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RIPARIAN VEGETATION AND PERCEPTION OF ECOSYSTEM SERVICES IN THE UPPER GAJAHWONG RIVER, YOGYAKARTA, INDONESIA

VEGETASI RIPARIAN DAN PERSEPSI LAYANAN JASA EKOSISTEM DI SUNGAI GAJAHWONG BAGIAN ATAS, YOGYAKARTA, INDONESIA

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Abstract

Research on riparian vegetation and ecosystem services perception is essential to encourage community involvement in river area management. Therefore, this study aims to examine the composition of riparian vegetation along the upper Gajahwong River and assess local community perceptions of the ecosystem services provided by riparian biodiversity. Vegetation composition was studied through a floristic survey using plots placed along transects at three locations; Hargobinangun, Sardonoharjo, and Minomartani. Community perception was assessed through a survey of 60 randomly selected residents from the three villages studied. Data analysis involved calculating species richness, and species diversity, and analyzing community perceptions based on response percentages. The study identified more than 70 plant species at each site, with a very high diversity index (>4). Species with high Importance Value (IV) included *Ficus racemosa* (3.11), *Dieffenbachia seguine* (4.40), and *Acalypha indica* (3.59). Dominant plant families included *Araceae*, *Fabaceae*, and *Moraceae*, which provide essential provisioning and regulating ecosystem functions. Regarding community perception, the study found that residents recognized ecosystem functions, including provisioning services, regulating services, and socio-cultural services. Their understanding of ecosystem services was influenced by cultural values, particularly Javanese traditions emphasizing the importance of nature conservation.

Keywords: Ecosystem services; Gajahwong; Perception; Riparian; Vegetation

Abstrak

Penelitian mengenai vegetasi riparian dan persepsi jasa ekosistem perlu dilakukan untuk membantu masyarakat agar terlibat dalam pengelolaan kawasan sungai. Sehingga, penelitian ini bertujuan untuk mempelajari komposisi vegetasi riparian di Sungai Gajahwong bagian atas dan persepsi masyarakat terhadap ecosystem services yang disediakan oleh biodiversitas riparian. Penelitian mengenai komposisi vegetasi dilakukan dengan survei floristik dengan menggunakan plot yang diletakkan pada transek di tiga lokasi, yakni di Hargobinangun, Sardonoharjo, dan Minomartani. Sedangkan penelitian mengenai persepsi masyarakat dilakukan dengan melakukan survey terhadap 60 residen yang terpilih secara acak pada tiga desa yang dikaji. Analisis data dilakukan dengan menghitung jumlah jenis, keragaman jenis, dan persepsi masyarakat dianalisis berdasarkan persentase jawaban. Penelitian menemukan lebih dari 70 spesies vegetasi riparian di masing-masing lokasi, sedangkan indeks keragaman sangat tinggi dengan angka >4. Spesies yang memiliki nilai IV tinggi di antaranya Ficus racemosa (3.11), Diffenbachia seguine (4.40), dan Acalypha indica (3.59). Beberapa famili yang dominan di antaranya adalah Araceae, Fabaceae, dan Moraceae. Ketiganya memiliki fungsi provisioning dan regulating yang penting bagi ekosistem. Terkait dengan persepsi masyarakat, penelitian menemukan bahwa masyarakat memahami fungsi ekosistem dalam bentuk provisioning services, regulating services, dan socio-cultural services. Pengetahuan mereka terhadap ecosystem services ini dipengaruhi oleh nilai budaya, khususnya budaya Jawa yang menekankan pentingnya konsevasi alam.

***Kata Kunci**: Ecosystem services; Gajahwong; Persepsi; Riparian; Vegetasi*

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INTRODUCTION

The riparian ecosystem comprises the biotic and abiotic assemblages along the river and stream network that are influenced by water dynamics (Olokeogun & Kumar, 2020; Urbanič et al., 2022). Riparian systems are threatened by multiple pressures from human and agricultural activities (Lu et al., 2022), climate change (Rogers et al., 2020), biodiversity threats, and changes in land use patterns (Soeprobowati et al., 2021; Xu et al., 2023).

