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Biomass Estimation of Brantas Riparian Zone Tree, Batu City, East Java

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Abstract. *Research to estimate carbon absorption using ecosystem productivity models carried out in riparian zones is still rare. This research aimed to determine the carbon and biomass potential in the Brantas River riparian zone, Batu City. The data obtained was retrieved using Microsoft Excel 2013 software. The data was tested differently using Paleontological Statistics, through normality and homogeneity tests, and continued with a different test. Different tests are carried out to determine the quality of the riparian zone between the observation stations. In addition, the Principal Component Analysis (PCA) is continued with Biplot and Cluster Analysis to understand the differences between the stations and to know the characteristics between stations. The biomass in the village of Sidomulyo is bigger than any other location. The biomass is about 8760 tons/ha with a carbon potential of 4380 tons. This value is very high compared to the entire location. The average potential carbon at each location ranges from 67 to 285 tons. Sidomulyo village's riparian zone, rich in carbon and biomass, requires preservation to prevent global warming due to carbon emissions. The closure of land at the site of the village of Sidomulyo did not cause the riparian zone in the village to become less. The results showed that although the village of Sidomulyo has a savage land cover and settlements, the carbon storage from trees in the riparian zone is huge. This research aids in developing conservation strategies for riparian zones with high carbon storage potential, supports climate change mitigation, and informs policymakers on sustainable land management practices in the Brantas River watershed.*

Keywords: *biomass, land cover, potential carbon, riparian zone*

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INTRODUCTION

Deforestation can significantly impact net primary production (NPP), which is the amount of carbon released from the atmosphere through photosynthesis. The study area of this research is the riparian zone of the Brantas River in Sidomulyo Village, Batu City, East Java, Indonesia. This area is significant due to its mixed land use, comprising natural vegetation, agricultural activities, and settlements, making it a representative model for understanding carbon and biomass dynamics in riparian ecosystems under varying land-use pressures. Furthermore, the Brantas River is a critical watershed in East Java, supporting biodiversity, local livelihoods, and regional water management, highlighting the importance of conserving its riparian zones. A study in Amazon Brazil found that selective deforestation and deforestation of specific plant species can affect forest dynamics and reduce NPP (Numazawa et al., 2020). Deforestation, when combined with nutrient management, can lead to a decline in forest cover, affecting savannization (Senna et al., 2014). However, agroforestry systems can increase NPP and carbon storage, affecting microclimates by increasing temperature and extreme buffering (Abou Rajab, 2016). Overall, forest cover can have complex and variable effects on NPP, influenced by factors like forest type, deforestation rate, and land use (Poulter et al., 2010).

Deforestation in riparian zones can significantly impact habitat structure and wildlife habitats (Zhao et al., 2010). Riparian zones are not considered crucial buffer zones for maintaining air quality. Studies show that deforested riparian zones can lead to higher oxygen concentrations, increased air pressure, and reduced organic matter in the area (Bleich et al., 2014; Torres-Bejarano et al., 2022). Riparian vegetation and soil structure also influence biological diversity from the taxonomic diversity of *Iguana cola* in Amazon Kolombia. Human intervention can lead to the growth of invasive species, nutrient depletion, and nutrient imbalance in the air system. The response of fish species to deforestation and rapid deforestation zones has been negative in West Amazon, Brazil, indicating the importance of protecting and managing riparian zones for wildlife health and habitat integrity (Brejao et al., 2018).

Deforestation and land use change can affect forest biodiversity and decrease NPP (Alberts et al., 2017). Results show parcel history, vegetation age, land use, and geomorphological variables drive biomass patterns. Human disturbance dominates, but lower-located patches show lower biomass. Similar approaches could be deployed in other regions (Huylenbroeck et al., 2021). Hydrological and stoichiometric variables can influence 68% of NPP variations in riparian zones (Liu et al., 2020). Deforestation in poor areas can negatively affect NPP, affecting carbon sequestration and local development.

Research on carbon segregation in agricultural areas, such as wastelands, is often conducted to understand the potential of carbon dynamically from vegetation. However, studies using an ecosystem productivity model in wastelands are still limited. Sensitivity to change is higher due to anthropogenic activities, such as land use and land manipulation. The study suggests that land use management in wastelands can influence NPP changes over time (Jiao et al., 2018).

In order to determine the significance and efficacy of the area in lowering carbon emissions, this current research intends to increase ecosystem productivity in the Brantas River catchment area by evaluating the potential for carbon storage in contaminated areas.

MATERIALS AND METHODS.

