Floristic Composition and Carbon Storage of Floor Vegetation in Community Forests of Ciamis Regency, West Jawa

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Abstract

Agroforestry-integrated community forests foster greater plant diversity compared to conventional agriculture, potentially offering significant ecological and societal benefits. However, the specific contribution of diverse floor vegetation within these forests to carbon cycling remains understudied. This study addresses this knowledge gap by comprehensively analyzing the floristic composition and carbon storage potential of floor vegetation in tropical community forests. Using a stratified random sampling design with quadrats to ensure representative data collection across various locations in Ciamis Regency, West Java, Indonesia, we identified 296 plant species belonging to 89 families. Our analysis revealed that the understory vegetation exhibits moderate species diversity and stores carbon ranging from 0.107 to 0.238 Mg C ha⁻¹, with an average sequestration potential of 0.730 Mg C ha⁻¹. These findings suggest that community forests harbor diverse floor vegetation communities with significant carbon storage and sequestration potential, providing valuable insights for environmentally sustainable community forest management and contributing to broader efforts towards climate change mitigation.

Keywords: *carbon storage, Ciamis Regency, community forests, floristic composition*

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Introduction

Forests play a critical role in mitigating climate change by acting as vital carbon sinks while safeguarding biodiversity and ecological balance. These combined benefits underpin crucial ecosystem services that support human well-being (Brockerhoff et al., 2017; Njana et al., 2021). Forest management and utilization have a long history in Indonesia, with community forests being one of the most common traditional forest management practices (Nugroho et al., 2023). Community forests integrated with agroforestry practices offer a synergistic triad of benefits: economic empowerment for local communities, enhanced social wellbeing, and ecological conservation (Putraditama et al., 2021; Mukhlis et al., 2022). Compared to seasonal agricultural land, these agroforestry-integrated forests exhibit greater carbon storage and reduced emissions, due to their greater vegetation diversity and higher biomass content. Additionally, this diverse vegetation enhances soil fertility, regulates microclimates, mitigates erosion, and supports water system stability (Sistla et al., 2016; Haggar et al., 2019; Kay et al., 2019; Besar et al., 2020).

Forest understories often harbor a substantial portion of overall plant diversity (Gilliam, 2014; Mestre et al., 2017; Landuyt et al., 2018), a pattern consistently observed across various forest ecosystems, including community forests

(Mucheye & Yemata, 2020; Mir et al., 2022). This layer encompasses floor vegetation a diverse assemblage of shrubs, herbaceous plants, ferns, grasses, lianas, and seedlings <1.5 m tall. This biologically rich community plays a critical role in shaping forest structure, function, and the provision of ecosystem services (Hubau et al., 2019; Landuyt et al., 2019; Deng et al., 2023).

Across diverse landscapes, community forests exhibit varying management practices reflecting local and cultural contexts. These practices can potentially influence the abundance and diversity of understory vegetation, thereby impacting its role in carbon cycling. Numerous studies have revealed that historical or ongoing alterations or disturbances in the canopy significantly affect understory floristic composition and richness (Duguid et al., 2013; Mestre et al., 2017; Su et al., 2019).

High plant diversity and carbon storage potential are well-established indicators of successful forest management practices (Boch et al., 2013; Paudel & Sah, 2015; Diao et al., 2022). Inventorying and monitoring floor vegetation diversity provide crucial data for sustainable forest management, aiding resource utilization, conservation, and biodiversity stewardship. This approach facilitates the tracking of temporal changes in understory composition, including those potentially linked to long-term shifts in

climate patterns, including those linked to climate change (Dubuis et al., 2013; Ohdo & Takahashi, 2021). During carbon storage assessments, the significant carbon sequestration capacity of floor vegetation cannot be overlooked due to its established ability to absorb atmospheric carbon dioxide (Zhao et al., 2021).

This study aims to explore the floristic composition of floor vegetation in the community forests of Ciamis Regency, West Java, and its contribution to carbon storage and carbon sequestration. Ciamis Regency, Indonesia, was selected as the study location due to its extensive tropical community forest cover (20,866.47 ha, constituting 14.32% of the total land area) and its ecologically relevant characteristics for this study (BPS Ciamis, 2021). These community forests, distributed across the mountainous and hilly north and south regions, are predominantly managed through agroforestry systems, where local communities integrate various forestry, plantation, agricultural, and medicinal plant species (Puspitojati et al., 2014). Ciamis community forests primarily contain tree species with timber potential, such as *sengon*, mahogany, mixed-species stands, and teak (Siarudin et al., 2023). Fruit production also represents a significant element, with mangosteen, durian, rambutan, jackfruit, and *duku* being widely cultivated alongside agricultural crops like coconut, cocoa, and banana. This upper canopy layer provides partial shade for the diverse floor vegetation, which primarily consists of naturally occurring species. Competitive interactions between floor vegetation species and intentionally planted crops may occur, potentially influencing crop growth (Puspitojati et al., 2014).

Previous studies in the Ciamis region have primarily focused on the floristic composition of natural forests within the Gunung Sawal Wildlife Reserve (Hidayat et al., 2017), tree biomass assessment (Indrajaya & Mulyana, 2020), and timber utilization practices (Siarudin et al., 2023). However, studies exploring the floristic composition of understory vegetation in community forests, its contribution to carbon

storage, and its role in carbon dioxide sequestration are currently limited. This study aims to address this gap by providing valuable scientific data to inform environmentally sustainable community forest management practices.

Methods

Study area Field data collection and sampling for this study were conducted between May 12th and August 12th, 2022, across four distinct locations within the community forests of Ciamis Regency, West Java, Indonesia (Figure 1). These locations, spanning an altitudinal gradient from 150 to 900 m asl, were chosen to capture the diversity of floor vegetation composition within the tropical community forest ecosystem. Selection criteria prioritized spatial separation and altitudinal variation to ensure representativeness. Additionally, considering Ciamis Regency's extensive area with diverse topography, community cultures, and farming practices employed in community forest management, these locations were strategically chosen for their accessibility and ease of obtaining local permits. The four selected locations were:

1. Kertaharja Village, Cijeungjing District (S7°18'23.09", E108°24'3.24"): Altitude 150–250 m asl, characterized by sloping hills and dominated by mahogany (*Swietenia mahagoni*) and *sengon* (*Albizia chinensis*) trees, with additional fruit trees like *duku* (*Lansium domesticum* var. *typica*) and mangosteen (*Garcinia mangostana*).

2. Kiarapayung Village, Rancah District (S7°12'39.19", E108°27'58.25"): Altitude 250–450 m asl, characterized by hilly terrain and dominated by mahogany (*S. mahagoni*), *sengon* (*A. chinensis*), and umbrella tree (*Maesopsis eminii*), with additional fruit trees like duku (*L. domesticum* var. *typica*).

3. Sumberjaya Village, Cihaurbeuti District (S7°14'13.72", E108°12'18.48"): Altitude 450–750 m asl, situated near the foothill of Mount Sawal, characterized by hilly topography and dominated by
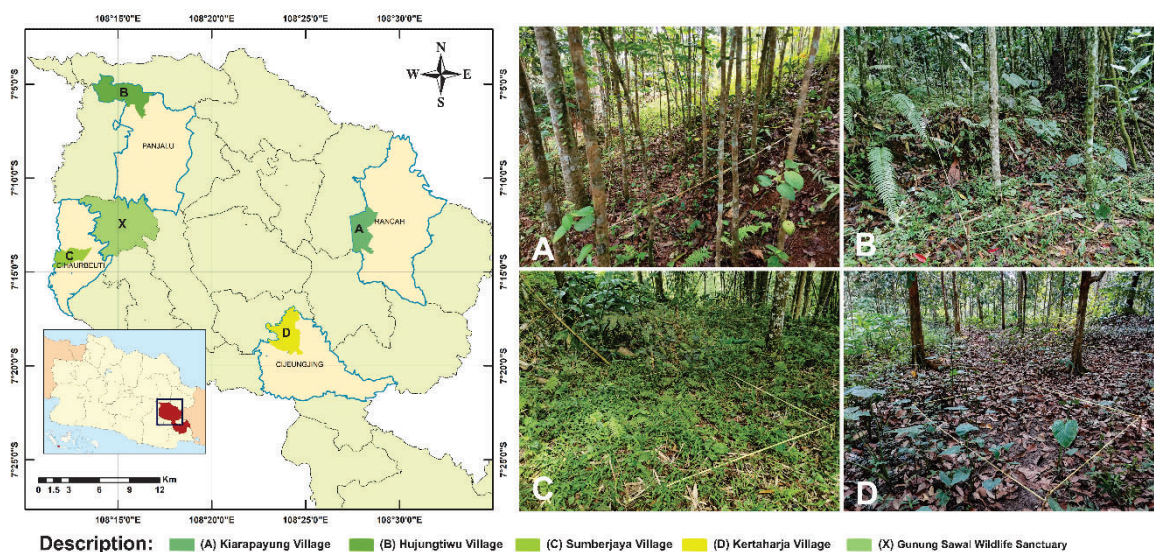

