

## Research article

# Preservation of Vegetation Diversity to Maintain the Riparian Ecosystem of the Sampean Watershed

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## Abstract.

Riparian vegetation on river borders can affect the riparian ecosystem of the watershed related to its function as a buffer zone and ecotone between water and land. A high diversity of riparian vegetation can indicate that the ecosystem of a river border is in good condition. Therefore, it is helpful to inventory the diversity of vegetation in the riparian zone, which was done in this study using the Shannon-Wiener diversity index. In this research, four plots measuring 5m x 5m, spread across upstream, middle, and downstream areas were used to analyze the types of vegetation, including trees, shrubs, and herbs. The diversity index ( $H'$ ) results revealed four vegetation species at the tree level, twelve species at the shrub level, and six species at the herb level. The range of  $H'$  values in all sample plots was  $1 < H' < 3$ , so the river border was shown to have moderate diversity, which indicated that the ecosystem in the Sampean watershed is relatively balanced. It is necessary to preserve the riparian buffer zone through riparian vegetation restoration management to improve the ecosystem balance of the Sampean watershed.

**Keywords:** riparian vegetation, watershed, Shannon-Wiener diversity index

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## 1. Introduction

The watershed as a water catchment area is an essential component in supporting the availability of water. It plays a vital role in maintaining water quality and reducing mass soil runoff from upstream to downstream plants in the riparian ecosystem help keep the sustainability of a watershed ecosystem. The riparian ecosystem is located on the riverbanks with various types of plants that can adapt to river water, often flooded when it rains [1]. Riparian plant species can be trees, shrubs, and herbs [2].

The riparian zone is a buffer zone between aquatic ecosystems, namely rivers and land. According to the Regulation of the Minister of Public Works and Housing of the Republic of Indonesia Number 28/Prt/M/2015 concerning the Determination of River Border Lines and Lake Border Lines, a river borderline is defined as a virtual line on

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the left and right of a riverbed designated as river protection boundary. The function of the river border as a river protection boundary is now gradually changing to becoming a place for community activities, affecting the function of the borderland as in the Sampean watershed. The community now uses the land for settlements (11,105 ha), irrigated rice fields (32,957 ha), and farmland or moor (27,108 ha) [3]. It indicates an increasing pressure on river borders due to land conversion.

Riparian plants have a crucial role in the watershed ecosystem. In biology, riparian plants act as filters for soil and water minerals and their substances. Also, they provide food for wild animals. In urban areas, riparian plants function as pollutant absorbers and can maintain the microclimate. In hydrology, riparian plays a role in preserving groundwater in infiltration and percolation. Plants in the riparian zone form a small ecological unit that can control the microclimate, become a habitat for wildlife, and maintain river and land ecosystems. However, currently, the river riparian zone faces many changes due to land conversion. The continuous decline in the balance of the riparian ecosystem leads to the loss of riparian function as a buffer space - it will indirectly impact the community.

Changes in land use around the banks of the Sampean watershed can change the natural ecosystem balance of the riparian. The ecosystem change can be identified using the index of vegetation diversity in the watershed border. The diversity index can function as a parameter to determine the balance of the riparian ecosystem in the watershed. Appropriate riparian management efforts can be determined from the analysis of vegetation diversity. Therefore, riparian zone conservation activities can be carried out to sustain the carrying capacity of the Sampean watershed for the environment and society.

## 2. Method

### 2.1. Time and Location

This research was conducted in the upstream, midstream, and downstream of the Sampean watershed. The downstream and midstream are located in Situbondo Regency, while the upstream is in Klampokan Village, Bondowoso Regency. Observations for primary data collection were carried out in May 2021 with four sample plot areas. The downstream plot coordinates were  $S07^{\circ}42.061'$   $E113^{\circ}56.982'$  and  $S07^{\circ}42.541'$   $E113^{\circ}58.686'$ ; midstream plot coordinates were  $S07^{\circ}45.209'$   $E114^{\circ}00.377'$ ; and the upstream plot coordinates were  $S07^{\circ}49.689'$   $E113^{\circ}56.208'$ .