Study Area and Location Map

This study was conducted in the riparian zone of the Brantas River, Batu City, East Java, Indonesia. Geographically, the study area is located at coordinates 7°49' - 7°54' N and 112°30' - 112°35' East. Batu City is located at an altitude between 800 and 1,700 meters above sea level, with most of the area being mountainous and rich in biodiversity. The study site included several segments of riparian zones with diverse vegetation conditions in terms of tree species, vegetation density, and land cover structure.

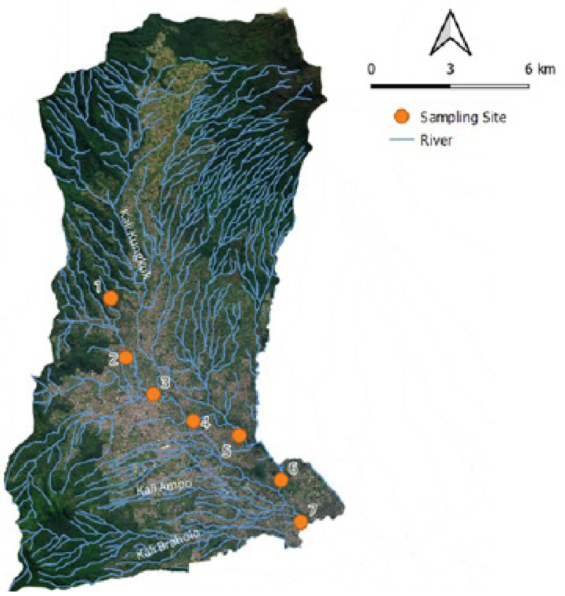


Figure 1. Sampling Site

A study area map was prepared using Geographic Information System (GIS) software, which included the administrative boundaries, main river flows, and the distribution of riparian segments used as observation points. Figure 1 shows the location map of the study area. Table 1 displays the topographical profile of Brantas riparian zone.

Table 1. Topographical profile of Brantas riparian zone

No.	Sampling site	Coordinate	Elevation (masl)	Width Estimation (m)
1	Gunungsari	-7.8322644; 112.5144957	1000	275.42
2	Sumberejo	-7.852519; 112.5196209	894	42.41
3	Sidomulyo	-7.8650138; 112.5291891	852	51.8
4	Temas	-7.874238; 112.543052	795	29.22
5	Torongrejo	-7.8791245; 112.5589455	683	194.89
6	Pendem	-7.8943616; 112.5734658	621	156.54
7	Dadaprejo	-7.9087337; 112.5802847	582	80.97

Table 2. Study Area Description, Coordinates, and Landcover Composition

No	Location	Land Cover Composition	Dominant Land Cover (LC)
1	Gunungsari	- Garden: 108,635 m² - Field: 4,814,991,429 m² - Settlement: 472,761,186.2 m² - Rice Field: 732,157,893.9 m² - Shrub: 4,098 m²	- Broad-leaved forest (79.98%) - Permanently irrigated arable land (12.16%) - Discontinuous urban fabric (7.85%)
2	Sumberejo	- Garden: 94,221,467 m² - Field: 73,942,084 m² - Settlement: 1,150,219,439 m² - Rice Field: 4,717,076,209 m²	- Permanently irrigated arable land (78.16%) - Discontinuous urban fabric (19.06%)
3	Sidomulyo	- Settlement: 2,177,856,902 m² - Rice Field: 3,842,205,717 m²	- Permanently irrigated arable land (63.82%) - Discontinuous urban fabric (36.18%)
4	Temas	- Grassland: 50,674,391.82 m² - Garden: 90,244,345.16 m² - Field: 182,641,323.8 m² - Settlement: 997,776,237 m² - Rice Field: 4,671,253,993.2 m² - Shrub: 104,691,490.9 m²	- Permanently irrigated arable land (76.61%) - Discontinuous urban fabric (36.18%)
5	Torongrejo	- Grassland: 1,035,123,553 m² - Settlement: 50,635,014.38 m² - Rice Field: 4,252,859,928 m² - Shrub: 650,690,342.9 m²	- Permanently irrigated arable land (71.01%) - Broad-leaved forest (17.28%) - Non-irrigated arable land (10.86%)
6	Pendem	- Grassland: 39,298,686.52 m² - Garden: 51,024,413.52 m² - Field: 21,867,605.79 m² - Settlement: 618,383,339.8 m² - Rice Field: 4,808,278,739 m² - Shrub: 389,184,754.5 m²	- Permanently irrigated arable land (81.11%) - Discontinuous urban fabric (10.43%) - Non-irrigated arable land (10.43%)
7	Dadaprejo	- Grassland: 49,668,079.43 m² - Field: 1,877,035,126 m² - Settlement: 1,910,190,932 m² - Rice Field: 898,781,349.5 m² - Shrub: 1,207,561,744 m²	- Discontinuous urban fabric (32.14%) - Broad-leaved forest (31.58%) - Non-irrigated arable land (20.32%) - Permanently irrigated arable land (15.12%)

