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Species composition, stand structure, and carbon stock in the agroforestry system of Wana Lestari Community Forestry, West Nusa Tenggara, Indonesia

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Abstract. *Akdah RD, Wijayanto N, Hartoyo APP. 2024. Species composition, stand structure, and carbon stock in the agroforestry system of Wana Lestari Community Forestry, West Nusa Tenggara, Indonesia. Biodiversitas 25: 3350-3358.* Climate change is characterized by shifting climate patterns that result in erratic weather phenomena. One of the major consequences of climate change is the reduction in biodiversity and the increased concentration of greenhouse gases (GHGs), primarily carbon. Agroforestry systems (AF) have emerged as a potential solution to mitigate these effects by conversing biodiversity and enhancing carbon stocks. This study aims to analyze the species composition and structure of tree stands and estimate the carbon stock in the AF of the community forest (HKm). The methods used employed included vegetation analysis, stand structure measurement using the Spatially Explicit Individual-based Forest Simulator (SExI-FS), and carbon stock estimation using allometric equations and destructive approaches for seedlings and understory levels. A total of 25 plots, each measuring 20×20 m, were used for data collection. The results show that the species composition in HKm Wana Lestari consists of 63 plant species from 40 families. The highest importance value index (IVI) was recorded for durian (*Durio zibethinus* Murray) at the pole growth level (90.34%), while coffee (*Coffea robusta* L.Linden) emerged as the dominant species within the agroforestry system. The diversity index (H') ranged from 0.40 to 2.29, indicating a medium category of diversity. The stand structure did not follow the expected "J" curve pattern. The total biomass and carbon stock across all growth levels were found to be 228.35 and 107.22 tons/ha, respectively. In conclusion, the agroforestry system in HKm Wana Lestari demonstrates notable species diversity and carbon storage potential, although its stand structure deviates from the ideal "J" curve, suggesting opportunities for further forest management improvements.

Keywords: Aboveground carbon, *Coffea robusta*, FOLU Net Sink, forest farming, SExI-FS

INTRODUCTION

Climate change refers to alterations in global climate patterns leading to unpredictable weather events. The increase in global temperatures has been primarily attributed to the rise in atmospheric greenhouse gases, such as carbon dioxide (CO_2), which are released directly into the environment (Prasad et al. 2017; Pratiwi et al. 2022). In response to global climate challenges, many countries have developed plans and policies aimed at managing natural resources, particularly forest resources, to reduce emissions (Meragiaw et al. 2021; Wannasingha et al. 2023). The Kementerian Lingkungan Hidup dan Kehutanan (2020) predicted a continued rise in greenhouse gas emissions in Indonesia. In 2019, emissions were recorded at 1,866,552 Gg CO_2e, reflecting an increase of 250,983 Gg CO_2e compared to 2018, with a 44% overall rise (Kementerian Lingkungan Hidup dan Kehutanan 2020).

The Indonesian government has taken steps to formulate an emission reduction policy through mitigation actions under Indonesia's FOLU Net Sink 2030 initiative. According to the Kementerian Lingkungan Hidup dan Kehutanan (2022), the FOLU Net Sink 2030 targets a condition where the rate of carbon absorption surpasses emission levels from forestry and land sectors by 2030. This mitigation effort aimed to reduce greenhouse gas emissions by implementing conservation measures, enhancing biodiversity, and increasing carbon stocks. Sustainable forest management through these measures not only addressed climate change by sequestering CO_2 but also ensured the future supply of materials and ecosystem services while promoting greener, circular economies (Kumar et al. 2016; Biadgligne et al. 2022; FAO 2022). A significant aspect of sustainable forest management includes agroforestry systems.

Agroforestry systems have been recognized for their potential to maintain soil fertility, improve land productivity, and support local livelihoods (Octavia et al. 2023). These systems also contributed to the economy and offered promising applications in social forestry (Octavia et al. 2022). Agroforestry involves the intensive management of land by combining forestry plants, agricultural crops, and livestock (Hartoyo et al. 2020), allowing for optimal results through ecological and economic interactions. Beyond enhancing productivity and providing economic benefits, agroforestry systems contributed to environmental services such as carbon storage (Santhyami et al. 2018).