Riparian vegetation encompasses a group of plants living on the banks of rivers, creeks, or streams that provide ecosystem services for native biodiversity, abiotic environments, and people inhabited along the water edges. It provides diverse ecosystem services, such as regulating microclimatic fluctuation, providing water, food, and any kind of benefit to people (Nóbrega et al., 2020; Riis et al., 2020), and expanding economic opportunities through ecotourism (Gkiatas et al., 2021). Riparian vegetation also offers protection from flood events and hydrologic drought associated with fluctuating precipitation (Albano et al., 2020; Gkiatas et al., 2021).

Research on the riparian ecosystem in Indonesia has received attention in recent years. Some of the research focuses on the diversity of riparian vegetation (Lukas et al., 2021; Pramadaningtyas et al., 2023; Saputra et al., 2021), assessment of river health (Setyoasri & Prastica, 2020), assessment of environmental services (Waskita et al., 2022). Moreover, studies on riparian ecosystems in Indonesia have not discussed the importance of the ecosystem in providing cultural benefits to people. It is observed from other studies that the cultural aspect is pertinent to the successful management of the overall ecosystem. Lee et al. (2020), for example, incorporate the social value of residents to develop planning and management of riparian zones. In another work, Saklaur (2022) recognized the sociocultural dimension of riparian inhabitants to develop a sustainable relationship between the ecosystem and the people.

Considering the importance of socio-cultural aspects to riparian management, this research aims to study the vegetation along the banks of the upper Gajahwong River in the Yogyakarta Province, as well as the socio-cultural perceptions of residents in the area. The choice of the watershed is motivated by the lack of studies on riparian ecosystems in small rivers, particularly within the Yogyakarta Province. Most of the published work on riparian vegetation focuses on big rivers in Indonesia, such as in Sebangau River, Kalimantan (Lukas et al., 2021) and Brantas River, East Java (Irawanto & Afifudin, 2024). Furthermore, the Gajahwong River serves as a significant water channel in the eastern part of Yogyakarta City, providing invaluable ecosystem services residing within its watershed (Ahdiaty & Fitriana, 2020). For many decades, the river has been used for diverse domestic and industrial purposes, thereby encountering anthropogenic pressures and pollutants (Risyanto & Widyastuti, 2004).

In addition, the upper part of the watershed has been extensively utilized for agriculture and tourism. However, this area also serves as a buffer zone for Mount Merapi National Park, making biodiversity conservation in the buffer zone crucial to support the national park's preservation efforts and the region's development as a nature-based tourism destination (Adirahmanta, 2005). On the other hand, concerns have arisen that tourism development might prioritize economic growth (Riyanti & Lesmana, 2022), potentially harming the environment. Considering these factors, this study highlights the importance of baseline knowledge about vegetation and its conservation to support regional development and conservation efforts.

Understanding the multifaceted dimensions of biodiversity and the socio-cultural aspects holds significance in formulating strategies for the sustainable management of river ecosystems. Consequently, there arises a need to develop knowledge of biodiversity and the socio-cultural aspects inherent to riparian zones. Thus, the overarching objectives of this study encompass; studying biodiversity and composition of riparian vegetation in the upper Gajahwong River and exploring the communities' perception of general ecosystem services provided by riparian biodiversity.

MATERIALS AND METHODS

The study was conducted in the upper Gajahwong River, in the Yogyakarta Province, encompassing three villages, Sardonoharjo, Hargobinangun, and Minomartani. The entire

Gajahwong River is a part of the Opak Watershed, which is one of the three main rivers in the Province of Yogyakarta.