Environmental Conditions

Batu city has a wet tropical climate with rainfall patterns influenced by the Asian monsoon system. Based on data from the Meteorological Station, the annual average temperature ranges from 18°C to 24°C, with average air humidity reaching 80%. Annual rainfall is in the range of 1,500 to 2,500 mm per year, with the peak of the rainy season occurring from November to April. The dominant wind blows from the southeast during the dry season (May-October) with an average speed of 10-20 km/hour.

The fertile andosol type, the result of the volcanic activity of Mount Panderman and Mount Arjuno, dominates the soil in the riparian zone of the Brantas River. The primary vegetation along the riparian zone consists of native trees such as *Ficus* sp., *Pterocarpus indicus*, and *Alstonia scholaris*, as well as some invasive species such as *Acacia mangium*. This riparian zone has an essential role as a regulator of the hydrological cycle and erosion barrier along the Brantas river.

Vegetation analysis was conducted on riparian areas with different environmental conditions, including segments with high tree density (>75% canopy), medium (50-75% canopy), and low (<50% canopy). Factors such as soil moisture, light intensity, and water availability were recorded to provide a more detailed picture of the tree habitat along the riparian zone.

Sampling Method and Data Collection

The research involved determining the plot using a ground cheek plot of 20m x 20m size. The purposive sampling method was used to collect data by adjusting the plot location from the Riparian zone of Brantas river Batu city.

Species Richness

Measures of species diversity usually include two components: richness and evenness. Richness represents the total number of species within a given area (Magurran, 2004). Species richness is influenced by various ecological processes and local habitat factors (Ma, 2005). Recent studies have shown that richness is a key determinant of biodiversity patterns and strongly impacts ecosystem functions (Soininen et al., 2012).

Tree Biomass Measurement

The age of plants was a crucial factor influencing biomass, productivity, and ecological balance in riparian zones. Plant age could be estimated based on diameter-at-breast-height (DBH) and tree ring analysis (dendrochronology) for species that form visible rings. Biomass was measured on plots of different sizes, with larger diameters measuring 20 x 20 meters and smaller diameters measuring 5-30 cm. The measurement process involved identifying the species of plant, measuring the plant's diameter, and comparing the plant's height and weight in the air. The plant's height and weight were measured in a heat chamber, and the plant's height (BJ) was measured using a scale with a length from one branch to the other, width from the base of the branch, and the base diameter and height.

The measurement of plant biomass was based on the Indonesian National Standard (SNI), which included the plant's normal, slanted, deformed, branched, supporting roots, and buttressed. The normal diameter was 1.3 meters from the root, the slanted was 1.3 meters from the root, the deformed was 1.3 meters from the root, the branch was 1.3 meters from the root, the supporting root was 1.3 meters from the root, and the buttressed was 20 cm from the root. The measurements were then compared using an allometric method (Duncanson et al., 2021).

Tree biomass measurement can use the biomass expansion factor (BEF) equation as follows:

$$Bap = v \times BJ \times BEF \times f$$

Description:

Bap : aboveground biomass (tree)(kg);
v : volume of wood without branches (m3);
BJ : the specific gravity of wood (kg/m3);
BEF : the biomass expansion factor (default 1.67).
f : the tree shape number factor (default 0.7)

Carbon Calculation from Biomass

Carbon calculation from biomass uses the following formula:

$$Cb = B \times \% \text{ organic } C$$

Description:

Cb : the carbon content of biomass (kg);
B : the total biomass (kg);
% organic C : the percentage value of carbon content, amounting to 0.47 or using the percentage value of carbon obtained from the results of measurements in the laboratory.

Carbon Stock Estimation per Hectare

The calculation of carbon stocks per hectare uses the following equation:

$$Cn = \frac{Cx}{1000} \times \frac{1000}{Lplot}$$

Description:

Cn : carbon content per hectare in each carbon pool in each plot, expressed in tons per hectare (ton/ha).
∑Cplot: total carbon content in the entire plot, expressed in tons
∑Cplot: total area of the plot expressed in hectares(ha).