Agroforestry also had potential in mitigating climate change impacts (Humnessa et al. 2022). Various calculations of carbon stocks in agroforestry systems have been reported: community forests in Maha Sarakhan Province, Thailand, showed values of 93.89 Mg C ha^{-1} in forest blocks under best practice management (Wannasingha et al. 2023), while cocoa-based agroforestry systems in Sumatra recorded 206.84 Mg C ha^{-1} (Santhyami et al. 2018). In Krui-Lampung, Damar agroforestry, dominated by Dipterocarpaceae species such as Shorea javanica, exhibited biodiversity comparable to natural forests with a carbon stock of 102.7 Mg C ha^{-1} (Hartoyo et al. 2022). Other agroforestry examples include oil palm and arrowroot systems in Tawau, Sabah (37.88 tons/ha) (Suardi et al. 2020) and traditional agroforestry in Gunung Halimun Salak National Park, which had a carbon concentration of 51.02 tons/ha (Hartoyo et al. 2022).

Given the importance of carbon sequestration, estimating carbon stocks and analyzing CO_2 absorption potential by examining species composition and stand structure in other agroforestry systems, such as in the Wana Lestari Karang Sidemen Community Forestry (HKm), has become essential. Community forests are areas of state forests managed sustainably by local communities or organized groups under agreements with the Forest Administration (FAO 2004). The Wana Lestari HKm, located in Karang Sidemen Village, North Batukliang District, Central Lombok District, West Nusa Tenggara Province, has been managed since 2010. However, data on species composition and carbon stocks in this HKm remain limited, necessitating further research.

This study aimed to analyze species composition and stand structure and estimate aboveground carbon stocks in the agroforestry systems of the Wana Lestari Karang Sidemen HKm in West Nusa Tenggara Province. The outcomes of this research will provide farmers with valuable insights into species composition and carbon stock potential, helping them assess land use options for reducing CO_2 emissions. Additionally, the findings will contribute to the government's database for managing HKm areas.

MATERIALS AND METHODS

Study area

The study was conducted between July and November 2022 in the Wana Lestari Community Forest (HKm), situated at coordinates 8°32'37"-8°30'13" South Latitude and 116°19'1.2"-116°19'27.8" East Longitude, at an elevation of 480 to 740 meters above sea level (m asl.) in Karang Sidemen Village, West Nusa Tenggara Province, Indonesia (Figure 1). The carbon content analysis was performed at the Forest Management Laboratory, Faculty of Forestry, Universitas Mataram, Indonesia.

Procedures

Establishing research plots

Data collection in the field involved establishing research plots by carefully selecting locations through purposive sampling, based on land criteria that followed an agroforestry pattern. A total of 25 plots were constructed. Each main plot measured 20×20 m^2 for trees and was divided into subplots to assess different plant growth stages: litter (1×1 m^2), seedlings and understorey (2×2 m^2), saplings (5×5 m^2), and poles (10×10 m) (Figure 2) (Badan Standardisasi Nasional 2019).