The vegetation survey was performed using a linear transect positioned along both the left and right edges of the river. All vegetation within the transects was identified and counted. Each transect spanned approximately 100 m in length, with 20 squared 2 × 2 m plots placed along the transect. All vegetation was identified on-site with the assistance of Google Lens, and books such as the Flora of Java (Backer & Van Den Brink, 1966) and Flora Malesiana (van Steenis, 1951). If identification at sampling sites was not feasible, vegetation samples were collected for identification at the Ecology Laboratory of UIN Sunan Kalijaga, Yogyakarta. Several parameters of floristic surveys were also calculated, including the number of species, the count of individual species, density, and frequency. The parameters were calculated using the following formula $density = \frac{total\ number\ of\ species\ A}{total\ area\ (m^2)}$; $relative\ density = \frac{density\ of\ species\ A}{total\ density\ of\ all\ recorded\ species} x100\%$; $frequency = \frac{total\ number\ of\ plots\ inhabited\ by\ species\ A}{total\ plots}$; $relative\ frequency = \frac{frequency\ of\ all\ species}{total\ frequency\ of\ all\ species}$x 100%; $importance\ value = relative\ density + relative\ frequency$. The Shannon-Wiener Diversity Index (H') is used to calculate the diversity index, as follows H'= -Σ Pi ln (Pi), where Pi= (ni/N); H'= Shannon-Wiener diversity index; ni= number of individuals of species i; N= the number of individuals of all species. The criteria for the diversity index's score are H'<1= low diversity; 1<H'≤3= moderate diversity; H'>3= high diversity.

Regarding the socio-cultural perception of the biodiversity of vegetation in riparian zones, the data were collected by conducting interviews with residents from 3 villages. Respondents were selected randomly, with each village represented by 20 respondents. In total, we had 60 respondents representing each location. The interview was similar to the concept of doorstep interview, where the respondents were interviewed at the location (Mitchell, 1980). The respondents were asked several questions, encompassing questions about provisioning services of biodiversity, regulating services of riparian zones, and the socio-cultural services of the ecosystem.

One of the topics explored in this simple survey is the public's knowledge regarding regulating services provided by riparian vegetation. Respondents were asked about their knowledge of the role of riparian vegetation in regulating microclimates, preventing floods and landslides, and providing habitat for other organisms. In this regard, respondents were given the option to answer yes or no to these questions. Subsequently, researchers elucidated respondents' answers through open interviews.

In addition, the study explored the importance of riparian vegetation in contributing to the socio-cultural dimensions of the people. In this instance, the study employed a simple survey, prompting respondents to articulate the role of riparian vegetation in supporting their socio-cultural activities. Subsequently, the findings were summarized in charts and tables.

RESULTS

Vegetation Surveys

In total, the vegetation surveys recorded 71 species in Hargobinangun, 76 species in Sadonoharjo, and 79 species in Minomartani. The plants were surveyed from riparian zones with varying cliff and water body configurations. The riparian zone in Hargobinangun was characterized by moderately steep cliff with slopes of 20–30%, whereas in Sardonoharjo and Minomartani were characterized by mild cliff slopes (Table 1).

Riparian plants found in Hargobinangun consisted of 71 species from 34 families. The highest species diversity came from the *Araceae* family (8 species), including *Caladium bicolor*, *Colocasia esculenta*, *Alocasia mycorrhizas*, *Diffenbachia seguine*, and *Xanthosoma sagittifolium*. In Sardonoharjo, there were 76 species from 30 families. The most abundant species come from the families *Araceae*, *Poaceae*, and *Euphorbiaceae*. Conversely, the families with the fewest species were ferns from the *Selaginellaceae* and *Marsileaceae* families. The segment was dominated by flat riverbanks with relatively low cliffs, providing a suitable habitat for grasses. Meanwhile, in the Minomartani segment, 79 species were recorded from 37 families. The most abundant species belong to the *Fabaceae* family. Among the *Fabaceae* members were shrubs such as *Mimosa pudica* and

Clitorea ternatea, and *perennial/tree* species including *Albizia chinensis*, *Leucaena leucocephala*, and *Samanea saman*. Table 2 presents an overview of the composition and parameters of the floristic survey, including the number of individuals, abundance, frequency, and importance value index (IV) at three research locations.