Figure 1 Four study locations with different altitudes, in community forest areas, Ciamis Regency, West Java, Indonesia.

mahogany (*S. mahagoni*), sengon (*A. chinensis*), *tali bamboo* (*Gigantochloa apus*), and robusta coffee (*Coffea canephora*).

4. Hujungtiwu Village, Panjalu District (S7°5'17.65", E108°15'9.29"): Altitude 650–900 m asl, characterized by steep hills and dominated by mahogany (*S. mahagoni*) and *sengon* (*A. chinensis*), with some areas planted with robusta coffee (*C. canephora*).

Daily rainfall around the study locations was recorded at 246.60 mm in 2021 and 255.39 mm in 2022. The average daily temperature was 27.47 °C in 2021 and 27.28 °C in 2022.

Materials and tools Field data collection involved diverse tools and methodologies. Plant samples were documented photographically and recorded on tally sheets. Location coordinates were recorded with a GPS. Microclimate data, including humidity, altitude, temperature, soil pH, soil moisture, and light intensity, were measured using a hygrometer, altimeter, thermometer, soil pH meter, tensiometers, and lux meter, respectively. Surveyor tape measures, plastic ropes, and a bamboo stick facilitated the establishment and measurement of sampling plots. Herbarium equipment was used for sample collection and subsequent identification, while a drying oven was utilized to prepare fresh samples for both herbarium archiving and biomass analysis.

Data collection and sampling techniques Data collection sites were purposefully selected based on the presence, uneven distribution, and altitudinal gradients of community forests. Quadrats served as the primary sampling unit, with their placement following a stratified random design. Sampling locations meeting the criteria were first numbered and randomly selected for quadrat placement. Subsequently, subplots were systematically established within each quadrant for floor vegetation sampling. Each study location encompassed a 1 ha (10,000 m²) sample area, within the recommended range for tropical rainforest vegetation surveys (1,000–50,000 m²) outlined by Ellenberg and Mueller-Dombois (1974) and Barbour et al. (1987).

Each 1-ha study location was subdivided into twenty-five 20 m × 20 m plots. Within each plot, we established four nested 10 m × 10 m subplots. A nested sampling design was employed to efficiently capture plant species diversity at multiple scales within the community. We sampled understory vegetation within four replicated 2 m × 2 m plots per subplot, resulting in 100 floor vegetation plots per study location (Figure 2). This design yielded a total sampled area of 400 m² for floor vegetation at each location, or 1,600 m² across all four locations. The sampled species included seedlings (<1.3 m tall), shrubs, vines, herbaceous plants, ferns, epiphytes, and grasses (Bartels & Chen, 2013; Jaroszewicz et al., 2021).

Percent cover for each species within each habitus was visually estimated using the method outlined by Ellenberg and Mueller-Dombois (1974) and Barbour et al. (1987). All encountered species were identified to the species level when possible; unidentified specimens were photographed in the field and some were collected for further herbarium identification. Species richness for each floor vegetation habitus was calculated as the total number of species recorded within each subplot, while overall cover represented the sum of individual species coverages. Additionally, environmental parameters, including air temperature, humidity, light intensity, soil pH, and moisture content, were measured.

The carbon storage potential of floor vegetation was estimated through a biomass assessment. Due to the variable sizes of community forests, a modified method adapted from Hairiah et al. (2011) was used. This approach utilizes two plot types: auxiliary plots (20 m × 20 m) and main subplots. Auxiliary plots mirrored the placement of floor vegetation sampling plots and contained four, evenly spaced 1 m × 1 m subplots. Destructive sampling was conducted in two 0.5 m × 0.5 m subplots within each auxiliary plot (Figure 2). All shrubs, seedlings (<5 cm stem diameter), lianas, herbaceous plants, grasses, ferns, and terrestrial orchids within these subplots were collected and weighed to determine the total fresh weight. Subsequently, a 100 g subsample from each subplot was oven-dried at 80 °C for 48 hours to a constant weight. Final dry weight was recorded as biomass (Hairiah et al., 2011; Ahmad et al., 2019; Sheikh et al., 2021).
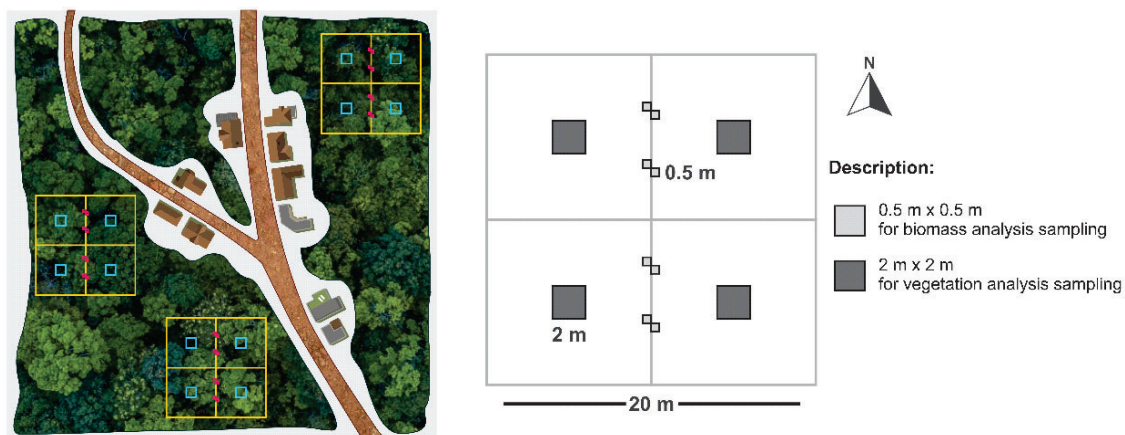

Figure 2　A visual illustration for sample plots placement.

Data analysis We analyzed floristic composition data to characterize community composition and diversity across the four sampling locations. This analysis involved calculating various diversity indices, including measures of α (alpha) and β (beta) diversity. α-diversity, representing species richness and evenness within a community, was assessed using the importance value index (IVI), Shannon-Wiener species diversity index (H'), evenness index (E), and dominance index (C). To quantify β-diversity, which reflects differences in species composition between communities, we employed the Sorensen similarity index within the community similarity index (IS) framework (Mahecha-Vásquez et al., 2017).