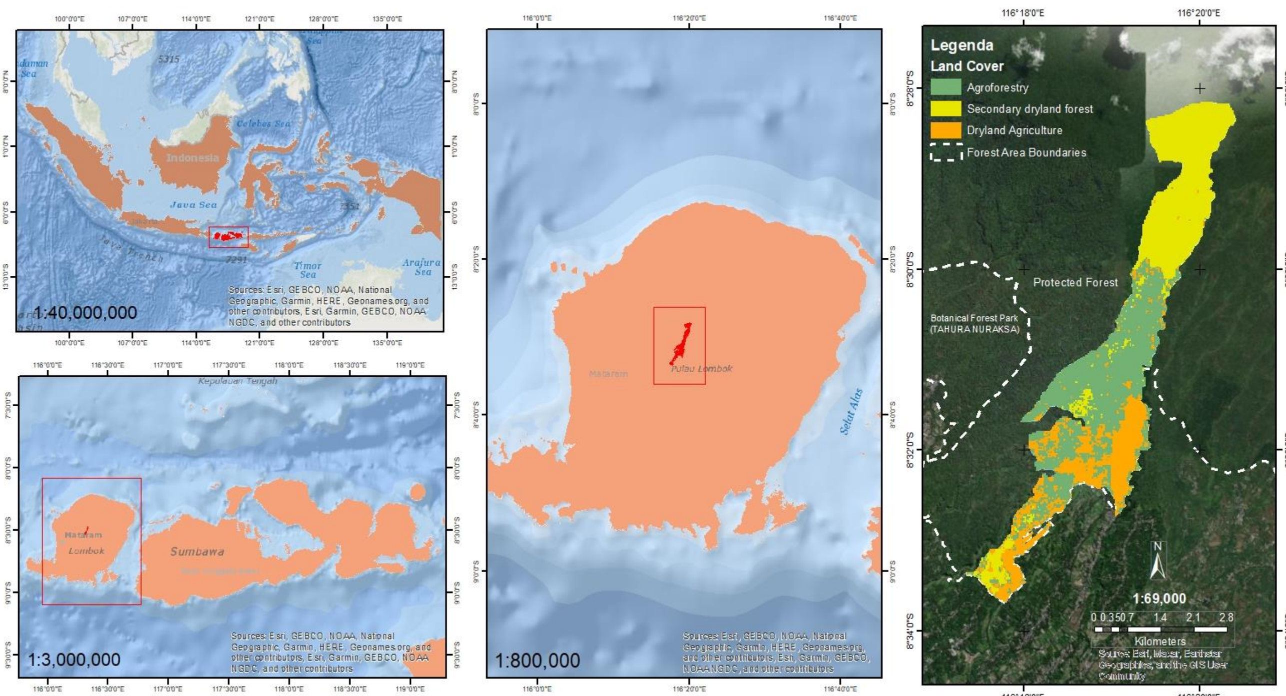

Figure 1. Map of research location in the Wana Lestari Community Forestry in Karang Sidemen Village, West Nusa Tenggara, Indonesia

Measurement of species composition and stand structure

Data on species composition and stand structure included growth parameters for trees and poles, such as species name (both Indonesian and scientific), diameter at breast height (DBH), tree branch height, total height, and the number of individuals per species (Badan Standardisasi Nasional 2019). The stand structure was assessed in terms of both horizontal and vertical arrangements, using the Spatially Explicit Individual-based Forest Simulator (SExI-FS) application. Stratification, or canopy layering, referred to the vertical arrangement of plants within the forest ecosystem. The horizontal structure was analyzed by examining the relationship between tree density and diameter class, while the vertical structure was assessed through the relationship between tree density and height class (Wijayanto and Prasetyo 2021).

Aboveground biomass measurement

The determination of aboveground biomass was carried out using a non-destructive sampling method, which involved the application of an appropriate allometric equation to avoid causing damage to trees and poles. In the observation plots, only the diameter at breast height (DBH), measured at 1.30 meters above ground level, was recorded for all trees. The biomass of seedlings and, undergrowth, and litter was measured using total wet weight parameters. All seedlings and undergrowth within the plots were cut, excluding the root portions, and their wet weight was recorded. Samples weighing approximately 300 grams were taken, placed in labeled plastic bags, and then dried in an oven at 85°C for 48 hours in the laboratory. After drying, the dry weight of each seedling, undergrowth sample, and litter (referring to dead leaves, twigs, and branches) was measured (Badan Standardisasi Nasional 2019).

Data analysis

Vegetation analysis

Importance Value Index (IVI) is used to measure species in a community by integrating their relative abundance, frequency, and dominance. IVI data analysis was carried out using guidelines by Soerianegara and Indrawan (1976):

$$\text{Density} = \frac{\text{Total number of individuals}}{\text{Size of plot}}$$

$$\text{Relative Density (RD)} = \frac{\text{Number of individuals of the species}}{\text{Number of individuals of all species}} \times 100\%$$

$$\text{Frequency (F)} = \frac{\text{Number of quadrats in which species occurred}}{\text{Total size of plots}}$$

$$\text{Relative Frequency (RF)} = \frac{\text{Number of occurrences of the species}}{\text{Number of occurrences of all species}} \times 100\%$$

$$\text{Dominance (Dm)} = \frac{\text{Total basal area of the species}}{\text{Total size of plots}}$$

$$\text{Relative Dominance (RDm)} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all species}} \times 100\%$$

IVI in the undergrowth, seedlings, and sapling = RD + RF

IVI growth of poles and trees = RD + RF + RDm

Species Diversity Index (H')

The species diversity index (H') was used to assess the level of plant species diversity within a forest community. The calculation employed the Shannon-Wiener index, as described by Ludwig and Reynolds (1988):

$$H' = \sum_{i=1}^{S} \frac{ni}{N} \ln \left(\frac{ni}{N}\right)$$

Where:

H' : Diversity index Shannon
ni : Total of individuals of type-I in a sample plot
N : Total of all individuals
S : Total of types found

A diversity index value lower than 1.50 indicates low diversity. Conversely, a diversity index ranging from 1.50 to 3.50 signifies moderate diversity, while a value greater than 3.50 indicates high diversity (Michell 1995).