Table 1. The environmental conditions and vegetation in the riparian zones of the upper Gajahwong River

	Hargobinangun	Sardonoharjo	Minomartani
Cliffs and riverbanks	Steep riverbanks with slopes of 20–30%	Less steep riverbanks, somewhat gentle cliffs	Gentle riverbanks, sloping cliffs, and fertile agricultural areas present
Waterbody	The water body is 5–6 m wide with a swift current	The water body is 6–7 m wide, with a fast-flowing stream, and dammed in several places due to sand mining sites.	The water body is 5–7 m wide, with constriction due to embankments.
Substrate	Sand, gravel, fairly large stones, medium-sized stones	Sand, gravel, and medium-sized stones	Sand, gravel, mud
The number of species	71	76	79
The number of family	34	30	37
Most diversified family	*Araceae*	*Araceae*	*Fabaceae* dan *Araceae*
H' index value	4.11	4.22	4.21
H' index intepretation	Intact ecosystem, high diversity	Intact ecosystem, high diversity	Intact ecosystem, high diversity

Table 2. Selected ten species with the highest IV index at the Upper Gajahwong River

Species	Family	Number of individuals	Frequency	Abundance (n/m^2)	IV (%)
Hargobinangun					
Ficus racemosa	*Moraceae*	4	17	0.08	3.11
Sellaginella doederleinii	*Selaginellaceae*	1	15	0.02	2.69
Colocasia argentea	*Araceae*	9	14	0.18	2.68
Desmodium gigantea	*Fabaceae*	5	14	0.1	2.60
Gomphrena globosa	*Amaranthaceae*	13	13	0.26	2.58
Celocasia esculenta	*Araceae*	3	14	0.06	2.56
Areca catechu	*Arecaceae*	2	14	0.04	2.54
Ficus benjamina	*Moraceae*	8	13	0.16	2.48
Manilkara kauki	*Sapotaceae*	8	13	0.16	2.48
Melia azedarach	*Meliaceae*	15	12	0.3	2.44
Sardonoharjo					
Diffenbachia seguine	*Araceae*	18	19	0.36	4.40
Chromolaena odorata	*Asteraceae*	15	19	0.3	4.09
Calliandra hematocephala	*Fabaceae*	12	19	0.24	3.78
Acalypha indica	*Euphorbiaceae*	14	17	0.28	3.72
Albizia chinensis	*Fabaceae*	10	19	0.2	3.57
Jatropa curcas	*Euphorbiaceae*	10	19	0.2	3.57
Hippobroma longiflora	*Apocynaceae*	15	15	0.3	3.56
Eriochloa procera	*Poaceae*	14	15	0.28	3.45
Manihot gladioli	*Euphorbiaceae*	7	20	0.14	3.39
Wedelia trilobite	*Asteraceae*	18	11	0.36	3.34
Minomartani					
Acalypha indica	*Euphorbiaceae*	14	13	0.28	3.59
Alocasia macrorrhizos	*Araceae*	8	6	0.16	3.58
Eleusina indica	*Poaceae*	10	13	0.2	3.58
Digitaria longiflora	*Poaceae*	12	10	0.24	3.38
Chromolaena odorata	*Asteraceae*	15	9	0.3	3.38
Amaranthus tricolor	*Amaranthaceae*	15	4	0.3	3.31
Mangifera indica	*Anacardiaceae*	14	6	0.28	3.28
Blumea lacera	*Asteraceae*	7	17	0.14	3.26
Gnetum gnemon	*Gnetaceae*	14	6	0.28	3.12

Species	Family	Number of individuals	Frequency	Abundance (n/m^2)	IV (%)
Salacca zalacca	*Arecaceae*	4	13	0.08	3.10