Species dominance was evaluated using the IVI of Cottam and Curtis (1956) (Equation *[1]*), encompassing relative density (Equation *[2]*), relative frequency (Equation *[3]*), and relative dominance (Equation *[4]*) to provide a comprehensive measure of a species' ecological importance within the community (Ellenberg & Mueller-Dombois, 1974; Barbour et al., 1987).

$$IVI = RD + RF + Rdo \qquad [1]$$

$$RD = \frac{density\ of\ a\ species}{total\ density\ of\ all\ species} \times 100\% \qquad [2]$$

$$RF = \frac{frequency\ of\ a\ species}{total\ frequency\ of\ all\ species} \times 100\% \qquad [3]$$

$$RDo = \frac{dominance\ of\ species}{total\ dominance\ of\ all\ species} \times 100\% \qquad [4]$$

The Shannon-Wiener diversity index (H') quantifies species diversity by considering both species richness and evenness within a community. It serves as a valuable parameter for comparing the compositional heterogeneity of plant communities across different forests. The index is calculated based on the proportional abundance of each species relative to the entire community (Equation *[5]*) (Barbour et al., 1987). Higher H' values (greater than 3) indicate high diversity, while values between 1 and 3 suggest moderate diversity. Communities with H' values less than or equal to 1 exhibit low diversity.

$$H' = -\sum(p_1\ ln\ p_1) \qquad [5]$$

Simpson's index (C) measures the dominance within a community by considering the proportional abundance of different species (Equation *[6]*). It ranges from 0 to 1, with low values (0 0.5) indicating high diversity and no single dominant species, while high values (0.5 1) suggest dominance by one or few species (Barbour et al., 1987).

$$C = \frac{\sum n(n-1)}{N(N-1)} \qquad [6]$$

The evenness index (E) quantifies the distribution of individuals across species within a community (Equation *[7]*). It incorporates both species richness and relative abundance to measure community evenness (Barbour et al., 1987). This ranges from 0 to 1, with 1 signifying perfect evenness (all species equally abundant) and 0 indicating extreme unevenness, where one or few species dominate while others are rare.

$$E = \frac{H'}{ln\,ln\,(S)} \qquad [7]$$

The Margalef species richness index (R) estimates species richness, defined as the number of distinct species within a defined area or ecosystem. Calculated by dividing the difference between the total number of species (S) and 1 by the natural logarithm of total individuals (N) (Equation *[8]*) (Margalef, 1958), this index distinguishes three categories: low (R < 3.5), moderate (3.5 < R < 5.0), and high (R > 5.0). High R values correspond to communities with greater species richness, while low values indicate limited species diversity.

$$R = \frac{S-1}{ln\,ln\,(N)} \qquad [8]$$

The Sørensen similarity index (IS), also known as the Sørensen coefficient, quantifies the resemblance between two communities based solely on shared and unique species presences (Equation [9]). The index is calculated as twice the number of species present in both communities divided by the sum of their individual species richness (Barbour et al., 1987). Ranging from 0 to 1, with 0 representing no shared species and 1 indicating complete compositional identity, this index reflects the degree of similarity between communities.

$$IS = \frac{2C}{a+B} \times 100 \qquad [9]$$

Floor vegetation biomass, estimated as the amount of living plant material per unit area, was calculated by drying individual species samples (oven drying) and multiplying their dry weight by the total study location area (in square meters) (Equation *[10]*). This provided species-specific biomass in grams per square meter (g m^{-2}). Summing the biomass of all species provided the total floor vegetation biomass for the area, also expressed in g m^{-2} (Hairiah et al., 2011)

$$Total\ dry\ weight\ (\text{g m}^{-2}) = \frac{dry\ weight\ subsample\ (g)}{fresh\ weight\ subsample\ (g)} \times$$
$$total\ fresh\ weight\ (g) \qquad [10]$$

Carbon storage within the vegetation was then estimated by multiplying the total biomass by a standard carbon conversion factor of 0.47 (Equation [11]). However, it is important to acknowledge that using a single conversion factor can introduce limitations, as carbon content can vary between species and environmental conditions. Future studies could explore species-specific conversion factors for a more accurate estimate (Hairiah et al., 2011).

$$Cb = B \times \%C \qquad [11]$$

The estimation of carbon dioxide sequestration involves calculating the net carbon balance within an ecosystem. This net carbon balance serves as a metric to quantify the amount of carbon dioxide removed from the atmosphere and stored

within the ecosystem. The calculation of CO_2 absorption is conducted using the formula outlined by Hairiah et al. (2011) as shown in Equation *[12]*.

$$Carbon\ dioxide\ sequestration\ =\ Carbon\ storage\ \times\ 3.67\ [12]$$

Result and Discussion

Floristic composition of floor vegetation A total of 296 plant species belonging to 89 families were identified from 318 specimens collected across four study locations. The inventory revealed 77 seedlings, 49 shrubs, 87 herbaceous plants, 39 lianas/vines, 15 grasses, and 31 ferns. Twenty specimens remained unidentified due to small or incomplete organs (Figure 3). Across the four study locations, plant species diversity and density exhibited spatial variations. At the first location, the community forest floor harbored 142 species (51 families) with a total of 9,655 individuals,

encompassing 37 seedlings, 23 shrubs, 44 herbaceous plants, 16 lianas, 6 grasses, 16 ferns, and one unidentified specimen (Figure 3). This location displayed a numerical dominance of grasses and shrubs. *Ottochloa nodosa* was the most abundant grass species, with 55,275 ind ha^{-1}. Similarly, *Ficus montana* was the most abundant shrub species, with 32,725 ind ha^{-1} (Figure 4). Canopy gaps within this location likely facilitated the establishment of additional species such as *Procris repens*, *Synedrella nodiflora*, and seedlings of *L. domesticum* var. *typica*, *C. canephora*, and *Hibiscus macrophyllus*. Morphological adaptations in these species, potentially including broad leaves for enhanced light capture and slender stems facilitating upward growth, might have contributed to their success in this light-abundant environment. This finding aligns with observations by Ravnjak et al. (2022), who demonstrated that canopy gap
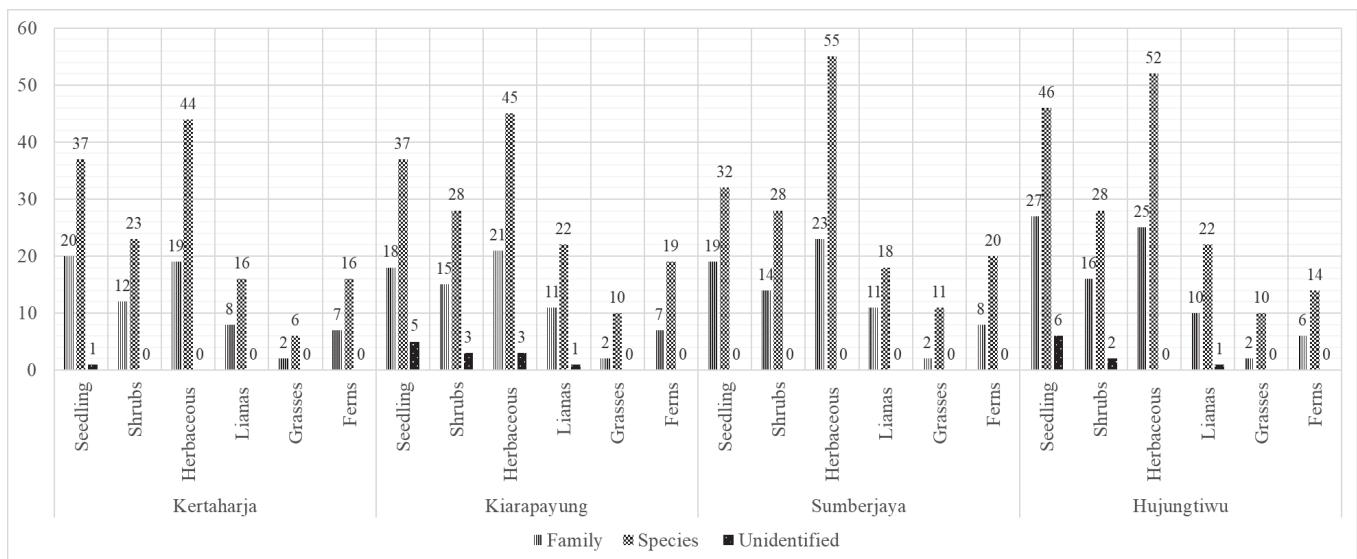

