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Exploring Riparian Vegetation Dynamics in East Java: A Focus on the Central Welang Watershed

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Abstract

Indonesia boasts 74 diverse ecosystems, with the riparian system, found in areas like the Welang watershed in Malang Regency, Pasuruan Regency, and Pasuruan City, standing out. These moisture-adapted vegetative zones act as key transitions between aquatic and terrestrial habitats. Human activities in the central Welang watershed could impact its rich vegetation. This study aimed to catalog plant species in the riparian zones and assess their influence on water quality. Utilizing an explorative quantitative descriptive method, research was conducted at four sites in the central Welang watershed in June 2023, encompassing vegetation inventory and water sampling. Findings revealed 67 individual plants from 29 families, predominantly trees, in the central Welang region. This count exceeds the downstream but is less than the upstream. Water quality met the standards, indicating no pollution. Nonetheless, the potential presence of heavy metals necessitates further studies. Understanding Welang's riparian dynamics provides insights into riverbank ecosystems in Indonesia and possibly Southeast Asia. As these zones bridge aquatic and terrestrial environments, they're pivotal for biodiversity, water management, and settlement planning. This research underlines the need to harmonize human progress with ecological conservation, especially as the global focus intensifies on sustainable practices. The study's outcomes can enhance global discussions on riparian ecosystem preservation.

Introduction

Indonesia stands as a beacon of mega-biodiversity, boasting approximately 74 distinct ecosystems [1]. Biodiversity encompasses the entirety of life on Earth, from plants to animals to microorganisms. It represents not just the species themselves but also the genetic variation within them and the diverse ecosystems they create [2]. One such remarkable ecosystem is the riparian ecosystem.

Riparian ecosystems function as transition zones between terrestrial and aquatic habitats, such as between land and rivers. These ecosystems bear unique morphological, physiological, and reproductive traits tailored to their wetland environments [3]. Furthermore, they play a pivotal ecological role and provide invaluable benefits for the sustainability of surrounding communities. Dominated by a variety of vegetation—including trees, shrubs, herbs, and grasses—riparian zones act as protective buffers on riverbanks [4]. In more expansive rivers, these zones might stretch to ≥50m, but in residential areas, they are often confined to a range of 10-15m. Intriguingly, riparian vegetation typically thrives about 20m away from both the left and right riverbanks [5].

But what makes riparian vegetation so indispensable? Firstly, it is intrinsically tied to both aquatic and terrestrial ecosystems. It plays a crucial role in improving water quality, resisting erosion, shading aquatic habitats, facilitating leaf compost formation, and offering refuge to a multitude of organisms [4]. Furthermore, it moderates aquatic flora growth, ensures soil stability, and combats pollution from human

activities such as pesticide, fertilizer, and oil usage. By doing this, riparian vegetation not only purifies river water but also enhances its overall quality [6]. Its roots further play a role in erosion prevention by binding the soil firmly [14].

Highlighting the Welang Watershed: this river flows through Malang Regency and Pasuruan Regency. Geographically, it is positioned between 112°30'00" to 113°30'00" East Longitude and 7°30'00" to 8°30'00" South Latitude [7]. The central section of the Welang Watershed intersects multiple districts and boasts a riparian zone that borders rice fields, plantations, and residential areas. This closeness significantly influences vegetation diversity. As such, a study has been launched to explore the diversity of riparian plants in this central section of the Welang Watershed and to discern the impact of this vegetation on water quality.

Metodology

2.1 Research Design

This study is grounded in an exploratory quantitative descriptive approach. Our primary aim is to characterize the riparian plants' state along the central section of the Welang River. By marrying both the descriptive and the combined quantitative-exploratory techniques, we aim for a holistic inventory of the riparian plants. Once our fieldwork is complete, all collected data undergoes a thorough analysis and interpretation phase to extract meaningful insights.