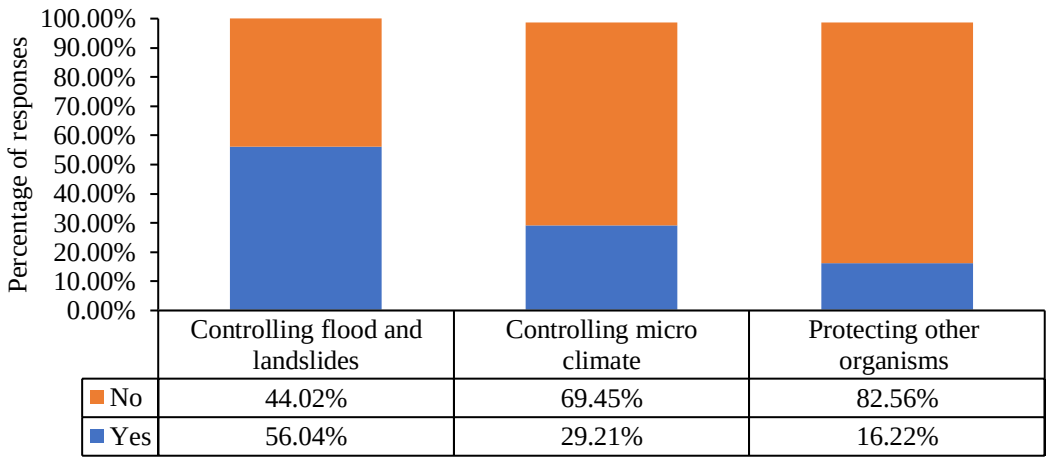
Perceptions of Ecosystem Services

The first dimension explored in this section was the importance of biodiversity to contribute to provisioning services. Respondents recalled at least 19 species that provide provisioning services, such as food supply and medicinal supplies, animal feed, construction materials, and firewood (Table 3).

Table 3. Species that provide provisioning services

Species	Local name	Utilization	Parts utilized
Medicine			
Acalypha indica	*Anting-anting*	Wound treatment	Leaf
Blumea lacera	*Sembung kuwuk*	High blood pressure medicine	Leaf
Melia azedarach	*Mindi*	Stomachache medicine	Leaf and fruit
Artocarpus altilis	*Sukun*	Diabetes medicine	Leaf
Mimosa pudica	*Puteri malu*	Gout medicine	Leaf, stem, and root
Food			
Alocasia macrorrhizos	*Senthe*	Vegetable and source of carbohydrates	Leave and tuber
Digitaria longiflora		Vegetable	Leaf
Amaranthus tricolor	*Bayam*	Vegetable	Leaf
Mangifera indica	*Mangga*	Fruit	Leaf
Gnetum gnemon	*Melinjo*	Food, vegetable	Seed and seed shell leaf
Salacca zalacca	*Salak*	Fruit	Fruit
Pandanus amaryllifolius	*Pandan*	Spice	Leaf
Artocarpus heterophyllus	*Nangka*	Vegetable	Fruit and seed
Cattle feed			
Chromolaena odorata	*Kirinyu*	Goat feed	All parts
Vernonia cinerea	*Sawi-sawian*	Cattle feed	Leaf
Ageratum conyzoides	*Babandotan*	Goat and rabbit feed	Leaf
Sphagneticola trilobata	*Seruni jalar*	Goat feed	Leaf
Building material and firewood			
Albizia chinensis	*Sengon*	Buiding material;	Stem and branch
Ficus racemosa	*Loa*	Firewood	Stem and branch

Next, a survey was conducted on the regulating services of biodiversity to assess public knowledge regarding the role of biodiversity in regulating microclimates, preventing floods and landslides, as well as protecting other living organisms (Figure 1). The survey revealed that 82.56% of respondents lacked awareness regarding the protective role of riparian vegetation for other organisms. Conversely, a majority of respondents (56.04%) were aware of the contribution of riparian vegetation to flood and landslide prevention.



	Controlling flood and landslides	Controlling micro climate	Protecting other organisms
No	44.02%	69.45%	82.56%
Yes	56.04%	29.21%	16.22%

Figure 1. The percentage of respondents who answered yes and no to the questions regarding the regulating service 1 provided by riparian vegetation

We inquired about the social and cultural activities related to riparian vegetation. Most people (64.79%) said that vegetation in riparian areas is linked to activities such as finding food and medicine, and many (53.52%) are involved in protecting these areas (Figure 2).