Figure 3   Floor vegetation diversity across four study locations based on habitus types.
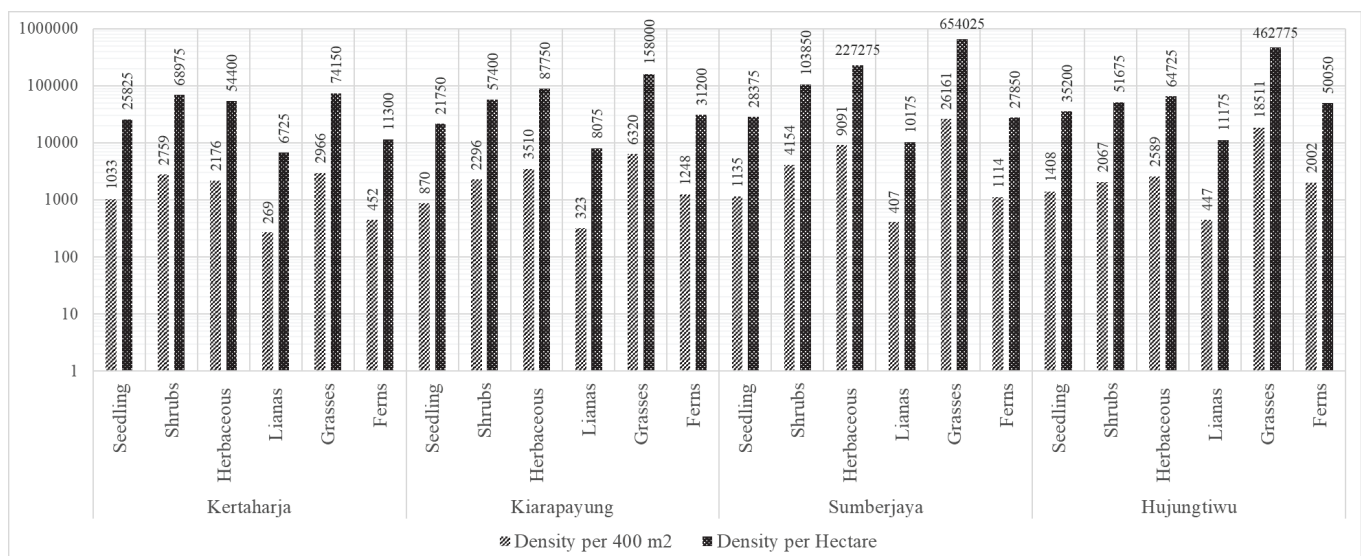

Figure 4   Floor vegetation density across four study locations based on habitus types.

formation allows sunlight penetration to the forest floor, facilitating the establishment and population growth of understory vegetation.

The understory vegetation at the second location displayed a distinct composition compared to the first. Here, 161 species (53 families) were identified, comprising 14,567 individuals of various habitus: 37 seedlings, 28 shrubs, 45 herbaceous plants, 22 lianas, 10 grasses, 19 ferns, and 12 unidentified specimens (Figure 3). *O. nodosa* remained the dominant grass species, exhibiting the highest individual density at 77,025 ind ha^{-1}. Among herbaceous plants, *Sphagneticola trilobata* achieved the highest abundance with 39,850 ha^{-1}, while *F. montana* maintained its dominance among shrubs with 18,325 ha^{-1}. Notably, *Selaginella plana*, displayed the highest density among all fern habitus, reaching 19,075 ind ha^{-1} (Figure 4).

The third location displayed high floor vegetation diversity, with 164 species distributed across 58 families (Figure 3). This diverse assemblage comprised 32 seedlings, 28 shrubs, 55 herbaceous plants, 18 lianas, 11 grasses, and 20 ferns. Remarkably, the total number of individuals (42,062) was substantially higher than the second location, highlighting the substantial spatial variability in community composition and abundance. *O. nodosa* and *O. hirtellus* dominated the grass layer, with densities of 368,550 ind ha^{-1} and 251,650 ind ha^{-1}, respectively (Figure 4). *Asystasia gangetica* was the most abundant herbaceous species with densities of 106,525 ind ha^{-1}, while *Spermacoce ocymifolia* dominated the shrub layer of 62,850 ind ha^{-1}. Interestingly, *S. plana* maintained its high abundance among ferns with 13,650 ind ha^{-1}, signifying its potential adaptability across diverse community forest habitats.

The fourth study location exhibited the highest species diversity, harboring 172 species distributed across 65 families (Figure 3). This diverse assemblage comprised 46 seedlings, 28 shrubs, 52 herbaceous plants, 22 lianas, 10 grasses, and 14 ferns, with nine specimens remaining unidentified. Despite having a lower individual density compared to the third location, the fourth location still surpassed locations one and two in total individual count, with 27,024 individuals recorded (Figure 3). Dominant grass species *O. nodosa* and *O. hirtellus* remained prevalent in the fourth location, maintaining high densities of 308,600 ind ha^{-1} and 112,225 ind ha^{-1}, respectively (Figure 4). *S. plana* continued to dominate the fern layer, reaching a density of 42,850 ind ha^{-1}. The shrub layer remained dominated by *S. ocymifolia,* with a density of 30,575 ind ha^{-1}. Notably, this location displayed a high abundance of *C. canephora* seedlings (20,475 ind ha^{-1}) (Figure 4). The presence of these seedlings suggests potential regeneration of this commercially valuable tree species within the community forest, potentially influencing future forest composition and dynamics.

Dominant species of floor vegetation Across the Ciamis community forests, *O. nodosa* and *O. hirtellus* emerged as the most dominant grass species, occurring in all four study locations. Their IVI ranged from 29.56% to 71.96% and 0.83% to 37.91%, respectively. *F. montana* stood out as the most dominant shrub species, with IVI values ranging from 4.37% to 27.54%. Notably, *S. plana* consistently exhibited the highest dominance among ferns across all locations, with IVI ranging from 2.77% to 18.44%. *A. gangetica* emerged as the most prominent herbaceous species, with IVI ranging from 0.24% to 27.28%. Among seedlings, *C. canephora* displayed the highest dominance, with IVI ranging from 3.68% to 12.18%. Finally, *Ipomea dichroa* consistently emerged as the most dominant liana species across all locations, exhibiting IVI values ranging from 0.97% to 3.98% (Table 1).

The distribution of IVI across multiple taxa often reflects species diversity within an ecosystem. A balanced representation of IVI values suggests a potentially well-functioning ecosystem with diverse and co-existing species. Our study revealed significant spatial variations in floor vegetation IVI across the Ciamis community forests. These variations likely stem from the influence of key environmental factors along the studied gradient. Factors such as soil fertility and climatic conditions play a crucial role in determining species richness within an ecosystem. Additionally, edaphic factors like soil texture, nutrient availability, groundwater levels, temperature, pH, and aeration significantly influence plant distribution patterns (Zhang et al., 2013; Zhou et al., 2017; Zhang et al., 2021). Moreover, local forest management practices can substantially influence both species richness and distribution (Paudyal et al., 2017), as evidenced by the observed variability in species composition and individual abundance across our study locations.

The first study location, a community forest cultivated with diverse fruit trees (*L. domesticum* var. *typica*, *N. lappaceum*, *G. mangostana*, and *S. zalacca.*), exhibited a dense canopy due to the close planting of these species. This dense canopy significantly reduced light intensity reaching the forest floor, hindering the growth of light-demanding vegetation, especially grasses. Consequently, other plant types with lower light requirements, such as herbaceous plants, shrubs, and tree seedlings, thrived and dominated the understory. *P. repens* and *O. nodosa* were observed to form clusters within canopy gaps, while seedlings of *L. domesticum* var. *typica* and *C. canephora* displayed a more solitary growth pattern. This observation aligns with previous studies by Ahmad et al. (2019) and Chevaux et al. (2022), who demonstrated the significant influence of tree density and crown cover on the abundance and diversity of understory vegetation, particularly herbaceous species.