Species Richness Index (Dmg)

The species richness index (Dmg) measures species richness within a community. This index can be determined using the Margalef richness index, as described by Magurran (1988) and Ludwig and Reynolds (1988):

$$Dmg = (S-1) / \ln N$$

Where:

Dmg : Index of richness
S : Total of species that are founded
N : Total of individual

Jørgensen et al. (2005) established that a species richness index value below 2.05 indicates low species richness. A value greater than 2.05 signifies high species richness.

The Evenness Index (E)

The species evenness index (E) measures the distribution of individuals among species within a community. Greater evenness in the distribution of individuals indicates a more balanced ecosystem. The species evenness index is calculated using the formula provided by Magurran (1988) as follows:

$$E = \frac{H'}{\ln S}$$

Where:

E : Index of evenness
H' : Index of diversity
S : Total of species

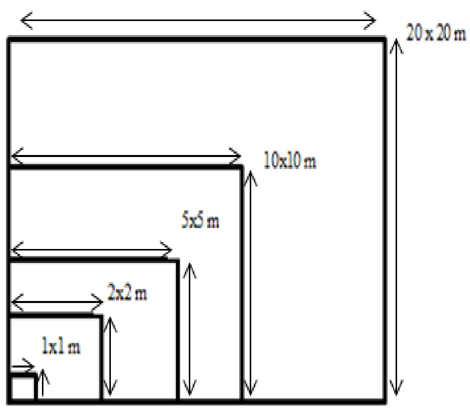

Figure 2. Design of research plot

The species evenness index (E) ranges from 0 to 1. Values close to 0 indicate low species evenness, meaning that the distribution of individuals among species is uneven. Conversely, values close to 1 suggest high species evenness, where the abundance of species is relatively uniform with a more equal distribution of individuals (Magurran 2004).

Type Dominance Index (C)

The species dominance index quantifies the degree of dominance exhibited by a particular species within a community (Hartoyo et al. 2020). This index, based on Simpson's (1949) method, is calculated using the following formula:

$$C = \sum_{k=0}^{n} \left(\frac{ni}{n}\right) 2$$

Where:
C : Index of dominance
ni : Density to-i
N : Total of density

Simpson's dominance index ranges from 0 to 1. A value approaching 1 indicates that one or a few species dominate the community. Conversely, a value close to 0 suggests that the community is characterized by a more even distribution of dominance among multiple species, or no single species dominates significantly.

Measurement of biomass and carbon

Carbon storage in Wana Lestari Karang Sidemen was estimated by calculating the weight of Aboveground Biomass (AGB). Standing biomass was measured using a non-destructive method with the allometric equation (Table 1). Allometric equations, which utilize easily measurable tree variables such as height, diameter, and canopy, can effectively estimate carbon in forest ecosystems. This approach provides a higher level of accuracy for both biomass estimation and carbon calculations (Biadgligne et al. 2022).

Calculations of undergrowth plant biomass and litter were analyzed using the following formula suggested by Badan Standardisasi Nasional (2019).

$$Botb = \frac{Bks \times Bbt}{Bbs} \quad \text{and} \quad Bos = \frac{Bks \times Bbt}{Bbs}$$

Where:
Botb : Total biomass/undergrowth organic matter (kg)
Bos : Total biomass/litter organic matter (kg)
Bks : Dry weight for example (kg)
Bbt : Total wet weight (kg)
Bbs : Wet weight for example (kg)

Carbon uptake calculations are analyzed using the formula (Badan Standardisasi Nasional 2019).

$$C_{tb} = Botb \times \%\ C\ organic$$
$$Cs = Bos \times \%\ C\ organic$$

Where:
C_{tb}: Carbon content of organic matter of lower plants (kg)
C_s : Carbon content of litter organic matter (kg)
Botb : Total biomass/ organic material of undergrowth (kg)
Bos : Total biomass/ litter organic matter (kg)
% C organic : Percent carbon value, equal to 0.47

RESULTS AND DISCUSSION

Plant species composition

The species composition of a plant community can be determined by through vegetation analysis (Locky and Bayley 2006; Bachry et al. 2020). A recapitulation of the total number of species and individuals at each level is provided in Table 2.