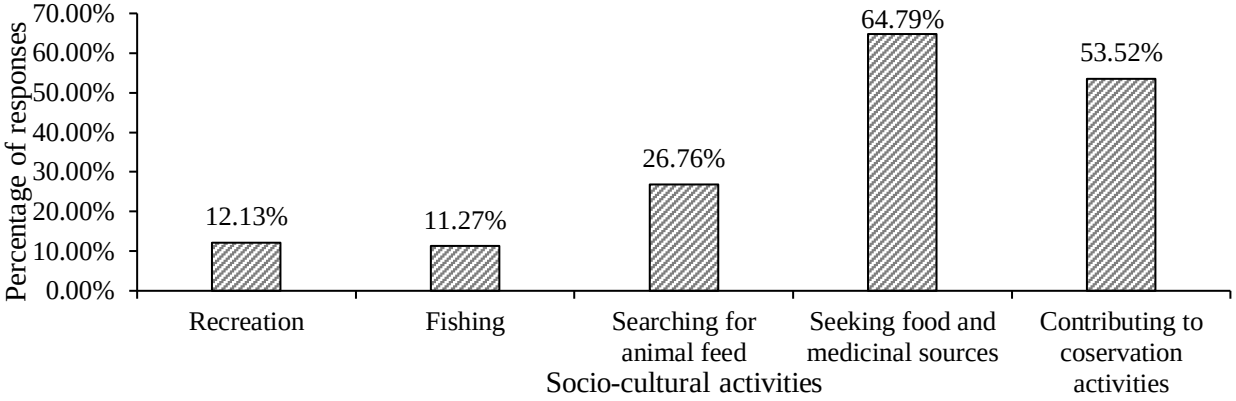


Figure 2. The percentage of respondents stating social activities related to riparian vegetation

DISCUSSION

Riparian plant diversity recorded in the upper Gajahwong varied according to habitats. Riparian vegetation could be found submerged, attached to the cliff of the riverbank, and inhabited moist habitats in the river bank. The diversity index values at the three research locations were nearly similar, all above H'= 4. The highest diversity index is found in Sardonoharjo, reflecting a high level of biodiversity. This high biodiversity provides numerous ecosystem services, including oxygen provision, protection of riverbanks from erosion, flood control, food sources, and medicinal resources.

In the Hargobinangun segment, the *Araceae* family is the most abundant, particularly the genus *Colocasia* (Table 2). *C. argentea* and *C. esculenta* have Importance Value Index (IV) scores of 2.68 and 2.56, respectively. Although their presence is not highly dominant, they hold ecological significance. Most members within the *Araceae* family exhibit a preference for aquatic habitats and have hydrophytic characteristics, as indicated by distinct leaf and stem morphology. Besides *Araceae*, many members of the *Poaceae* family, including *Pennisetum purpureum* (elephant grass), were also found along the riverbanks. The presence of elephant grass was not due to natural growth but rather its cultivation by residents for livestock feed.

Next the Sardonoharjo segment, it was dominated by flat riverbanks with relatively low cliffs, providing a suitable habitat for grasses (Table 1). Thus, members of the *Asteraceae* family, such as *Chromolaena odorata* and *Wedelia trilobata*, were frequently observed. The widespread distribution of *Asteraceae* across tropical latitudes can be attributed to their remarkable adaptability (Moreira-Muñoz & Muñoz-Schick, 2007). Similarly, the members of *Poaceae* such as *Eleusina indica*, *Digitaria longiflora*, and *Eriochloa procera* could easily be observed. The plants belonging to this family were mostly used for cattle feed. Additionally, grasses from the *Poaceae* family have the potential to improve the stability of banks in shallow erosion channels., as reported by Zegeye et al. (2017). The fine roots of *Poaceae* exhibit mechanical properties to improve soil protection (Liu et al., 2022).

