of plants in the environment is moderate. This is triggered by environmental conditions and human factors that affect the types of plants planted in that environment. As is the case in the residential environment, where the diversity is very abundant due to human factors that plant various types of plants in their environment.

Plant dominance can be defined as the control of one plant species over another so that dominance can be seen with the Important Value Index (INP). Important value index (INP) is an index that is calculated based on the total relative density (KR), relative frequency (FR), and relative dominance (DR). INP describes the important role of a type of vegetation in an ecosystem (Handayani & Yustiah, 2014). The composition of plant species and diversity of plants in an area depends on several environmental factors, such as humidity, nutrition, sunlight, topography, source rock, soil characteristics, canopy structure and history of land use (Yuliantoro & Frianto, 2019).

We can see the character of perennials that have the potential as river erosion barriers in the research results, which we can see in the industrial environment dominated by the species *Gigantochloa apus (Schult. f.) Kurz ex Munro* or bamboo apus, this is because the function of apus bamboo is very suitable for the community and its role as an erosion barrier. Because bamboo has a strong fibrous root structure, it can resist erosion, and economically almost all parts of the bamboo can be used and utilized. The residential area is dominated by the species *Calliandra houstoniana (Mill.) Standl.*, while in the rice field the study area is dominated by the *Pinus merkusii Jungh species. & Vriese ex Vriese*. This is because the rice fields in the research area are included in the tourist forest zone (Bumi Perkemahan Bedengan), which triggers the dominance of pine species.

Plant roots increase soil stability by increasing soil cohesiveness so that the soil is safer against landslides. However, sometimes plants can also trigger landslides due to the additional weight of the trees, and increase the infiltration which allows more water to infiltrate into the soil, consequently lowers the shear stress. Vegetation is also able to improve soil aggregation. The formation of soil aggregates starts from the destruction of the lumps of soil by plant roots. The roots of the plants enter the lumps of soil and give rise to weak places, then split into secondary grains. The root system also causes the aggregate to become stable. Besides the root system, the presence of plant residues is also very helpful in the formation and consolidation of soil aggregates. With good soil aggregation, the soil will be more resistant to rainwater blows. The number and stability of soil pores increases so that the infiltration capacity of the soil also increases. Another effect of vegetation on soil erosion is increasing groundwater loss. Loss of groundwater from plants occurs through evaporation and transpiration, while exposed soil only occurs through evaporation. Thus the land where plants grow will dry quickly, so that it has a large infiltration capacity, thereby reducing the volume of surface runoff (States et al., 2009).

Of the many plants found along the Brantas river in the research area, plants or plants that are suitable for use in erosion prevention and use in crop rotation systems must meet the requirements of having a root system that does not cause severe competition for plants but has good soil binding properties. and does not require a high level of soil fertility, grows fast, and produces many leaves, for example, *Albizia falcata* (sea sengon), *Pithecellobium saman benth* (rain tree), *Erythrina sp*. (dadap), *Gliricidia sepium, Leucaena glauca or Leucaena leucocephala, Albizia procera Benth, Acacia melanoxylon, Acacia mangium, Eucalyptus saligna, Cinchona succirubra, Gigantolochloa apus* (bamboo apus), *Dendrocalamus asper* (bamboo betung) *Bambusa vulgaris* (bamboo wulung) (wiedarti, sri. ramdan, 2014). Examples of plants that meet these criteria are bamboo. Bamboo has a strong fibrous root structure, so it can resist erosion. The bamboo shrub grows fast and tolerates the environment well and can increase effective water catchment sources, making it suitable for reforestation in open or deforested areas.

Bamboo is also suitable as a protective plant for the banks of rivers or ravines. Some other benefits of bamboo are: (1) Easy to plant, and does not need special attention. (2) There is no need to plant bamboo on a large scale, factories are built, and the results will be continuously obtained without replanting (3) long, dense and flexible fibers are not easily broken. (4) The growth rate of bamboo in its vegetative growth is the fastest, no other plant is faster. (5) It has an excellent elasticity. Example: A clump of burned bamboo can grow even if the tsunami disaster struck in Aceh in December 2004, bamboo can still stand when other trees fall. (6) High economic value because almost all parts of the body can be used and utilized. Bamboo shoots can be used as food that has high nutritional value, the leaves are used to wrap food, the stems are used as architectural materials, and can be used as handicrafts or musical instruments. The stem fibers in bamboo can also be used to make paper.