2.2 Study Setting

Fieldwork for this research was conducted in June 2023, focusing on the central section of the Welang watershed. Our data collection strategy divided the area into four stations, each chosen for strategic coverage: Station 1 at the National Road Bridge, Station 2 at the Dompo/Dam Licin Bridge, Station 3 near the Pagarkeling Bridge, and Station 4 close to the Semut/Dam Selowongko Bridge. The rationale behind our station selection was to ensure comprehensive coverage, capturing the initial, mid, and terminal sections of the central Welang region.

2.3 Equipment and Materials

A variety of tools were indispensable to our research: stationery for detailed note-taking, a digital camera to capture visual data, pH meters to evaluate water acidity or alkalinity levels, Total Dissolved Solids (TDS) meters for gauging dissolved substances in the river, thermometers for temperature records, hygrometers for humidity measurements, luxmeters to determine light intensities, and anemometers to measure wind speeds. Complementing these tools, our primary research materials were the riparian plants present at each station and water samples from the central section of the Welang River.

2.4 Procedure and Data Analysis

Our research methodology can be visualized as a three-step journey. First, the preparation phase, during which we identified and earmarked observation stations, setting the stage for in-depth plant exploration, identification, and water sampling. Following this, our fieldwork phase consisted of tracing plant distributions, species identification, meticulous recording of observations, and photographing relevant subjects. Once our on-ground activities concluded, the data processing and analysis phase took precedence. Here, we delved deep into the collected data, processing and analyzing it to derive insights which then informed our subsequent discussions.

Results and Discussion

This research is a continuation of previous research conducted in the upstream and downstream parts of the Welang Watershed. Welang Watershed is one of the rivers that pass through three areas administrative that is Malang Regency, Regency Pasuruan, and Pasuruan City. Welang Watershed own a winding groove *(mender*) and is a stream that flows throughout the year (*perennial*) [7]. In [3] mentioned that the Welang watershed area from upstream and downstream is 498.03 km. The condition of the Welang watershed moment This experience problem environment due to human activities, especially in the central part of the watershed which is adjacent to settlements and is also influenced by human activities (Figure 1).