Vegetation analysis in the HKm Wana Lestari area revealed a total of 63 plant species, with 12631 individuals per hectare and 18 families at the tree, pole, and sapling levels, and 28 families at the lower plant level. The highest species diversity was observed at the tree growth level, with 19 species and 249 individuals per hectare. Dominant plant species across the tree, pole, and sapling stages included members of the Malvaceae family, such as *bayur* (*Pterospermum javanicum* Jungh), durian (*Durio zibethinus* Murray), cocoa (*Theobroma cacao* L.), and *waru* (*Hibiscus tiliaceus* L.).

Table 2. Recapitulation of the total of species and total of individuals found

Growth rate	Total of species	Total of individuals (Ind/ha)
Undergrowth[a]	37	11672
Seedling	3	148.00
Sapling	13	778.24
Pole	16	23.20
Tree	19	10.04
Total		12631

Notes: [a] is not included in the tree growth rate

Table 1. Biomass allometric equations for carbon estimation in aboveground

Species or plant type	Allometric equation*	Source
Mixture	Y = ρ × exp (-1,499 + 2,148 ln (D) + 0,207 (ln (D))2 +0,0281 (ln(D))3	Chave et al. (2005)
Coffee (*Coffea* sp.)	Y = 0.2811 D2,0635	Arifin (2001)
Cocoa (*Theobroma cacao*)	Y = 0.1208 D1,98	Yuliasmara et al. (2009)
Sengon (*Falcataria falcata*)	Y = 0.113 D2,345	Krisnawati et al. (2012)
Teak (*Tectona grandis*)	Y = 0.20091 × D2,30	Krisnawati et al. (2012)

Notes: *Y: biomass (kg/tree). D : diameter at breast height (cm). ρ : wood density (g/cm^3)

Importance Value Index (IVI)

Importance Value Index (IVI) is used to rank species based on their ecological importance and to identify dominant species at each growth stage within a community (Susilowati et al. 2020; Rambey et al. 2021). The high value of relative density (RD), relative frequency (RF), relative dominance (RD), and importance value index (IVI) for each species are summarized in Table 3.

The highest Importance Value Index (IVI) at the tree level was recorded for the durian plant (*D. zibethinus*) with an IVI of 68.54%. At the pole, sapling, and seedling levels, the highest IVI values were observed for durian (*Durio zibethinus*) (IVI = 90.34%), coffee (*C. robusta*) (IVI = 124.39%), and coffee (*C. robusta*) (IVI = 166.97%), respectively. At the lower plant level, the highest IVI was for swamp millet (*Isachne globosa*) with an IVI of 65.83% (Table 3).

Diversity Index (H'), Richness Index (Dmg), Evenness Index (E), and Dominance Index (C)

The values of the species diversity index (H'), richness index (Dmg), evenness index (E), and dominance index (C) at the tree, pole, sapling, undergrowth, and seedling levels are summarized in Table 4.

The species diversity index (H') values across various growth stages ranged from medium to low. The highest H' value was recorded at the growth stage (2.29), indicating medium diversity, while the sapling (0.58) and seedling (0.40) levels fell into the low diversity category.

The species richness index (Dmg) varied across growth stages, with the highest value observed at the undergrowth level (4.53), followed by the tree level (3.26) and the pole level (3.01).

The species evenness index (E), which ranges from 0 to 1 (Magurran 2004), showed values close to 1 at the tree (0.78), sapling (0.74), and pole (0.71) growth stages, indicating relatively high evenness. In contrast, the evenness index was lower at the seedling (0.37) and undergrowth (0.47) levels.

The Simpson dominance index (C) also ranges from 0 to 1, with the highest C value recorded at the seedling stage (0.80) and the lowest values observed at the tree (0.16), pole (0.19), sapling (0.23), and undergrowth (0.33) stages.

Stand structure

The stand structure in each plot can be seen in Figure 3. The visualization of the structure profile and distribution of vegetation at the tree and pole levels revealed the highest density in plot 8, medium density in plot 17, and lowest density in plot 10. According to Soerianegara and Indrawan (1976), there are five strata: A, B, C, D, and E. However, the Karang Sidemen Community Forest (HKm) exhibits four canopy stratifications: A, B, C, and D.