Based on the calculated IVI, *O. nodosa* emerged as the most dominant species overall and among grasses, exhibiting the highest IVI of 29.56% (Table 1). Among shrub species, *F. montana* and *Phyllanthus pulcher* achieved high dominance with IVI values of 27.54% and 15.88%, respectively. *P. repens* stood out as the most prominent herbaceous species, attaining an IVI of 17.06%, followed by *Homalomena pendula* (9.15%) and *Wurfbainia compacta* (5.70%). Regarding seedlings, *L. domesticum* var. *typica* displayed the highest dominance (IVI: 12.55%), followed by *C. canephora* (7.08%) and *H. macrophyllus* (3.96%). The fern species *Thelypteris parasitica* exhibited the highest IVI (6.3%) among ferns, followed by *Pteris ensiformis* (5.53%) and *Lygodium circinnatum* (3.24%). Notably, lianas displayed

the lowest overall IVI in this location. Among lianas, *Ficus recurva* emerged as the most dominant with an IVI of 4.20%, followed by *I. dichroa* (2.52%) and *Centrosema pubescens* (2.27%).

The second location was dominated by *S. mahagoni* trees, typically reaching heights of 10 30 m. Other commonly cultivated species included *A. chinensis* and *M. eminii*, both often exceeding 10 meters in height. Wider spacing between these trees facilitated increased light penetration to the forest floor, promoting the growth of diverse floor vegetation, particularly grasses and herbaceous plants. Here, *S. trilobata* and *O. nodosa* were frequently observed clustering in gaps amongst the larger trees. Notably, both species are considered weeds by farmers, who often remove them to increase canopy space for cultivating high-value crops like *W. compacta*. This management practice likely contributed to the abundance of *W. compacta* in this location. Based on our analysis, *O. nodosa* possessed the highest IVI among all grasses (30.69%), followed by *Lophatherum gracile* (19.91%). Herbaceous species held the second-highest collective IVI, with *S. trilobata* and *W. compacta* achieving the highest individual values (18.04% and 13.90%, respectively). *F. montana* remained the most dominant shrub species, exhibiting an IVI of 13.82%. Among ferns, *S. plana* held the highest IVI (11.61%). Seedlings were dominated by *C. canephora* (IVI 7.40%), followed by *L. domesticum* var. *typica* (4.86%) and *Arenga pinnata* (4.26%). For lianas, *Piper muricatum* displayed the highest IVI (2.47%), followed by *Paederia foetida* (1.50%) and *Dioscorea esculenta* (1.44%) (Table 1).

The third location presented a distinct ecological contrast compared to the previous two. Dominated by dense populations of *G. apus*, this site showed minimal evidence of forest management practices. Nevertheless, scattered plantings of *Vanilla planifolia* by local farmers were observed near some sampling points, thriving under the shade canopy of *Theobroma cacao* trees. In areas without dense bamboo cover, *H. macrophyllus* and *S. mahagoni* reached heights of 5 30 m. Coffee seedlings and diverse herbaceous vegetation flourished in the gaps between these trees. Despite the presence of bamboo cover, the understory received greater light penetration compared to the first location, where large timber and fruit trees dominated. This increased light availability created a suitable environment for the establishment and dominance of grasses and herbaceous plants, with *O. nodosa* and *A. gangetica* emerging as the most abundant species, respectively. This finding aligns with Ou et al. (2015), who reported increased dominance of grasses and herbaceous vegetation in bamboo forests compared to mixed natural forests. Conversely, while this location displayed fewer seedling species than others, individual seedling abundance was higher. This finding supports Rother et al. (2018) who demonstrated that the presence of bamboo influences the community structure and dynamics of early seedling establishment. Habitats with bamboo displayed higher seedling abundance, emergence, and mortality compared to non-bamboo habitats.

Analysis of the IVI in the third location revealed the dominance of certain grass, herbaceous, shrub, fern, seedling, and liana species. Among grasses, *O. nodosa* maintained the highest dominance (IVI 55.10%), followed by *O. hirtellus* (IVI 37.91%). *A. gangetica* emerged as the most dominant herbaceous species (IVI 27.28%), with *S. nodiflora* following (IVI 8.80%). *S. ocymifolia* achieved the highest IVI among shrubs (11.07%), while *F. montana* held an IVI of 5.22%. *S. plana* remained most dominant among ferns (IVI 4.73%), closely followed by *T. parasitica* (IVI 4.67%). Seedling diversity was lower, with *S. mahagoni* dominating (IVI 4.04%), followed by *C. canephora* (IVI 3.68%) and *H. macrophyllus* (IVI 2.45%). Liana species displayed the lowest average IVI, with *I. aitonii* having the highest value (3.98%), followed by *Vigna luteola* (3.06%) and *Tetrastigma* sp. (0.89%) (Table 1).

The fourth study location exhibited characteristics resembling a natural forest, including high species diversity and potentially complex plant community interactions. This unmanaged location harbored diverse large trees, such as *A. chinensis*, *S. mahagoni*, *Baccaurea racemosa*, and *L. domesticum* var. *typica*. Notably, *C. canephora*, abundantly planted here, emerged as the most common seedling. The forest floor displayed dense understory vegetation dominated by herbaceous plants, ferns, and grasses, primarily within canopy gaps. Bartels and Chen (2013) demonstrated that the composition of the broadleaf tree canopy directly influences the distribution of forest floor vegetation, including shrubs and herbaceous plants. This abundant floor vegetation likely plays a vital role in nutrient cycling and soil stabilization, while potentially providing key food sources and habitat for various insects, small mammals, and ground-dwelling birds.

Intriguingly, *F. montana* exhibited abundant growth even in low-light conditions within this location. This observation aligns with Bain et al. (2014), who reported the species' high adaptability to unfavorable environments. This adaptability likely explains its dominance across all four study locations. Notably, grasses maintained the highest IVI values, led by *O. nodosa* (IVI 71.96%) and *O. hirtellus* (IVI 28.61%). Ferns also reached their highest IVI here, with *S. plana* being the most dominant (IVI 18.44%). Despite this, seedling diversity remained lower than in other locations, with *C. canephora* exhibiting the highest IVI (12.18%)–the highest observed across all locations. Among shrubs, *S. ocymifolia* dominated (IVI 9.73%), while *S. trilobata* was the most dominant herbaceous species (IVI 6.32%). Lianas exhibited a similar pattern, displaying the lowest average IVI of all habitus. Among lianas, *V. luteola* was the most dominant species (IVI 4.08%), followed by *P. foetida* (IVI 2.22%) and *Piper caducibracteum* (IVI 1.41%) (Table 1).

The majority of floor vegetation species (excluding seedlings) across the four study sites comprised r-selected species adapted to high light intensity, clustered growth in unshaded areas, and short lifespans with rapid development and early reproduction. These traits enable them to thrive in unpredictable or disturbed habitats, allowing them to quickly colonize newly available resources and establish themselves before the environment changes or competition intensifies (Barbour et al., 1987).

Variations in species composition among shrubs, grasses, and herbaceous plants across the study locations likely result

Tab1e 1   50 species of floor vegetation with the highest species density, relative density, relative frequency, relative coverage and important value index in four study locations