Data Analysis

The data obtained were tabulated in Microsoft Excel 2013 software. The data were tested differently using Paleontological Statistics through normality tests and homogeneity tests followed by difference tests. Difference tests were conducted to determine the quality of the riparian zone between observation stations (Gunungsari, Sumberejo, Sidomulyo, Temas, Torongrejo, Pendem, and Dadaprejo). In addition, a Principal Component (PCA) analysis was carried out, followed by a Biplot and Cluster analysis, to understand the differences between stations and determine the stations' characteristics.

RESULTS AND DISCUSSION

Physical Profile of Brantas Riparian Zone

The study conducted a ground check using purposive sampling and plot analysis to determine elevation and precipitation levels. The study's location was selected from seven sampling locations, including Gunungsari, Sumberejo, Sidomulyo, Temas, Torongrejo, Pendem, and Dadaprejo, as shown in Table 2. Sites were chosen to represent a gradient of human activities, such as agricultural practices, urbanization, and natural areas, enabling an analysis of their impact on the riparian ecosystem. The precipitation levels were measured between 29.22-275.42 meters, with the tidal range being 29.22-275.42 meters. The tidal range in Brantas river was 118.75 meters.

Riparian Land Cover

The study also analyzed land cover in the riparian zone of Brantas river, using QGIS to create a map based on national geographic data from various municipalities, provinces, and districts. The map included six types of land use, including irrigated arable land, agricultural use, discontinuous urban fabric, non-irrigated arable land, and broad-leaved forest. The map's findings were based on the CORINE land cover part two, which includes illustrations that categorized land cover into permanently irrigated arable land agricultural use, discontinuous urban fabric, non-irrigated arable land, and broad-leaved forest. The map's results showed that the land use in the Brantas river from Gunungsari (upstream) to Dadaprejo (downstream), with the riparian zones including weed, plantation, permanent crop, settlement, arable, and bush. The study also used QGIS for the map's projection and ground checks, which were based on data from the National Geographic Information System (JIGN).