Table 3. Five species that have highest IVI at each growth level

Growth rate	Species	RD (%)	RF (%)	RDm (%)	IVI (%)
Undergrowth[a]	Swamp millet (*Isachne globosa* (Thunb.) Kuntze)	51.72	14.11	-	65.83
	Pastureweed (*Cyathula prostrata* (L.) Blume)	23.89	9.82	-	33.71
	Betel (*Piper betle* L.)	2.14	11.66	-	13.80
	Spreading dayflower (*Commelina diffusa* Burm.f.)	7.06	5.52	-	12.58
	Fiddlehead fern (*Diplazium esculentum (*Retz.) Sw.)	2.49	9.82	-	12.31
Seedling	Coffee (*Coffea robusta* L.Linden)	89.19	77.78	-	166.97
	Kapok (*Ceiba pentandra* (L.) Gaertn.)	8.11	11.11	-	19.22
	Jackfruit (*Artocarpus heterophyllus* Lam.)	2.70	11.11	-	13.81
Sapling	Coffee (*Coffea robusta* L.Linden)	85.19	77.78	-	124.39
	Cocoa (*Theobroma cacao* L.)	5.99	16.39	-	22.39
	Durian (*Durio zibethinus* Murray)	0.75	18.03	-	18.79
	Avocado (*Persea americana* Mill.)	0.22	4.92	-	5.14
	Jackfruit (*Artocarpus heterophyllus* Lam.)	0.13	4.92	-	5.05
Pole	Durian (*Durio zibethinus* Murray)	26.90	30.00	33.45	90.34
	Cocoa (*Theobroma cacao* L.)	25.52	8.00	21.87	55.39
	Avocado (*Persea americana* Mill.)	8.28	16.00	10.55	34.82
	Coffee (*Coffea robusta* L.Linden)	5.52	8.00	4.28	17.80
	Jackfruit (*Artocarpus heterophyllus* Lam.)	2.76	6.00	4.47	13.23
Tree	Durian (*Durio zibethinus* Murray)	33.33	20.91	14.30	68.54
	Dadap (*Erythrina variegata* L.)	13.65	11.82	19.60	45.08
	Kapok (*Ceiba pentandra* (L.) Gaertn.)	7.63	10.00	19.32	36.95
	Sengon (*Falcataria falcata* (L.) Greuter & R.Rankin)	4.82	3.64	13.08	21.53
	Jackfruit (*Artocarpus heterophyllus* Lam.)	6.43	10.00	3.71	20.14

Notes: RD: Relative density; RF: Relative frequency; RDm: Relative dominance; IVI: Importance Value Index. [a] is not included in the tree growth rate. (-): Not calculated

Table 4. Values of H', Dmg, E, and C at each growth stage

Growth rate	The value of each index			
	Diversity index (H')	Richness index (Dmg)	Evenness index (E)	Dominance index (C)
Undergrowth[a]	1.69 (Sd)	4.53 (Ti)	0.47	0.33
Seedling	0.40 (Rd)	0.55 (Rd)	0.37	0.80
Sapling	0.58 (Rd)	1.69 (Rd)	0.74	0.23
Pole	1.97 (Sd)	3.01 (Ti)	0.71	0.19
Tree	2.29 (Sd)	3.26 (Ti)	0.78	0.16

Notes: [a] is not included in the tree growth rate. Ti: High; Sd: Medium; Rd: Low