No.	Species Name	Family	Kertaharja Density ha	RD (%)	FR (%)	RDo (%)	IVI (%)	Kiarapayung Density per ha	RD (%)	FR (%)	RDo (%)	IVI (%)	Sumberjaya Density per ha	RD (%)	FR (%)	RDo (%)	IVI (%)	Hujungtiwu Density per ha	RD (%)	FR (%)	RDo (%)	IVI (%)
1	*Ottochloa nodosa*	Poaceae	55,275	3.73	2.93	3.73	29.56	77,025	6.83	2.71	6.83	30.69	368,550	17.32	2.73	17.32	55.10	308,600	23.01	3.27	23.01	71.96
2	*Oplismenus hirtellus*	Poaceae	825	0.02	0.46	0.02	0.83	29,150	2.38	1.11	2.38	11.49	251,650	11.13	2.85	11.13	37.91	112,225	9.01	2.99	9.01	28.61
3	*Ficus montana*	Moraceae	32,725	10.44	3.55	10.44	27.54	18,325	6.08	2.71	6.08	13.82	7,875	2.22	2.26	2.22	5.22	4,900	1.23	2.42	1.23	4.37
4	*Lophatherum gracile*	Poaceae	14,000	3.91	2.93	3.91	12.64	41,275	5.99	2.59	5.99	19.91	2,425	0.18	1.43	0.18	1.84	9,200	1.33	2.28	1.33	4.97
5	*Selaginella plana*	Selaginellaceae	2,175	1.10	0.77	1.10	2.77	19,075	4.15	2.22	4.15	11.61	13,650	2.96	0.48	2.96	4.73	42,850	10.25	1.85	10.25	18.44
6	*Asystasia gangetica*	Acanthaceae	3,425	1.68	1.08	1.68	4.18	925	0.29	0.37	0.29	0.91	106,525	15.49	1.66	15.49	27.28	300	0.06	0.14	0.06	0.24
7	*Coffea canephora*	Rubiaceae	2,675	3.82	2.16	3.82	7.08	6,075	4.00	1.72	4.00	7.40	3,975	1.88	1.43	1.88	3.68	20,475	7.30	1.85	7.30	12.18
8	*Spermacoce ocymifolia*	Rubiaceae	4,250	1.98	2.01	1.98	5.74	2,625	0.17	1.72	0.17	2.61	62,850	2.71	2.38	2.71	11.07	30,575	2.36	2.84	2.36	9.73
9	*Sphagneticola trilobata*	Asteraceae	25	0.00	0.15	0.00	0.17	39,850	5.50	1.60	5.50	18.04	6,675	1.71	0.71	1.71	3.05	20,250	2.75	0.57	2.75	6.32
10	*Wurfbainia compacta*	Zingiberaceae	2,750	1.63	2.93	1.63	5.70	6,050	9.65	2.59	9.65	13.90	3,525	2.69	1.78	2.69	4.81	2,050	1.57	0.71	1.57	2.58
11	*Lansium domesticum var. typica*	Meliaceae	11,725	3.99	3.70	3.99	12.55	3,750	2.10	1.72	2.10	4.86	4,125	1.49	0.24	1.49	2.12	850	0.67	1.14	0.67	1.93
12	*Miconia crenata*	Melastomataceae	3,075	0.98	2.31	0.98	4.57	7,925	2.02	2.59	2.02	6.78	3,225	0.48	2.61	0.48	3.40	6,350	1.20	3.13	1.20	5.26
13	*Homalomena pendula*	Araceae	2,725	5.56	2.47	5.56	9.15	3,000	4.45	1.11	4.45	6.39	575	0.48	0.48	0.49	1.02	1,475	1.84	0.85	1.84	2.91
14	*Synedrella nodiflora*	Asteraceae	7,600	1.74	0.46	1.74	5.35	3,825	0.73	0.74	0.73	2.52	39,600	2.78	2.26	2.78	8.80	5,025	0.75	1.28	0.75	2.78
15	*Christella parasitica*	Aspleniaceae	3,125	2.08	2.93	2.08	6.31	2,450	0.67	1.97	0.67	3.31	54,600	1.55	2.61	1.55	4.67	3,125	1.56	1.99	1.56	4.01
16	*Procris repens*	Urticaceae	18,000	8.83	0.77	8.83	17.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	*Phyllanthus pulcher*	Phyllanthaceae	14,850	7.72	2.01	7.72	15.88	125	0.05	0.12	0.05	0.21	-	-	-	-	-	-	-	-	-	-
18	*Xanthosoma sagittifolium*	Araceae	575	0.29	0.46	0.29	0.99	3,150	2.99	1.72	2.99	5.58	6,200	3.58	2.49	3.58	6.67	1,400	0.77	1.56	0.77	2.54
19	*Ayapana triplinervis*	Asteraceae	4,775	3.46	0.77	3.46	6.21	11,025	4.15	1.23	4.15	8.41	-	-	-	-	-	-	-	-	-	-
20	*Arenga pinnata.*	Arecaceae	625	1.86	1.70	1.86	3.82	1,600	2.34	1.48	2.34	4.25	450	0.35	0.95	0.35	1.34	850	2.30	1.85	2.30	4.28
21	*Justicia procumbens.*	Acanthaceae	2,550	0.50	2.01	0.50	3.56	2,775	0.23	1.60	0.23	2.59	8,525	0.84	1.78	0.84	3.44	1,375	0.11	1.56	0.11	1.88
22	*Paspalum conjugatum*	Poaceae	2,675	0.42	0.46	0.42	1.99	1,400	0.24	0.74	0.24	1.36	16,200	1.22	2.26	1.22	5.02	8,425	0.98	0.85	0.98	3.08
23	*Hibiscus macrophyllus*	Malvaceae	4,650	0.50	1.54	0.50	3.96	775	0.26	1.48	0.26	1.95	6,400	0.30	1.54	0.30	2.45	275	0.15	1.00	0.15	1.18
24	*Swietenia mahagoni*	Meliaceae	75	0.28	0.77	0.28	1.08	2,375	1.21	1.23	1.21	3.10	4,800	1.80	1.78	1.80	4.04	275	0.22	0.85	0.22	1.11
25	*Christella subpubescens*	Aspleniaceae	275	0.09	0.31	0.09	0.51	1,700	1.09	1.97	1.09	3.53	2,000	0.49	0.24	0.49	0.91	1,600	2.49	1.56	2.49	4.29
26	*Pteris ensiformis*	Pteridaceae	3,025	1.65	2.62	1.65	5.53	1,225	0.40	2.09	0.40	2.83	175	0.03	0.36	0.03	0.40	50	0.00	0.28	0.00	0.29
27	*Ananas comosus*	Bromeliaceae	700	4.26	1.08	4.26	5.63	350	0.37	0.62	0.37	1.09	275	0.25	0.59	0.25	0.87	150	0.73	0.43	0.73	1.18
28	*Schismatoglottis calyptrata*	Araceae	600	0.15	0.46	0.15	0.86	6,875	4.06	1.23	4.06	7.18	375	0.25	0.24	0.25	0.52	25	0.01	0.14	0.01	0.16
29	*Ipomoea dichroa*	Convolvulaceae	1,075	0.38	1.70	0.38	2.52	425	0.11	0.74	0.11	0.97	4,025	1.69	1.90	1.69	3.98	825	0.14	1.00	0.14	1.25
30	*Dieffenbachia seguine*	Araceae	2,225	1.61	0.15	1.61	2.69	5,675	2.16	0.49	2.16	4.21	775	0.95	0.24	0.95	1.26	125	0.10	0.14	0.10	0.26
31	*Commelina benghalensis*	Commelinaceae	1,750	0.06	0.93	0.06	1.71	525	1.07	0.37	1.07	1.58	4,475	0.15	1.78	0.15	2.35	3,775	0.34	1.42	0.34	2.32
32	*Vigna luteola*	Fabaceae	25	0.00	0.15	0.00	0.16	-	-	-	-	-	1,200	2.82	0.12	2.82	3.06	4,000	1.92	1.56	1.92	4.08
33	*Hellenia speciosa*	Costaceae	1,250	0.98	1.70	0.98	3.19	350	0.15	0.62	0.15	0.86	-	-	-	-	-	1,375	1.46	0.85	1.46	2.52
34	*Hyptis capitata*	Lamiaceae	-	-	-	-	-	575	0.06	0.86	0.06	1.08	2,450	0.77	1.90	0.77	2.91	2,500	0.85	1.11	2.34	1.58
35	*Chromolaena odorata*	Asteraceae	75	0.01	0.31	0.01	0.35	825	0.22	0.99	0.22	1.43	2,700	1.10	1.31	1.10	2.66	775	1.00	0.71	1.00	1.83
36	*Strobilanthes phyllostachya*	Acanthaceae	1,425	1.47	0.93	1.47	2.99	925	0.69	0.25	0.69	1.19	450	0.03	0.24	0.03	0.31	2,300	0.57	0.43	0.57	1.34
37	*Scleria terrestris*	Cyperaceae	1,325	0.06	1.54	0.06	2.15	2,075	0.82	1.11	0.82	2.50	75	0.03	0.12	0.03	0.15	1375	0.17	0.43	0.17	0.80
38	*Ficus septica.*	Moraceae	625	0.78	1.54	0.78	2.58	525	0.12	1.35	0.12	1.62	600	0.31	0.95	0.31	1.32	-	-	-	-	-
39	*Centotheca lappacea*	Poaceae	-	-	-	-	-	5,475	0.92	1.23	0.92	3.65	5,700	0.31	0.83	0.31	1.68	-	-	-	-	-
40	*Nephrolepis biserrata*	Nephrolepidaceae	200	0.21	0.46	0.21	0.76	1,475	1.49	0.62	1.49	2.51	25	0.00	0.12	0.00	0.12	1,200	0.58	1.14	0.58	1.90
41	*Curculigo latifolia*	Hypoxidaceae	450	0.11	0.46	0.11	0.76	775	0.82	0.62	0.82	1.65	425	0.77	0.48	0.77	1.28	475	0.93	0.57	0.93	1.57
42	*Pleocnemia irregularis*	Polypodiaceae	100	0.01	0.31	0.01	0.36	1,375	0.79	0.86	0.79	2.03	1,300	0.71	1.54	0.71	2.38	200	0.10	0.28	0.10	0.41
43	*Lygodium circinnatum.*	Lygodiaceae	1,200	0.58	2.16	0.58	3.24	425	0.05	1.11	0.05	1.27	375	0.26	0.36	0.26	0.65	-	-	-	-	-
44	*Archidendron pauciflorum*	Fabaceae	625	0.23	0.77	0.23	1.26	1,650	0.84	2.46	0.84	3.76	50	0.01	0.12	0.01	0.13	-	-	-	-	-
45	*Paederia foetida*	Rubiaceae	650	0.05	0.46	0.05	0.79	725	0.06	1.23	0.06	1.49	250	0.02	0.48	0.02	0.52	875	0.11	1.99	0.11	2.23
46	*Maesopsis eminii*	Rhamnaceae	25	0.02	0.15	0.02	0.18	675	0.18	0.99	0.18	1.35	1,700	0.37	1.19	0.37	1.72	850	0.21	1.42	0.21	1.76
47	*Syngonium podophyllum*	Araceae	1100	1.61	0.31	1.61	2.38	1,325	0.97	0.49	0.97	1.82	250	0.09	0.48	0.09	0.59	50	0.04	0.14	0.04	0.19
48	*Phyllanthus urinaria*	Phyllanthaceae	150	0.00	0.15	0.00	0.22	350	0.01	0.86	0.01	0.97	3,600	0.14	2.14	0.14	2.62	500	0.06	0.85	0.06	0.99
49	*Artocarpus heterophyllus*	Moraceae	125	0.21	0.77	0.21	1.04	50	0.00	0.25	0.00	0.26	500	0.60	0.71	0.60	1.36	675	0.42	1.56	0.42	2.08
50	*Ficus recurva*	Moraceae	1,100	2.67	1.08	2.67	4.20	100	0.04	0.12	0.04	0.19	50	0.01	0.24	0.01	0.25	-	-	-	-	-
	Total		241,375	100	100	100	300	364,175	100	100	100	300	1,051,550	100	100	100	300	675,600	100	100	100	300