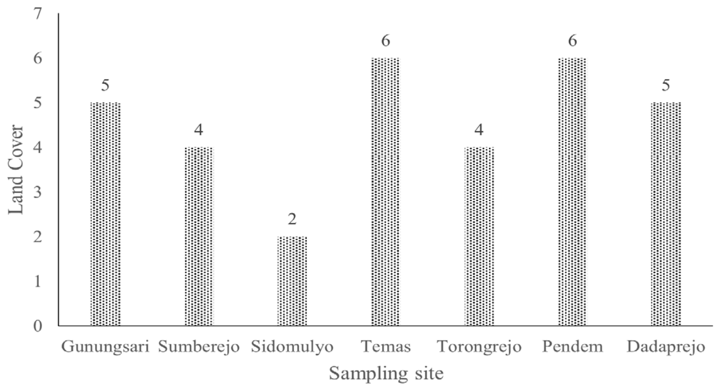


Figure 2. The number of land cover for each site

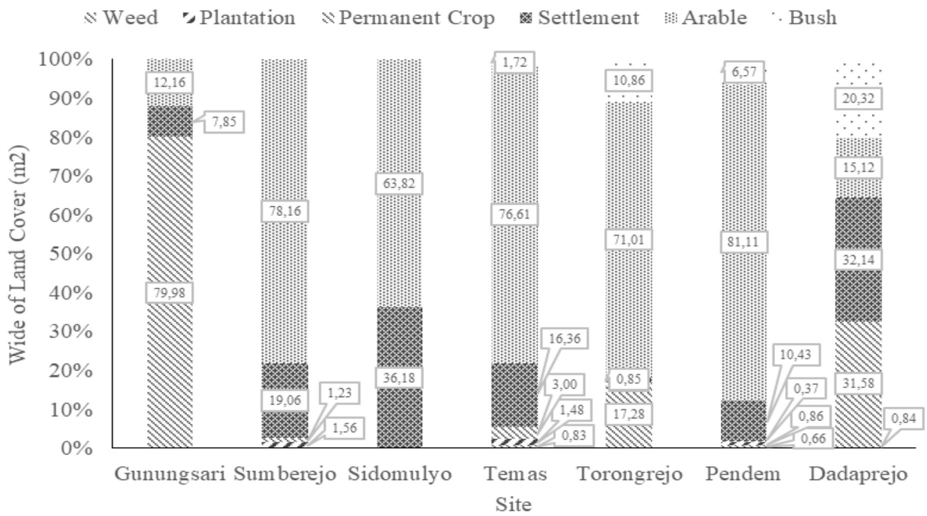


Figure 3. The wide of land for each type of land cover

The study analyzed land cover proportions using data from INA-geoportal and used ImageJ to calculate land cover with a 1:2500 scale. The results in Figure 2 and Figure 3 showed that the most significant proportion in land cover proportions is land, particularly in Gunungsari, with a range of 12.16-81.11%. Land cover proportions are highest in Pendem and Gunungsari, with a range of 0.00-36.18%. However, land cover proportions are highest in Dadaprejo, with areas like Sumberejo, Temas, Torongrejo, Pendem, and Dadaprejo having the highest proportions. The study highlights the importance of land cover proportions and land area in Dadaprejo, as many areas in the region are relevant to land use and land cover

Tree Species Richness

The study aims to determine the biomass of trees in Brantas river by identifying each tree using a tree identification tool and comparing its species distribution at different locations.

The study identified 21 species of trees in Table 3, including *Albizia chinensis*, *Alstonia scholaris*, *Artocarpus heterophyllus*, *Ceiba pentandra*, *Cocos nucifera*, *Dalbergia latifolia*, *Diospyros kaki*, *Durio zibethinus*, *Leucaena leucocephala*, *Mangifera indica*, *Muntingia calabura*, *Neolamarckia cadamba*, *Persea americana*, *Pinus merkusii*, *Samanea saman*, *Swietenia mahagoni*, Syzygium *antisepticum*, *Syzygium aqueum*, *Tamarindus* *indica*, *Tectona grandis* and *Toona sureni*. The species identified are mainly characterized by large numbers of individuals, with the largest species being *Albizia chinensis* (sengon), *Artocarpus heterophyllus* (nangka), and *Tectona grandis* (jati). However, a large number of individuals do not contribute to tree species distribution in different locations. The study found that the most significant tree species are in Sumberejo and Dadaprejo,

Table 3. Species Richness of Tree in Brantas Riparian Zone

Site	Species	Local Name	Count	Species Richness	Total (idv)
Gunungsari	*Artocarpus heterophyllus*	Nangka	3	6	16
	Durio zibethinus	Durian	1		
	Persea americana	Alpukat	3		
	Samanea saman	Trembesi	2		
	Pinus merkusii	Pinus	4		
	Diospyros kaki	Kesemek	3		
Sumberejo	*Tamarindus indica*	Asem	2	7	21
	Swietenia mahagoni	Mahoni	2		
	Artocarpus heterophyllus	Nangka	9		
	Alstonia scholaris	Pulai	4		
	Albizia chinensis	Sengon	2		
	Muntingia calabura	Karsen	1		
	Leucaena leucocephala	Lamtoro	1		
Sidomulyo	*Tectona grandis*	Jati	8	3	12
	Eugenia cuprea	Kitambaga	3		
	Ceiba pentandra	Randu	1		
Temas	*Neolamarckia cadamba*	Jabon	4	3	12
	Swietenia mahagoni	Mahoni	5		
	Artocarpus heterophyllus	Nangka	3		
Torongrejo	*Mangifera indica*	Mangga	1	4	9
	Swietenia mahagoni	Mahoni	4		
	Cocos nucifera	Kelapa	2		
	Tectona grandis	Jati	2		
Pendem	*Samanea saman*	Trembesi	1	5	18
	Albizia chinensis	Sengon	11		
	Ceiba pentandra	Randu	1		
	Dalbergia latifolia	Sonokeling	2		
	Swietenia mahagoni	Mahoni	3		
Dadaprejo	*Ceiba pentandra*	Randu	3	7	11
	Tectona grandis	Jati	1		
	Albizia chinensis	Sengon	2		
	Toona sureni	Suren	2		
	Syzygium aqueum	Jambu Air	1		
	Durio zibenthinus	Durian	1		
	Samanea saman	Trembesi	1		

while the most abundant are in Sidomulyo and Temas.

Wood density measures the amount of actual wood material in a unit volume of wood, as shown in Table 4. Achieving the measurement is a ratio of the mass of wood dried in the oven or air divided by the green volume of the wood. Wood density varies depending on the species of tree and the environment in which the tree grows. Different parts of the tree also have different densities: branches have a lower wood density than the trunk.