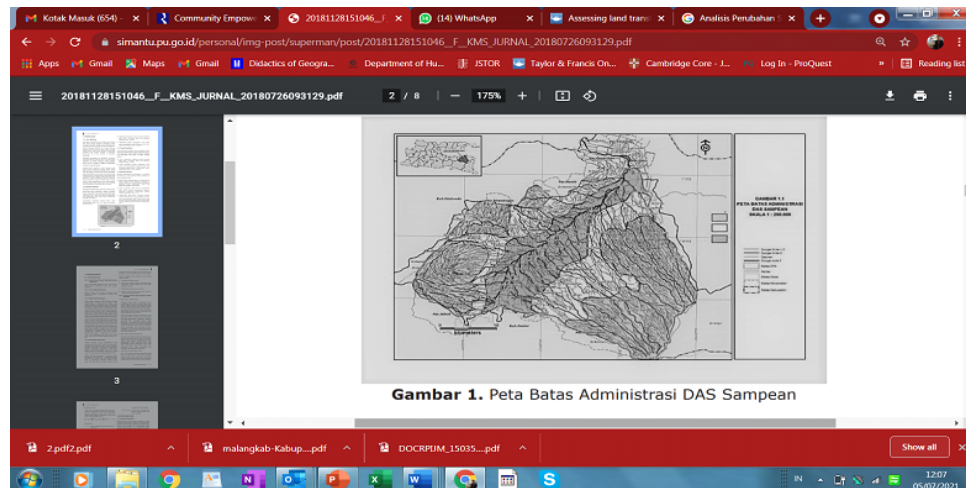


Figure 1: The Administrative Borderlines of the Sampean Watershed [7].

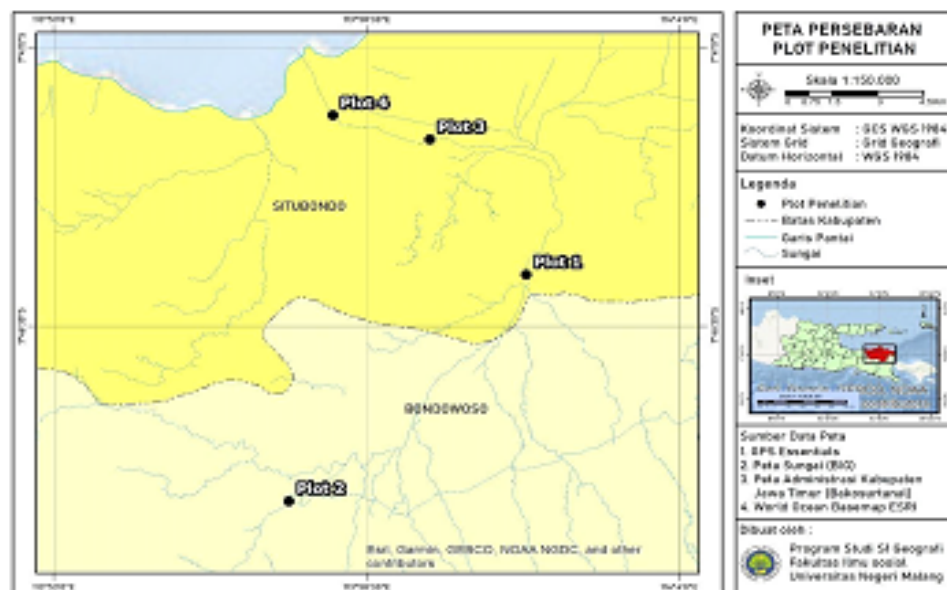


Figure 2: Map of the Study Sites.

## 2.2. Research Procedure

This study used a quantitative descriptive method. [4] states that descriptive research seeks to describe phenomena that occur following reality. Then, a quantitative approach is used to examine a particular population or sample [5]. The research sample was taken using the plot method with a plot size of 5m x 5m for trees, shrubs, and herbs. The plot was mapped using a plastic rope, tape measure, pegs, and GPS. The data recorded in each plot consisted of the species name and the number of individuals documented with the camera. Finally, the types of plants were identified using the sources from USDA (<https://plants.sc.egov.usda.gov/>) and related journals as data analysis.

## 2.3. Data Analysis

Analysis of riparian vegetation inventory data was carried out using the Shannon-Wiener Diversity Index. This index was used to identify the level of plant species diversity in the observation area. A biodiversity index analysis follows a mathematical model [6]. A place is said to have high species diversity if it has an even species richness. The formula for the Shannon-Wiener diversity index is as follows:

$$H' = - \sum (n_i) (N)$$

H' = diversity index

ni = number of individual vegetation types i

N = total individual vegetation for all species

## 3. Result and Discussion

### 3.1. Vegetation Diversity in Sampean Watershed

The watershed of the Sampean River is a regional watershed located between Bondowoso and Situbondo Regency. The watershed covers an area of about 1,206 km<sup>2</sup> with a river length of 70 km. The Regulation of the Minister of Public Works and Housing of the Republic of Indonesia Number 28/Prt/M/2015 [12] concerning the Determination of River Border Lines and Lake Border Lines Article 6 states that the watershed area of more than 500 km<sup>2</sup> belongs to the criterion of a large river. Hence, the Sampean watershed falls in this group. The Sampean watershed has an undamaged border and is located outside the urban area. Thus, the ideal distance of the river border is at least 100 meters from the left and right banks of the riverbed along the river channel. According to the land use data, the Sampean watershed border area is mainly used as irrigated rice fields, fields or moorlands, and residential land. In taking the plots, we chose a riparian zone far from the settlement to obtain a pristine area unaffected by human activities with minimal degradation.