from frequent disturbances, such as selective thinning, pruning, and large tree harvesting by landowners. These disturbances create canopy gaps, increasing light availability and soil nutrient levels, which in turn fosters the proliferation of understory vegetation, including herbaceous plants, ferns, and grasses. The substantial presence of seedlings across all locations suggests ongoing natural tree regeneration. In this process, seedlings replace disturbed or harvested trees, gradually altering the canopy composition over time. This natural regeneration process presents potential for application in forest management, offering opportunities to establish new stands following timber harvests. By implementing disturbance regimes that promote the desired species composition, forest managers can potentially accelerate the establishment of mature forest stands.

Diversity index Analysis of multiple diversity indices revealed a moderately diverse floor vegetation community across the four study locations. The species diversity index values ranged from 2.35 to 3.27 (Figure 5), indicating the presence of several species with no single dominant species, suggesting a balanced community composition. This finding aligns with the Simpson's Dominance Index (C) analysis, which revealed consistently low values (0.09-0.25) across all species (Figure 5), further confirming the absence of dominant species. Additionally, the species richness index revealed high values ranging from 15.31 to 17.84 (Figure 5), indicating a relatively large number of distinct species in each location, suggesting high species diversity. Such high diversity promotes ecosystem stability and resilience through several mechanisms. It provides functional redundancy, meaning that if one species decline, others can compensate, maintaining crucial ecosystem functions.

Additionally, diverse communities exhibit asynchrony, where different species respond differently to environmental fluctuations and disturbances, preventing widespread impacts on the entire community (Tilman et al., 2014; Goswami et al., 2017; Sasaki et al., 2019; Schmitt et al., 2020). These characteristics contribute to the overall health and resilience of the studied ecosystems.

Evenness and similarity Analysis of the species evenness index revealed moderate values ranging from 0.45 to 0.65 across all floor vegetation species (Figure 5). This suggests a patchy or uneven distribution of different vegetation types within the Ciamis community forest, rather than a perfectly uniform spread. The observed clustering of floor vegetation species could be attributed to several factors, including uneven light intensity reaching the forest floor due to the canopy structure. The presence of canopy gaps likely creates areas with varying light conditions, leading to the development of distinct patches with species adapted to those specific environments. This heterogeneity in light availability can create a mosaic of microhabitats, favoring a diverse range of plant species with different shade tolerances (Tian et al., 2023).

The similarity index for the floor vegetation communities in each study location displayed a moderate level of resemblance, ranging from 56.69% to 66.67% (Table 2). The most similar communities were found in Kertaharja and Kiarapayung, suggesting shared species composition. While not identical, these locations share a significant portion of their species or characteristics, indicating ecological similarity or common environmental conditions. Notably, both areas feature the cultivation of similar production timber trees and fruit trees, potentially contributing to this observed
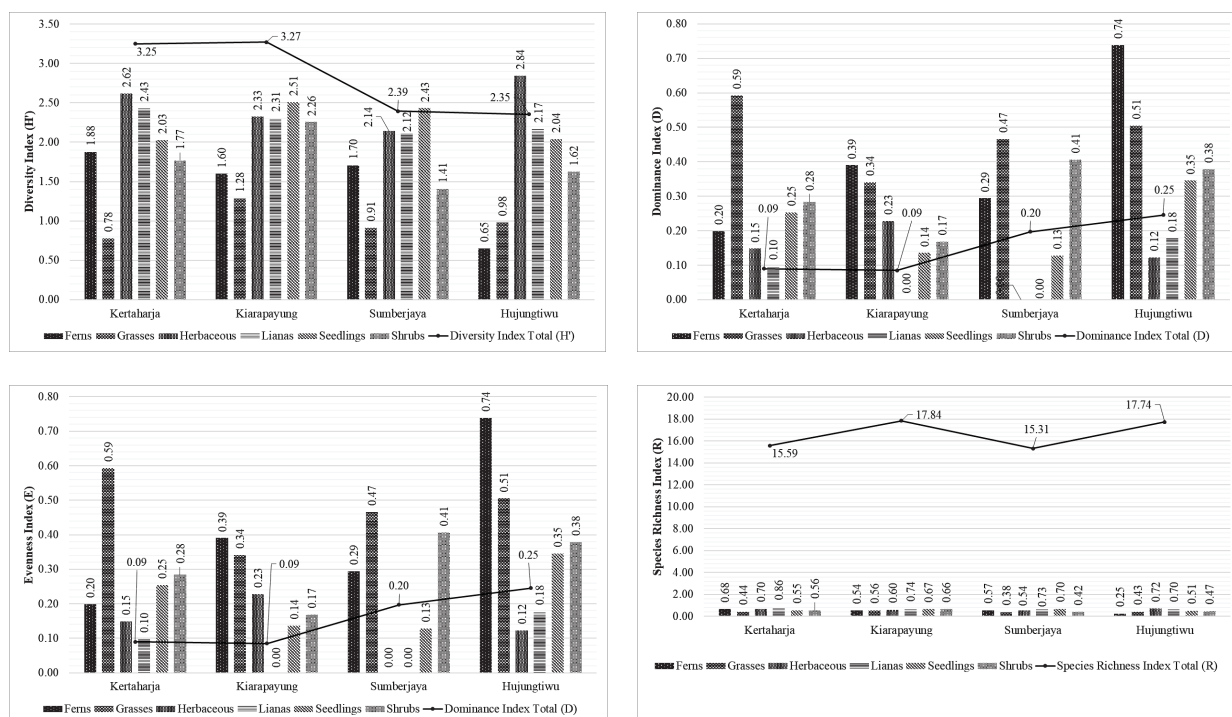

Figure 5 Index values of diversity, evenness, dominance and species richness in the four study locations.

similarity.