Diversity measurements were also conducted to determine the diversity of trees at each location, as shown in Table 5. The determination of tree diversity was carried out using the Shannon-Wiener diversity index. It is known that the diversity value of all locations ranges from 0.824 - 1.846. The highest diversity value is in Dadaprejo Village. At the same time, the lowest diversity value is in Sidomulyo Village. The average diversity in the riparian zone for trees is 1,337. This average diversity value is included in the moderate diversity category.

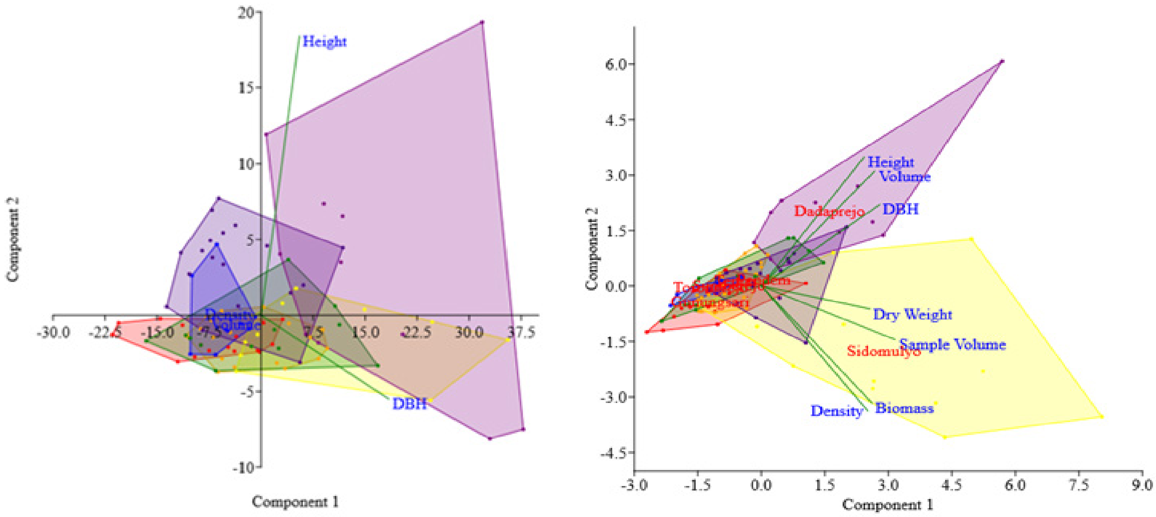
Table 4. Wood density of tree in Brantas Riparian Zone

Species	Wood Density (g/cm3)	References
A. heterophyllus	0.53	(Chave et al., 2009; McPherson et al., 2016)
D. zibethinus	0.52	(Chave et al., 2009; McPherson et al., 2016)
P. americana	0.55	(Chave et al., 2009; McPherson et al., 2016)
S. saman	0.51	Chave et al., 2009; McPherson et al., 2016
P. merkusii	0.53	Chave et al., 2009; McPherson et al., 2016
D. kaki	0.63	(Chave et al., 2009; McPherson et al., 2016)
T. indica	0.98	Chave et al., 2009; McPherson et al., 2016
S. mahagoni	0.75	Chave et al., 2009; McPherson et al., 2016
A. scholaris	0.38	Chave et al., 2009; McPherson et al., 2016
A. chinensis	0.30	Chave et al., 2009; McPherson et al., 2016
M. calabura	0.30	Detienne & Jacquet, 1983
L. leucocephala	0.69	Chave et al., 2009; McPherson et al., 2016
T. grandis	0.60	(Chave et al., 2009; McPherson et al., 2016)
S. antisepticum	-	
C. pentandra	0.31	(Chave et al., 2009; McPherson et al., 2016)
N. cadamba	-	
M. indica	0.55	(Chave et al., 2009; McPherson et al., 2016)
C. nucifera	0.52	(Chave et al., 2009; McPherson et al., 2016)
D. latifolia	0.77	Richter & Dallwitz, 2000
T. sureni	0.27	Orwa et al., 2009
S. aqueum	-	