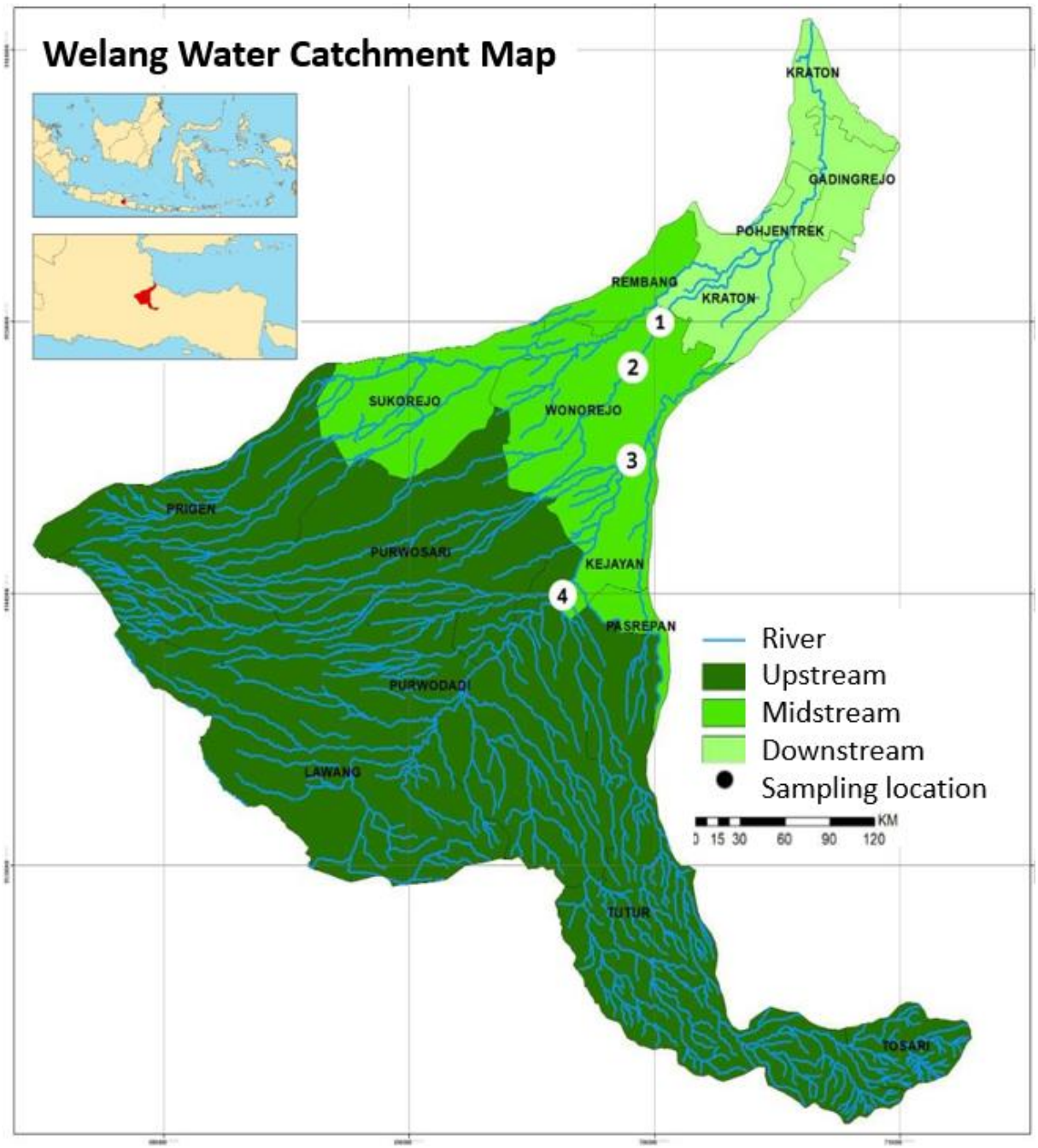

Figure 1. Location map research in section in the middle of the Welang watershed

Retrieval of research data in the section in the middle of the Welang watershed held in four different stations (Figure 1). Four station part in the middle of the Welang watershed theare in the District Success and Rembang Regency Pasuruan. Furthermore, the results of the research in the form of observation and identification show that there are various types of vegetation that grow on the banks river part in the middle of the Welang watershed which is presented in the appendix 1.

The research results presented in Appendix 1 show that 67 individuals of riparian vegetation were found living on the edge part the middle of the Welang watershed. All of these individual vegetation come from 29 different families, among others is *Acanthaceae, Anacardiaceae, Annonaceae, Apocynaceae, Asteraceae, Boraginaceae, Cannabaceae, Caricaceae, Convolvulaceae, Euphorbiaceae, Fabaceae, Lamiaceae , Lauraceae, Lecythidaceae , Liliaceae, Malvaceae, Meliaceae, Moraceae , Muntingiaceae, Musaceae, Myrtaceae, Oxalidaceae, Passifloraceae, Poaceae, Poly trichaceae, Rubiaceae, Sapindaceae, Sapotaceae*, and *Sterculiaceae*. The most dominant family in the vegetation that grows in

this part in the middle of the Welang watershed based on Appendix 1 is Fabaceae with a total of 12 species consisting of 14 riparian individuals.

The highest number of riparian vegetation was found at station II with a total of 23 individuals and at station IV with a total of 22 riparian individuals based on the data in Appendix 1. In general, riparian vegetation dominates the in the middle of the Welang watershed is habitual vegetation tree. That's very good in guard edge of the Welang watershed from erosion and flooding due to its characteristics typical from strong tree gripped firm soil and stems. In addition, ground cover vegetation also plays an important role in maintaining riverbank ecosystems from danger erosion. Vegetation own role in reduce erosion Because vegetation protect land from kinetic energy of falling raindrops to ground, hold particle land in place through roots and litter that can absorb water [15].