The calliandra plant (*Calliandra houstoniana (Mill.) Standl.*) has the criteria of being easy to grow, has deep enough roots, binds the soil and captures rainwater has a function of resisting erosion, some parts of the calliandra plant can be used by the community and industry, among others, the leaves can used for animal feed because it has high protein, dry stems and branches can be used for energy (firewood). Apart from calliandra, another type of tree vegetation that can function in soil bioengineering is *Leucaena leucocephala* (Sittadewi, 2018). Guava and coffee plants have deep enough root systems that can function to bind the soil to reduce soil erosion. The morphological conditions in areas with high landslide hazard are generally hilly and undulating so that they have steep slopes. This type of petai plant is suitable for planting on agricultural land as part of an agroforestry system because it has deep roots, light crowns, tree branches that are easy to grow and also easy to prune.

Types of woody plants such as sengon are the most effective plants in minimizing the occurrence of landslides (Simanjuntak, 2015). Many types of plants can be planted to reduce the potential for landslides based on the height and elevation of the area, including Pilang (*Acacia leucophloea*), Cempedak (*Artocarpus champeden*), Breadfruit (*Artocarpus communis*), Neem (*Azadirachta indica*), Candlenut (*Aleuritas mollucana*), Cashew nuts (*Anacardium occidentale*), sugar palm (*Arenga pinnata*), resin (*Agathist alba*), durian (*Durio zibethinus*) and various other plants according to the instructions in the book Vegetative Engineering to Reduce Landslide Risk from the Ministry of Environment and Forestry (Mussadun et al., 2020). There are 19 types of plants obtained with their suitability for landslide mitigation purposes based on the requirements for plant mitigation with deep root types, high transpiration (indicated by the ability to produce litter), and not having the potential to bind water (plants with taproots) belonging to clove plants, lamtoro, coffee, candlenut, mahogany, cacao, calliandra, durian, cashew, kluwak, banyan, trembesi, ketapang, teak, jabon, mindi, sengon, tanjung and kepuh (Adhitya *et al*., 2017).

Control of erosion and surface runoff of mahogany stands is mostly controlled by the presence of litter and undergrowth. Breeding activities by selecting the best individuals will produce superior mahogany seeds which can increase wood production and reduce surface runoff and erosion. The level of erosion and the amount of surface water runoff in mahogany stands aged 2, 5, and 9 years tended to decrease with increasing plant age. Mahogany can act as an indicator of water conservation. In drought conditions, mahogany sheds its leaves as a stress response. Leaf water potential is associated with the relative water content. Overall leaf fall under water stress conditions is a strategy to delay drought by reducing transpiration and maintaining water balance. This condition of stress response does not occur in areas that contain a lot of water stores (Mashudi, 2016).

Conclusion

The results of the study found 824 individuals with 49 species in 25 perennial families. The plant diversity index of the residential environment is high with the number H' 3.06, in the Industrial environment the diversity is moderate with the number H' 2.67, as well as in the Rice field/Field environment the diversity is moderate as shown in the data with the number H' 1.9. Species *Gigantochloa apus (Schult. f.) Kurz ex Munro* and species *Pinus merkusii Jungh. & Vriese ex Vriese* dominates in the research area. While the recommended plants that have the potential as erosion barriers are *Albizia falcata* (sea sengon, jeunjing), *Pithecellobium saman benth* (rain tree), *Erythrina sp.* (dadap), *Gliricidia sepium, Leucaena glauca* or *Leucaena leucocephala, Albizia procera Benth, Acacia melanoxylon, Acacia mangium, Eucalyptus saligna, Cinchona succirubra, Gigantolochloa apus, Dendrocalamus asper, dan Bambusa vulgaris*.

Acknowledgments

This research was carried out with granted by internal finance universitas negeri Malang from the PNBP funding of the State University of Malang 2021.

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