Table 5. Tree Diversity in Brantas Riparian Zone

No	Species	Gunungsari	Sumberejo	Sidomulyo	Temas	Torongrejo	Pendem	Dadaprejo
1	*Albizia chinensis*	-	+	-	-	-	+	+
2	*Alstonia scholaris*	-	+	-	-	-	-	-
3	*Artocarpus heterophyllus*	+	+	-	+	-	-	-
4	*Ceiba pentandra*	-	-	+	-	-	+	+
5	*Cocos nucifera*	-	-	-	-	+	-	-
6	*Dalbergia latifolia*	-	-	-	-	-	+	-
7	*Diospyros kaki*	+	-	-	-	-	-	-
8	*Durio zibethinus*	+	-	-	-	-	-	+
9	*Leucaena leucocephala*	-	+	-	-	-	-	-
10	*Mangifera indica*	-	-	-	-	+	-	-
11	*Muntingia calabura*	-	+	-	-	-	-	-
12	*Neolamarckia cadamba*	-	-	-	+	-	-	-
13	*Persea americana*	+	-	-	-	-	-	-
14	*Pinus merkusii*	+	-	-	-	-	-	-
15	*Samanea saman*	-	-	-	-	-	+	+
16	*Swietenia mahagoni*	-	+	-	+	+	+	-
17	*Syzygium antisepticum*	-	-	+	-	-	-	-
18	*Syzygium aqueum*	-	-	-	-	-	-	+
19	*Tamarindus indica*	-	+	-	-	-	-	-
20	*Tectona grandis*	-	-	+	-	+	-	+
21	*Toona sureni*	-	-	-	-	-	-	+
	Shannon Diversity Index	1.537	1.641	0.824	1.078	1.273	1.165	1.846
	Tree Density	14	21	12	12	9	18	11

Biomass measurement is determined by measuring the diameter at the breast height of the tree, tree height, and tree volume. Using the allometric formula, the following data are obtained (Figure 4.a). The results of the biplot analysis show that Dadaprejo village has several trees with larger diameters and tree heights compared to other villages. This is followed by trees in the riparian zone of Sidomulyo village. This is also shown in Figure 4.b hat the biomass in Sidomulyo village is greater than other locations. It was obtained that 8759,811 tons/ha with a carbon potential of 4379,906 tons. This value is very



(a) (b)

Figure 4. Tree profile based on diameter, height, volume, tree specific gravity (a), and tree biomass profile (b) with Biplot analysis

high compared to all locations. The average carbon potential at each location is only around 66.7 - 284.6 tons. With the high value of carbon and biomass potential in Sidomulyo village, the riparian zone in this village needs to be conserved because it has great carbon potential. The large carbon potential, if intervened by human activities, will indirectly impact the release of carbon in nature. This is highly avoided because it creates the potential for global warming due to the release of carbon into the environment.

Land cover in the Sidomulyo village location does not necessarily cause the riparian zone in this village to become smaller. The results show that although the Sidomulyo village has rice fields and residential land cover, the carbon storage from trees in the riparian zone is very large.

The Influence of River Topography on Abiotic Factors of the Environment

Riparian width in the Brantas River plays a vital role in the ecosystem. In some studies, riparian width can affect abiotic environmental factors. The smallest riparian width is in Temas Village, and the largest is in Gunungsari Village. This depends on the regulatory service in controlling pollutants that arise from human activities around the riparian area.

Previous studies explored the use of riparian buffer strips (RBS) for conservation and rivers from deteriorating ecological conditions and water quality. RBS was set up and tested, showing a significant decrease in solids, total nitrogen, and total phosphorus in a width of 20m. The catchment area per 1 ha in RBS is 12 ha. Suppose a 20m wide RBS is installed in the largest agricultural area with an area of 72.049 ha. In that case, the catchment area per 1 ha can be estimated to be 4 ha, reducing the burden of nonpoint agricultural pollution by more than 79%. These findings indicate that RBS is suitable and versatile to reduce nonpoint agricultural pollution and improve ecological conditions (Manaye et al., 2021).

Riparian buffer zones are essential for maintaining water quality, reducing sediment accumulation, and preventing erosion (Morandi et al., 2020). Another study found that 7.5 and 15 m wide strip filters significantly reduced the concentrations of sediment and highly sediment-associated contaminants. However, they had less effect on distributed contaminants (Tay & He, 2023).

Another study found that nitrogen loss via interflow and phosphorus loss via overland flow were the dominant processes in riparian grasslands during land cultivation. The average annual total nitrogen (TN) loss in conventional fertilizer treatments was 4.28 ± 0.10 kg hm^{-2} via overland flow and 26.17 ± 3.68 kg hm^{-2}. The average annual total phosphorus (TP) loss in conventional fertilizer treatments was 0.83 ± 0.43 kg hm^{-2} via overland flow and 0.15 ± 0.02 kg hm^{-2} via interflow (Chang et al., 2022).

This study examined surface layer sediments' physical and chemical properties in the Dongting Valley before and after flooding. The results showed an increase in total soil phosphorus and nitrogen before the flood, while soil TP increased after the flood. The best-fitting multi-regression model, except for SMC, showed a parabolic trajectory throughout the flood duration (Andraczek et al., 2023).