These findings suggest that management practices for one forest community within this similarity range may have some applicability to others. However, further investigations are crucial to understand the specific ecological and environmental factors driving this similarity before implementing management decisions.

Potential carbon storage and carbon dioxide sequestration Analysis revealed an average total carbon storage of 0.199 Mg C ha^{-1} in the floor vegetation across the four study locations, with a corresponding CO_2 sequestration rate of 0.730 Mg C ha^{-1}. Notably, the floor vegetation in the Hujungtiwu community forest exhibited the highest carbon storage (0.238 Mg C ha^{-1}) and CO_2 sequestration (0.873 Mg C ha^{-1}), while the Kertaharja community forest displayed the lowest values (0.107 Mg C ha^{-1} and 0.392 Mg C ha^{-1}, respectively) (Table 3). For comparison, previous studies report a wide range of above-ground carbon storage in tropical forest understories. Besar et al. (2020) reported that carbon storage in the shrub layer ranged from 0.03 to 0.14 Mg C ha^{-1} in an agroforestry system in Sabah, Malaysia, and was approximately 0.07 Mg C ha^{-1} in natural tropical forests. Afentina et al. (2022) reported diverse values across different land-use types in Central Kalimantan, Indonesia: 2.1 Mg C ha^{-1} in rubber plantations, 3.32 Mg C ha^{-1} in secondary forests, 4.62 Mg C ha^{-1} in forest plantations, 5.30 Mg C ha^{-1} in forests with rattan, and 3.21 Mg C ha^{-1} in secondary peat forests.

Furthermore, Darmawan et al. (2022) estimated an above-ground carbon storage of approximately 269.2 Mg C ha^{-1} in the natural forest of Bukit Tigapuluh National Park. Additionally, Rutishauser et al. (2013) reported average above-ground carbon storage values of 378 Mg C ha^{-1} and 316 Mg C ha^{-1} for unmanaged lowland Dipterocarp forests and secondary forests in Sumatra and East Kalimantan, respectively. Across four community forests, our study revealed significant spatial variability in floor vegetation

carbon storage and CO_2 sequestration. This variation likely stems from a complex interplay of factors, including canopy cover, species diversity, and plant density. Canopy cover can restrict light availability in dense areas, hindering understory growth and carbon accumulation. Forests with higher species diversity, like Hujungtiwu, may exhibit niche partitioning and more efficient resource utilization, leading to greater carbon storage (Li et al., 2019; Xu et al., 2020; Baul et al., 2021). Moreover, increased plant density in forests like Sumberjaya potentially contributes to higher biomass and carbon sink capacity (Baul et al., 2021). Beyond these factors, carbon dynamics are influenced by a wide range of variables, including vegetation type, structure, composition, age, management practices, elevation, and broader geographical features (Liu et al., 2018; Måren & Sharma, 2021; Anderson et al., 2022). Future investigations should delve deeper into these diverse drivers to fully comprehend the observed spatial variations in floor vegetation carbon storage and CO_2 sequestration.

Microclimate Measurements revealed significant variations in microclimatic conditions across the four study locations, influenced by both geography and local forest management practices. Community forests with denser canopies exhibited higher air humidity compared to those with more canopy gaps, mirroring the ability of tree cover to retain moisture and moderate temperatures (Wang et al., 2023).

The first location, characterized by a dense canopy, had the highest air humidity (75.71%) and average daily temperature (27.73°C). However, light intensity reaching the forest floor was the lowest (360.17 lux), potentially due to reduced penetration through the canopy. This, in turn, could explain the lower average soil humidity (78.50%) observed here, likely due to increased evaporation from exposed soil.

The second location had the lowest average air humidity (64.77%) due to its unique planting pattern which allowed sunlight to reach the ground. This resulted in higher daily

Table 2 Community similarity index in the four study locations

No	Forest location	Similarity index (%)			
		Kertaharja	Kiarapayung	Sumberjaya	Hujungtiwu
1	Kertaharja		66.67	58.82	56.69
2	Kiarapayung			59.69	57.66
3	Sumberjaya				57.74
4	Hujungtiwu				

Table 3 The total potential for carbon storage and carbon dioxide sequestration in the four study locations

Study locations	Average dry weight /biomassa (g/0.25m^2)	Average dry weight/biomassa (kg/m^2)	Average dry weight/biomassa (Mg C ha^{-1})	Average %C	Potential carbon storage (Mg C ha^{-1})	Potential CO_2 sequestration (Mg C ha^{-1})
Kertaharja	5.676 ± 5.455	0.023 ± 0.022	0.227 ± 0.218	0.011 ± 0.010	0.107	0.392
Kiarapayung	11.376 ± 8.851	0.046 ± 0.035	0.455 ± 0.354	0.021 ± 0.017	0.214	0.785
Sumberjaya	12.593 ± 11.965	0.050 ± 0.048	0.504 ± 0.479	0.024 ± 0.022	0.237	0.869
Hujungtiwu	12.649 ± 11.338	0.051 ± 0.045	0.506 ± 0.454	0.024 ± 0.021	0.238	0.873
Average total	10.574 ± 2.873	0.043 ± 0.011	0.423 ± 0.115	0.020 ± 0.005	0.199 ± 0.054	0.730 ± 0.198

light intensity (441.76 lux) and a slightly cooler air temperature (26.41°C), possibly influenced by both elevation and the presence of shading trees. Interestingly, this location also had higher average soil humidity (80.50%) compared to the first, potentially due to improved moisture retention by ground vegetation.

The third location exhibited moderate air humidity (68.11%) and temperature (27.31°C). While high-altitude locations typically experience cooler temperatures, the presence of bamboo, which provides less shade compared to other trees, allows for increased sunlight exposure and warmer air. This location also had the highest daily light intensity (859.36 lux), promoting diverse floor vegetation like grasses and herbaceous plants. Additionally, the presence of these plants and bamboo leaf litter on the forest floor likely contributed to the highest average soil humidity (90.54%).

The fourth location possessed the coolest air temperature (23.23°C) due to its elevation and dense canopy blocking direct sunlight. Despite this, the daily light intensity on the forest floor remained moderate (396.63 lux). This location also had higher floor vegetation cover compared to the first, possibly due to less management intervention, leading to a more natural forest resemblance. The dense canopy and vegetation cover contributed to relatively high air humidity (72.87%) and soil moisture (90.20%). This study highlights the complex interplay of geographical factors and forest management practices in shaping diverse microclimates within community forests. Understanding these variations is crucial for sustainable forest management and conservation efforts.

Conclusion

This study revealed diverse floor vegetation communities in Ciamis community forests, with variations driven by management practices and influencing microclimate. Despite moderate diversity, specific dominant species emerged like *O. nodosa* and *F. montana*. These communities exhibited moderate carbon storage and sequestration, with potential for enhancement through diverse management strategies. Future studies should delve deeper into the drivers of carbon dynamics and the role of floor vegetation in community forests as a natural climate solution.

Acknowledgement

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