The middle of the Welang watershed is area settlements are very close to human activities, so the role of vegetation on the river bank is very important its existence. Owned riparian vegetation can be a buffer on the flow of the River because can changing nutrients, sediments, materials organics, pesticides, and ingredients toxic from Genre surface [16]. In addition, [8] mentions that tree function on the edge river is as amplifier transect river, tree own a strong root system grips the soil, so that the soil becomes firm because it is bound by soil roots. In results research [9] mentioned that the Welang watershed part middle own low Erosion Index values, one of which is influenced by vegetation closing ground.

Total amount of riparian vegetation found grow in parts in the middle of the Welang watershed based on Appendix 1 is 57 species. This amount is greater than the riparian vegetation found in parts downstream of the Welang watershed with a total of 37 vegetation types [10]. Meanwhile, when compared with the amount of riparian vegetation in the section upstream of the Welang watershed, total vegetation on the part in the middle of the Welang watershed more little, total riparian vegetation found in the upper reaches of the Welang watershed is as many as 163 species [11]. Overall results of research on riparian vegetation in the Welang watershed showing that from the upstream, middle, to downstream the number of riparian vegetation species found is decreasing.

In addition to studying the vegetation, this research also assessed environmental factors and water quality. These influential variables, which potentially impact the diversity and health of the vegetation, are detailed in Table 1.

Based on Table 1. The highest water temperature was found at Station 1 with a value of 58.7 ^{o}C, followed by Station 3 with a temperature of 30.1 ^{o}C, Station 4 with a temperature of 29.55^{o}C and the lowest water temperature was found by Station 2 with value 28.5 ^{o}C. The average temperature at the four stations has a numeric value approaching also more from 30 ^{o}C. According to [10] the water temperature above 30 indicates that the water flow is warm.

Table 1. Environmental Factors and Water Quality

Parameter	Station 1	Station 2	Station 3	Station 4
Hours (WIB)	10:14	10:48	13:45	14:08
Water Color	Brown muddy	Brown muddy	Somewhat brown	Somewhat brown
Lux	720	1140	34100	11800
Air Temperature (^{o}C)	31.95	33.5	37.8	35.4
Humidity	59	55	42	46.5
PH meter	6.75	6.89	6.98	7.76
TDS (mg/L)	208.5	150.5	128.5	127.5
Water Temperature (^{o}C)	28.7	28.5	30.1	29.55

In the table also obtained values Total Dissolved Solids (TDS) or Total Dissolved Solids. High TDS levels make the water cloudy [12]. The highest TDS is owned by Station 1 of 208.5 mg/L while the lowest TDS is owned by Station 4 with a value of 127.5 mg/L. This value indicates that the water quality is still in normal conditions, because the TDS quality standard for river water is not more than 1000 mg/L [13]. Not only that, in Table 1. Values are also listed pH. The lowest pH value is owned by Station 4 with a value of 7.76 and the lowest value is owned by Station 1 with a value of 6.75. These values are in normal conditions according to [13] which states that the pH value for river water is in the range of 6-9.

Riparian vegetation in the midle Welang watershed can affect water quality. Riparian vegetation has a water-ecological function for the environment and biota [18]. Riparian vegetation in the environment maintains ecosystem stability in the oxygen, carbon, nitrogen and water cycles, a function that riparian areas [19]. The differences in water quality in the middle Welang watershed can be seen in Table 1, Stations 2 and 4 have better water quality than the others. This is because the amount and type of vegetation is greater there. Differences in environmental characteristics, patterns of human activities, land use, sources of pollution, and types of riparian vegetation can influence water quality [17]. This is because the roots of riparian vegetation can serve as a buffer against pollutants or materials carried to river banks by residential, agricultural, industrial and other streams. Riparian vegetation acts as a barrier to nutrients and chemicals transported by water from the left and right banks of the river, preventing them from entering the river body [20]. Riparian vegetation plays a direct role in the natural purification of river water [17].