Buffer zones are essential for maintaining water quality, reducing sediment accumulation, regulating surface runoff, and protecting biodiversity (Zermeno-Hernandez et al., 2020; Zhang et al., 2022). However, they are degraded due to human activities and land-use changes. The optimal width is determined by maximizing the ratio of benefits to and maximizing the ratio of benefits to biodiversity.

Land Use in Riparian Zones

Riparian width in the Brantas River playsRiparian land use is a significant driver of river ecosystem processes, with nitrate concentrations decreasing along streams with more natural riparian areas and increasing along streams with more urban and agricultural land use. Longitudinal variation in water chemistry also differs between watersheds and natural riparian areas, indicating that water quality also depends on riverine habitat. Longitudinal variation in water chemistry has proven to be a simple, helpful, and inexpensive approach to assessing the effects of land cover and riverine habitat on water quality (Andraczek et al., 2023).

The study found that riparian forests are essential for reducing nutrient export to downstream ecosystems. Urban Land (UL) and Agricultural Land (AL) have large negative contributions to each buffer, which are major nonpoint pollutant sources and influencing factors. The active contribution of Wetland (WL) and Forestry Land (FL) is greatest in small buffer distances of 0-200 m. The negative effect of Industrial Land (IL) on water quality is only significant in small buffer distances. The effect of landscape patterns on water quality is more important at large spatial scales than at small scales.

One of the main causes of water quality decline is changes in land use and land cover in rapidly developing urban areas. The characteristics of river water quality responses to land use depend on the spatial scale. At the circular buffer scale, total nitrogen (TN) is more closely related to land use, while at the riparian buffer scale, there is a stronger correlation between land use and algal biomass.

Land Use and Biomass Relationship

Land use and cover change (LUCC) significantly impacts the terrestrial carbon cycle, causing significant losses of grasslands, croplands, and built-up areas. Natural factors (11.05%) and human activities (8.25%) drive LUCC, with natural factors such as climate and vegetation succession slightly higher. Total carbon storage increased by 1.32 Pg C, stored in vegetation and soil biomass. Deforestation caused a large loss (about 29.81 Tg C/year), while increases occurred through Grain to Green, cultivation, and afforestation activities. LUCC significantly influences the increase in sequestration in China's terrestrial carbon stocks, which affects the accuracy of estimates and understanding of the impacts of human activities on the regional carbon balance (Schmitt et al., 1999). Between 2001 and 2019, Arkansas experienced significant land cover and land use changes, with major transitions mainly between forests and grasslands. A total of 1,233,327.52 tC of biomass carbon was lost during this period. The primary driver of biomass carbon emissions is forest change due to its high vegetation carbon density, especially in southwestern and southern Arkansas. Carbon storage decreased in the first period but increased in the subsequent period due to tree removal and regrowth cycles. Urban expansion in Arkansas affected 0.2% of forests and 0.6% of cropland, resulting in a biomass carbon loss of 543,401 tC. This transition is unlikely to be converted to other land use units, indicating the importance of land use planning in urban areas. Although overall carbon stocks are negative, land cover and land use in Arkansas have shown stable and reversible changes over the past 18 years. Future research is needed to improve the accuracy of biomass carbon emissions due to land cover and land use changes in Arkansas (Dindaroglu et al., 2015).

CONCLUSION

The study used QGIS to create a map based on national geographic data and categorized land use into irrigated arable land, agricultural use, discontinuous urban fabric, non-irrigated arable land, and broad-leaved forest. The land cover proportions were highest in Dadaprejo, with areas like Sumberejo, Temas, Torongrejo, Pendem, and Dadaprejo having the highest proportions. The study identified 21 tree species, the most significant of which were Sumberejo and Dadaprejo. The diversity of trees was measured using the Shannon-Wiener diversity index, with Dadaprejo having the highest diversity value. The study found that Sidomulyo village has a high carbon potential, indicating the need for conservation efforts. The study reveals that the potential carbon in the riparian zone of the Brantas River, Batu City, is 5392 tons, and the biomass in this area is 10785 tons/ha.

AUTHOR CONTRIBUTION

Hamdani Dwi Prasetyo designed the research, supervised all the processes, and wrote the manuscript; Ari Hayati collected and analyzed the data and wrote the manuscript.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the research, authorship, or publication of this study. Additionally, no external funding was received that could influence the objectivity or integrity of the research findings.

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