In Minomartani, the presence of *Fabaceae* (Table 2) is particularly interesting considering its location in densely populated areas and being a research site with relatively high cliffs. *Fabaceae* is known as a family whose species can store water within their bodies (Ow et al., 2019). One particularly dominant member of the *Fabaceae* in the segment is the rain tree (*Samanea saman*). This tree is large, with extensive branching, and buttress roots capable of erosion control, and water storage. Moreover, several species of *Fabaceae* promise a high level of carbon sequestration, such as *Albizia saman* and *Senna* sp. (Fajariani et al., 2020). Therefore, *Fabaceae* plays an important role in protecting the environment from the effects of carbon and pollution

In recent times, there is growing concern regarding the perception of the service ecosystem as communities play the most crucial and direct role in making decisions and managing the ecosystem

in which they reside (Teixeira et al., 2018). Thus, environmental management must consider the communities' knowledge of ecosystem services (Muhamad et al., 2014). In this regard, this research confirmed that the residents had been able to comprehend knowledge about the contribution of riparian vegetation to ecosystem services. As shown in Figure 1, 82.56% of respondents demonstrated limited awareness of the ecological role of riparian vegetation in supporting other organisms. In contrast, 56.04% of respondents recognized its function in mitigating floods and landslides. Notably, respondents were able to identify only four specific uses of riparian vegetation. However, their knowledge of provisioning services is limited to the general use of plants. Some other services such as aromatic sources, genetic pools, and sources of chemical compounds were not mentioned by the respondents.

Additionally, in terms of regulating services, people agree that riparian vegetation exhibits important properties in controlling bank erosion, regulating microclimate, and protecting other organisms (Figure 1). Respondents mentioned that there are plant species capable of preventing erosion and maintaining water, such as the banyan tree. *Ficus benjamina* from the *Moraceae* family. This tree is known for its water storage capacity and is often found near water sources. The presence of large tree species indicates that the riverbanks are still in good condition (Abernethy & Rutherfurd, 2001).

Furthermore, this research confirms that communities possess a strong comprehension of the socio-cultural services provided by riparian vegetation (Figure 2). The inquiry reveals that a significant portion of people recognize the importance of riparian vegetation for providing socio-cultural services, with the majority linking it to essential activities like obtaining food and medicine (64.79%). Additionally, more than half of the respondents are actively engaged in efforts to protect these areas (53.52%), highlighting both the ecological and cultural significance of riparian zones. Moreover, cultural values and lifestyles significantly influence their perception of these services (García-Llorente et al., 2020). In this context, respondents most influenced by Javanese culture exhibit a profound appreciation for nature and conservation as integral components of their daily values (refer to Figure 2). Terms such as "*niteni*" (pay careful attention), "*gemati*" (nurture), and "*guru-uri*" (conserving for the next generation) (Wijaya & Faturochman, 2019) serve as driving forces for socio-cultural values within the society.

CONCLUSION

The upper Gajahwong region exhibits diverse riparian plant species across various habitats, from submerged areas to moist riverbanks. High diversity index values could be observed in the region, with Sardonoharjo exhibiting the highest diversity. In Hargobinangun, the dominance of Araceae species adapted to aquatic environments is notable, while in Sardonoharjo, *Poaceae* grasses thrive on flat riverbanks, serving as cattle feed. In Minomartani, *Fabaceae* particularly the rain tree, aids in water storage and erosion control and is crucial in populous areas. In terms of the community perception, this research acknowledges that the community showcases an understanding and knowledge of ecosystem services provided by the riparian vegetation. Regarding provisioning services, the community understands the contribution of plants to providing food, medicine, and other utilization. People also know the contribution of riparian vegetation in controlling erosion and microclimate, and protecting other organisms. Finally, people accept the socio-cultural services of riparian vegetation and the Javanese values play a significant role in shaping attitudes towards environmental conservation, highlighting the need for culturally sensitive conservation approaches. We recommend that further qualitative research be performed to understand the community's perceptions of environmental services, especially focusing on the economic valuations of the services provided by the riparian ecosystem.

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