Based on the observations on the four plots, the composition of riparian vegetation types consisted of 22 plant species divided into four tree species, 12 shrubs species, and six herbs species.

The diversity index is essential information about a (biological) community. The diversity index combines species richness and evenness in a single value. Species diversity generally uses several indexes, but the most widely used in determining species diversity is the Shannon-Wiener Index (H'). The criteria for the Shannon-Wiener

TABLE 1: Riparian Vegetation Composition in Sampean Watershed Plots.

Type	Local Name	Latin name	Quantity (ind./25m <sup>2</sup> )				Number of Individuals
			Upstream	Midstream		Downstream	
			Plot 2	Plot 1	Plot 3	Plot 4	
Tree	Kerantungan	<i>Durio oxleyanus</i>	1	-	-	-	1
	Mango	<i>Mangifera indica</i>	2	-	-	-	2
	Raintree	<i>Samanea saman</i>	-	-	1	-	1
	Banana	<i>Musa paradisiaca</i>	-	-	-	6	6
Shrub	Meniran	<i>Phyllanthus urinaria</i>	-	3	-	-	3
	Morel Berry	<i>Physalis angulata</i>	-	1	-	-	1
	Sourgrass	<i>Oxalis barrelieri</i>	10	5	7	-	22
	Wild Yam	<i>Dioscorea alata</i>	10	-	18	-	33
	Sembukan leaves	<i>Paederia foetida</i>	3	-	-	-	3
	Sidaguri leaves	<i>Sida rhombifolia</i>	7	-	-	-	7
	Mangsian leaves	<i>Phyllanthus reticulatus</i>	8	-	10	-	18
	River tamarind	<i>Leucaena leucocephala</i>	-	-	5	8	13
	Awar-Awar leaves	<i>Ficus septicum</i>	-	-	2	-	2
	Kelor leaves	<i>Moringa oleifera</i>	-	-	-	1	1
	Cassava	<i>Manihot esculenta</i>	-	-	-	5	5
	Kirinyuh leaves	<i>Chromolaena odorata</i>	-	-	8	-	8
	Herb	Goosegrass	<i>Eleusine indica</i>	-	43	-	-
Putri Malu leaves		<i>Mimosa pudica</i>	3	3	10	12	28
Elephant Grass		<i>Pennisetum purpureum</i>	5	15	15	33	68
Wild Spinach		<i>Amaranthus spinosus</i>	-	2	-	-	2
Prairie Cupgrass		<i>Eriochloa contracta</i>	52	-	-	38	90
Wild Water spinach		<i>Water spinach</i>	-	8	-	4	12
Number of individuals			101	80	76	107	369
Number of types			10	8	9	8	22

Source: Author, 2021

diversity index (H') is as follows: (a) if the value of  $H' \leq 1$ , the level of diversity is low; (b) if the value is  $1 < H' < 3$ , the level of diversity is moderate; (c) and if the value of  $H' \geq 3$ , the level of diversity is high.

The vegetation type and quantity influence the high and low species diversity in an area. A (biological) community is said to have high diversity if it comprises many species with the same or almost the same species abundance. Otherwise, if the community is composed of a few species and only a few species are dominant, the species diversity is low. Table 2 indicates the value of the vegetation diversity index in the four observation plots of the Sampean watershed.

TABLE 2: The Shannon-Wiener Diversity Index (H') Sampean Watershed, May 2021.

Type	Quantity (ind./25m2)			
	Upstreams	Midstream		Downstream
	Plot 1	Plot 2	Plot 3	Plot 4
Tree	3	-	1	6
Shrub	38	9	50	14
Herb	60	71	25	87
Number of Individuals	101	80	76	107
Number of Species	10	8	9	8
Diversity Index (H')	1.67	1.44	1.98	1.64
H' maximum	2.3	2.1	2.2	2.1

Source: Author, 2021

Table 2 indicates that the diversity index (H') in the first observation plot, the second observation plot, the third observation plot, and the fourth observation plot fall into the moderate diversity level ( $1 \leq H' \leq 3$ ). These conditions indicate that the productivity is moderate, the condition of the ecosystem is balanced, although there are indications of moderate ecological pressure. Ecological stresses are physical, chemical, or biological aspects that limit the productivity of an ecosystem and measurable environmental problems. Many different complex-reaction levels to stress exist, including changes in energy, respiration, nutrient cycling, and community structure [8].