The ability of a body of water to self-purify is the ability to remove organic matter, plant nutrients, or other pollutants from a lake or river through the biological activity of the community living within it. Self-cleaning is often related to the oxidation of organic materials by aerobic organisms [21]. The function of riparian vegetation biota is to serve as a spawning, feeding, and nursery zone for various types of aquatic biota [22]. The first function of the bank is to serve as a nursery for biota living in the mangrove ecosystem. The second function is to serve as a feeding area, as it is capable of producing large amounts of detritus from leaves and trees, ensuring the availability of food for the riparian biota increases [27]. The third function is to provide a spawning ground for certain fish, protecting them from predators and finding an optimal environment for separating and raising their young [23]. In addition, it is a supplier of shrimp larvae, fish, and the other biota [24].

The type and amount of vegetation at stations 2 and 4 are greater than at other stations, so the amount of waste produced and therefore the sources of detritus are greater. Litter is an important part of the transfer of organic matter from vegetation to soil. Nutrients produced during the decomposition process of waste in the soil are of great importance as a source of detritus for aquatic ecosystems, as they support the life of various aquatic organisms [25]. Falling garbage undergoes a decomposition process by macrobenthos, which is then further converted into detritus by microorganisms. Detritus is a source of highly nutrient-rich food for various types of aquatic organisms, which can then be used by higher organisms in the food web [26].

Based on the obtained environmental and water quality parameter values, it can be said that the condition of the Welang watershed part middle still classified as normal because it does not exceed the value of the river water quality standard. However, to validate this, it is necessary to carry out further metal-related tests of weight contained in the Welang watershed part middle. Although in normal conditions, it still needs efforts to maintain the condition of the waters of the Welang watershed part middle. One of them is by planting various riparian plants that are able to grow [10]. Therefore, the initial study of riparian vegetation in the Welang watershed part middle can be a reference for further research especially potency deep riparian vegetation phytoremediation.

Conclusion

From the conducted research, we can ascertain that the central section of the Welang watershed houses 67 individual riparian plants spanning 29 distinct families, with trees being the predominant form. While the vegetation density in this central section surpasses that of the downstream area, it is less dense

compared to the upstream region. With respect to environmental parameters and water quality, the central section of the Welang watershed is not deemed polluted, adhering to the set quality standards. Nonetheless, it is crucial to conduct further examinations, particularly concerning the presence of heavy metals.

The findings from this research have broader implications for wider ecological and environmental studies. The presence and distribution of riparian vegetation, along with water quality metrics, can serve as pivotal indicators for understanding the health and sustainability of watersheds. Furthermore, this information can inform conservation and urban planning decisions, ensuring a balance between human activities and the preservation of natural habitats. The knowledge gained from this study also provides a foundation for subsequent research, offering a comprehensive understanding of the ecosystem dynamics within the Welang watershed and potentially serving as a model for other similar watersheds globally.

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Appendix 1. Riparian vegetation section in the middle of the Welang watershed