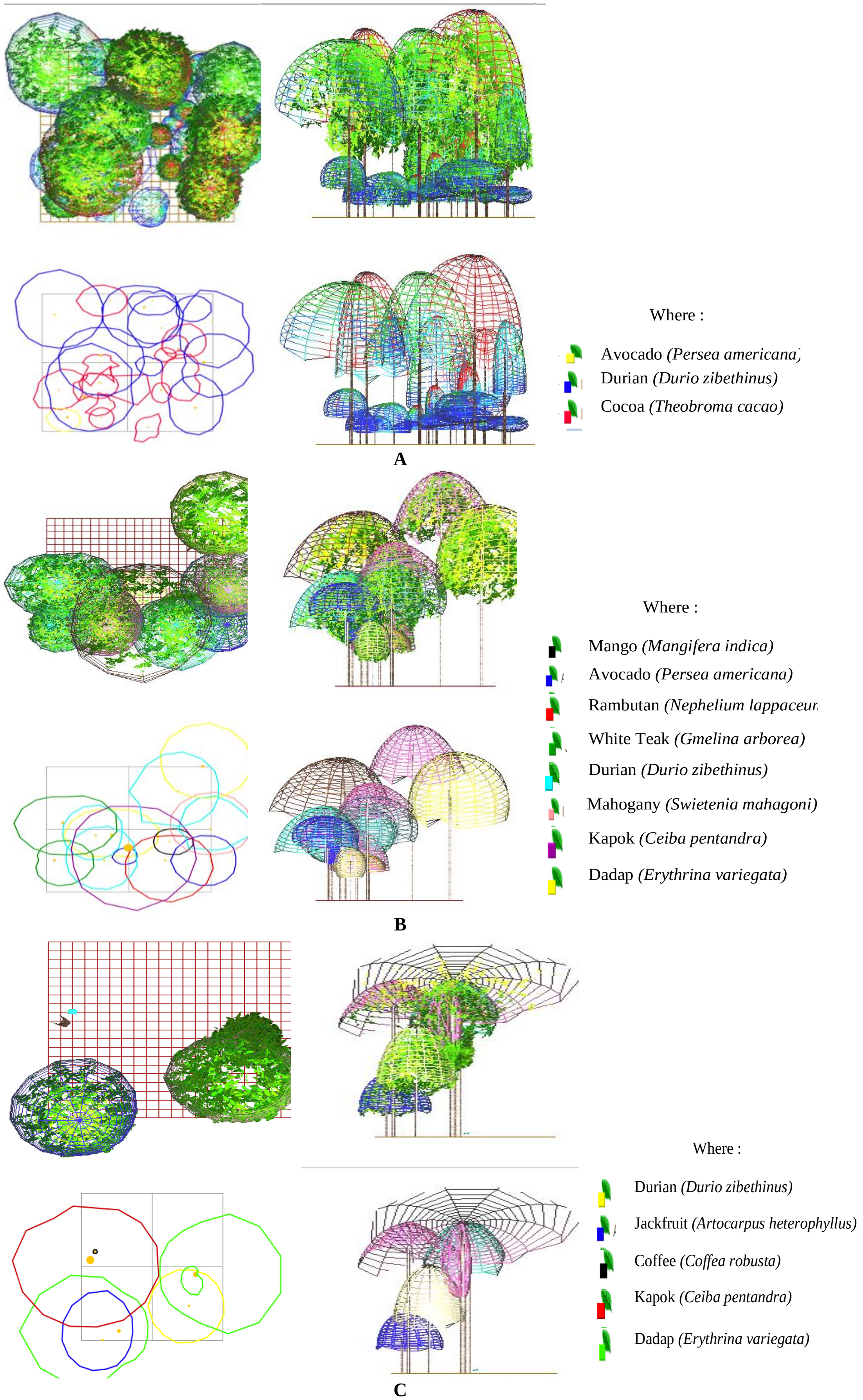

Figure 3. Visualization of horizontal and vertical structures based on levels A. High; B. Medium; C. Low

In stratum A, the dominant species include *kapok* (*C. pentandra*) and dadap (*E. variegata*), reaching heights of 36 to 38 meters. Stratum B primarily consists of vegetation at the tree level, with some at the pole level, including durian (*D. zibethinus*), *kapok* (*C. pentandra*), *sengon buto* (*Enterolobium cyclocarpum* (Jacq.) Griseb.), *dadap* (*E. variegata*), white teak (*Gmelina arborea* Roxb. ex Sm.), *sengon* (*F. falcata*), and jackfruit (*A. heterophyllus*), with heights ranging from 20 to 30 meters.

Stratum C and D are predominantly characterized by vegetation at the pole and sapling levels, including durian (*D. zibethinus*), rambutan (*Nephelium lappaceum* L.), coffee (*C. robusta*), cocoa (*Theobroma cacao* L.), avocado (*P. americana*), and longan (*Dimocarpus longan* Lour.).

The horizontal structure curve of the vegetation does not form an inverted "J" shape, which is attributed to community activities in the area (Figure 4).

Estimation of forest biomass and carbon

The measurement of aboveground biomass was determined using the allometric equation (Biadgligne et al. 2022). Carbon calculations were subsequently performed based on the biomass estimates obtained from this equation. The total carbon across all levels (trees, poles, saplings, seedlings, undergrowth, and litter) amounted to 107.22 tons per hectare, with a total biomass of 228.35 tons per hectare, as detailed in Table 5.