One of the natural forms of ecological pressure is natural disasters, such as floods that reduce the diversity of watershed vegetation, especially in areas dominated by herbaceous plants. Floods easily wash away these plants because their roots are less able to bind the soil. It causes the existing biota to be lost and new types to appear. The land conversion around the watershed into settlements, aquaculture, tourism, illegal logging, and waste pollution represent ecological pressures caused by human activities [8]. The ecological pressure of the Sampean watershed mainly comes from human activities by changing the function of the riparian zone into irrigated rice fields and fields.

Moderate or balanced ecosystem conditions indicating the interaction between biotic and abiotic components in the Sampean watershed are still quite good. According

to Andrewartha and Birch in [9], an ecosystem is a complex and interactive system composed of all living organisms in an area and its physical environment (soil, water, climate, and habitat). The balance of the ecosystem must be maintained to create a good environment. An ecosystem can be balanced if all the biotic and abiotic components are at the proper dose - the right amount and role in the environment.

Vegetation diversity levels in an ecosystem will affect species diversity. The vegetation diversity index in the Sampean watershed is moderate, dominated by shrubs and herbaceous species. Riparian vegetation is a habitat for various types of vertebrate and invertebrate fauna. Some vertebrate fauna species often found along rivers are birds, small mammals, frogs or toads, and reptiles such as snakes and lizards. The invertebrate fauna is dragonflies, grasshoppers, beetles, butterflies, snails, mosquitoes, spiders, and various types of fish. The diversity of habitats from upstream to downstream of the Sampean watershed strongly supports multiple types of vegetation and animals to create a complete ecosystem.

Vegetation diversity can also affect soil infiltration rate - denser diversity means more pores are created, causing the infiltration rate to be large. However, the physical properties of the soil also influence infiltration. A large infiltration rate can reduce surface runoff. Herbs and shrubs have shallow roots, so their ability to absorb and retain water is low. Meanwhile, trees have solid and deep roots, so they have high absorption and are robust in keeping water. Based on the sample plots, the species in the Sampean watershed are dominated by herbaceous plants of the *Eriochloa contracta* or prairie cup grass species and shrubs that have shallow roots, so tree vegetation with strong roots is needed to maintain the infiltration rate.

### 3.2. Preservation of Riparian zone in Sampean Watershed

The Sampean watershed has a moderate diversity index. It can be improved through river restoration by planting trees to restore habitat. In addition, riparian vegetation management efforts are needed to maintain the watershed ecosystem. Replanting riparian areas can be carried out by selecting appropriate local plants to strengthen soil absorption and resilience. We can also use plants already existing in the Sampean watershed area. The analysis of the riparian vegetation composition in the Sampean watershed shows that tree species are very minimal. A sample of five m<sup>2</sup> shows only one or (a maximum of) two trees. According to Yudianingrum [10], green open space in the riparian zone consists of three zones. Zone 1 are trees located closest to the riverbank, Zone 2 are shrubs, and Zone 3, the farthest from the river and closest to

other land uses (settlements), are herbs. The Sampean watershed has more herbs and shrubs than trees, so what to do is planting on river borders, especially in Zone 1. We can use local trees such as rain trees, a high CO<sub>2</sub> absorber, mango, and kerantugan. We can also plant alternative tree species suitable to grow in border areas, like fast-growing ketapang as a shade plant, sengon buto as a source of bird feed and shade plants, bungur trees, and cape trees.

In addition to planting trees, some other criteria exist for the management of riparian vegetation. The criteria, according to the Minister Regulation of Public Works (2008) [11], include the following. (a) Vegetation must have a robust root system to resist soil escape. (b) Vegetation can grow well on solid soil. (c) The root system enters the soil and does not damage construction and buildings. (d) Vegetation must have variable growth speed dominated by fast-growing species, resistant to pest and plant disease. (e) Plant spacing is half-close to close, covering 90% of the total planting area. (f) The canopy is quite shady and compact, in the form of local plants and cultivated plants, dominated by annual plants and plants that invite birds. Besides riparian vegetation management efforts, the public must be educated to stop doing activities that accelerate the rate of degradation in river borders. The public must be aware of the importance of riparian zones, including the zone in the Sampean watershed. All of these efforts help to balance the riparian zone.

## 4. Conclusion

The vegetation diversity in the riparian zone of the Sampean watershed has an index value of 1.67 upstream, 1.71 midstream, and 1.64 downstream that are included in the medium category ( $1 \leq H' \leq 3$ ). Those conditions indicate that the Sampean watershed has a balanced ecosystem with the possibility of moderate ecological pressure. Ecological pressure naturally comes from flood disasters and artificially comes from land conversion dominated by irrigated rice fields, dry fields, and settlements—all of these decrease the H' index. In all sample plots, the riparian vegetation in the Sampean watershed is dominated by herbaceous plants and shrubs having shallow roots. Thus, river restoration is needed by planting trees with solid root characteristics, especially in Zone 1, to maintain water infiltration and erosion.



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