No.	Family	Species name	Local name	Station				Total
				I	II	III	IV	
1	Acanthaceae	*Barleria prionitis*	Hedgehog flower				1	1
2	Anacardiaceae	*Lannea coromandelica*	Jaranan	1	1			2
3	Anacardiaceae	*Mangifera indica*	Mango	1	1	1		3
4	Annonaceae	*Annona squomosa*	Srikaya			1		1
5	Annonaceae	*Polyalthia longifolia*	Glodogan				1	1
6	Apocynaceae	*Cascabella thevetia*	Kidney				1	1
7	Apocynaceae	*Wrigtia tomentosa*	Earring			1		1
8	Asteraceae	*Chromolaena odorata*	Grass please				1	1
9	Boraginaceae	*Cordia bantamensis*	Kendal		1			1
10	Cannabaceae	*Oriental trema*	guess				1	1
11	Caricaceae	*Carica papaya*	Pawpaw			1		1
12	Convolvulaceae	*Ipomea asiatica*	Spinach		1			1
13	Convolvulaceae	*Meremia emerginata*	gotu kola forest		1			1
14	Euphorbiaceae	*Ricinus communis*	Kepyar distance		1			1
15	Fabaceae	*Albizia lebbekoides*	Filled				1	1
16	Fabaceae	*Albiza palcataria*	Sengon				1	1
17	Fabaceae	*Albizi procera*	Wangkal				1	1
18	Fabaceae	*Calopogonium mucunoides*	Calopo		1			1
19	Fabaceae	*Cassia fistula*	Overcome				1	1
20	Fabaceae	*Derris elliptica*	tube		1			1
21	Fabaceae	*Leucaena leucocephala*	Chinese map		1	1		2
22	Fabaceae	*Fragrant Mimosa*	Mimosa		1		1	2
23	Fabaceae	*Mucuna propruena*	Kara snorts		1			1
24	Fabaceae	*Parkia speciosa*	Petai			1		1
25	Fabaceae	*Pterocarpus indicus*	Sonombang			1		1
26	Fabaceae	*Senna spectabilis*	Godong seno		1			1
27	Lamiaceae	*Gmelina arborea*	White Teak			1		1
28	Lamiaceae	*Gmelina arborea*	White teak				1	1
29	Lauraceae	*Persea americana*	Avocado			1		1
30	Lecythidaceae	*Barrigtonia acutangula*	Freshwater mangroves		1			1
31	Liliaceae	*Hypobattrum peutialicum*	Funnel flower				1	1
32	Malvaceae	*Ceiba Petandra*	Cottonwood				1	1
33	Malvaceae	*Kleinhovia hospita*	Katimaha				1	1
34	Malvaceae	*Urena lobatta*	Pulutan	1	1			2
35	Meliaceae	*Dysoxylum gaudicaudiaum*	Kedoya		1			1
36	Moraceae	*Ficus hispida*	Against fig leaves				1	1
37	Moraceae	*Ficus racemosa*	Fig		1		1	2
38	Moraceae	*Ficus virens*	White fig			1		1
39	Muntingiaceae	*Muntingia calabura*	Cherry		1			1
40	Musaceae	*Musa paradisiaca*	Banana	1		1		2
41	Myrtaceae	*Syzygium littorale*	Coffee guava		1			1
42	Oxalidaceae	*Averrhoa belimbi*	Vegetable starfruit			1		1
43	Passifloraceae	*Passiflora foetida*	Rebusa		1		1	2
44	Poaceae	*Bambusa blumea*	Bamboo		1	1		2
45	Poaceae	*Bambusa vulgaris*	Yellow bamboo			1		1
46	Poaceae	*Cymbopogon citratus*	Lemongrass				1	1
47	Poaceae	*Gigantochola apus*	Bamboo rope		1			1

No.	Family	Species name	Local name	Station				Total
				I	II	III	IV	
48	Poaceae	*Gigantocloa aster*	Water bamboo				1	1
49	Poaceae	*Pennisetum purpureum*	Elephant grass				1	1
50	Poaceae	*Pragmites orca*	Housing		1			1
51	Poaceae	*Schizostachyum tiaminsi*	Thorn bamboo	1				1
52	Polytrichaceae	*Pogonantera panicium*	Moss				1	1
53	Rubiaceae	*Nouclea orientalist*	Marsegu wood		1			1
54	Sapindaceae	*Dimocarpus longans*	Longan			1		1
55	Sapindaceae	*Schleichera oleosa*	Kesambi				1	1
56	Sapotaceae	*Manilkara akras*	Sapodilla			1		1
57	Sterculiaceae	*Melochia umbellata*	Paliasa	1				1
		Total		6	23	16	22	67