At the tree level, the total carbon was 10.05 tons per hectare, with a corresponding biomass of 21.59 tons per hectare. The dominant species at this level included sengon buto (*E. cyclocarpum*), avocado (*P. americana*), kapok (*C. pentandra*), waru (*H. tiliaceus*), durian (*D. zibethinus*), and white teak (*G. arborea*).

Table 5. Total amount of biomass and carbon at growth level

Growth rate	Biomass (Tons/ha)	Carbon (Tons/ha)
Litter[a]	0.66	0.31
Undergrowth and seedlings[a]	0.49	0.23
Sapling	161.03	75.68
Pole	44.58	20.95
Tree	21.59	10.05
Total (Tons/ha)	228.35	107.22

Notes: [a] : Not included in the tree growth rate.

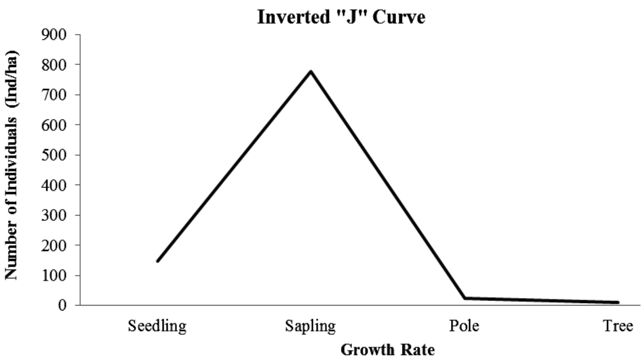

Figure 4. Individual trees with their regeneration

At the pole level, the total carbon was 20.95 tons per hectare, with a biomass of 44.58 tons per hectare, including species such as avocado (*P. americana*), durian (*D. zibethinus*), and jackfruit (*A. heterophyllus*).

The sapling level had a total carbon value of 75.68 tons per hectare, with a biomass of 161.03 tons per hectare, predominantly consisting of coffee (*C. robusta*).

The total carbon values for undergrowth and seedlings were 0.23 tons per hectare with a biomass of 0.49 tons per hectare. For litter, the total carbon value was 0.31 tons per hectare, with a biomass of 0.66 tons per hectare.

Discussion

The plant species composition provided a detailed overview of the dominant vegetation types at the research location. Agroforestry components in the HKm Wana Lestari area consist of forestry plants, multipurpose tree species (MPTs), and agricultural/plantation plants. The local community followed an irregular planting pattern without consistent spacing. This research indicates that the agroforestry-based community forests are relatively densely populated. Farmers do not practice intensive care, leading to fields filled with various planted and naturally growing trees. The species composition results (Table 2) show that the undergrowth level had the highest species count, followed by trees, poles, and saplings.

The total number of species in this study was fewer compared to Wiryono et al. (2016), who identified 101 plant species (including 38 tree species with a diameter >10 cm) in Dusun II Harapan Makmur Village. In contrast, Darmawati et al. (2021) found 33 tree species at the Bina Widya UNRI Campus. Similarly, Evizal et al. (2016) reported 36 shade tree species in the Sumberjaya coffee plantation. Differences in species count and individual distribution across levels are likely related to habitat conditions.

The importance value index (IVI) highlights dominant species based on relative density, frequency, and dominance (Table 3). Species with the highest IVI are considered ecologically dominant, playing a significant role in their ecosystem (Darmawati et al. 2021). Durian (*D. zibethinus*), coffee (*C. robusta*), and swamp millet (*I. globosa*) showed the highest IVI at tree, pole, sapling, seedling, and undergrowth levels. These species are highly adaptable, with significant influence on forest structure and habitat.

The species diversity index (H') across growth levels ranged from low to medium (0.37-2.29), with the tree level showing the highest H' value of 2.29 (medium category), while the sapling and seedling levels had the lowest at 0.58 and 0.40, respectively. The results are consistent with Darmawati et al. (2021), where H' values ranged from 0 to 2.34 (low to medium). A higher species diversity index reflects greater ecosystem stability, with more species contributing to resilience. The Shannon-Wiener index increases with species richness and evenness (Susilowati et al. 2020).

Species richness, defined as the absolute number of species in a given population, was highest at the undergrowth, tree, and pole stages in this study. Larger numbers of species but fewer individuals lead to higher richness index values (Susilowati et al. 2020). The species evenness index (E) and Simpson's dominance index (C) range from 0 to 1. Relatively even species distributions were found at the pole and stake levels, while sapling levels had species dominance.

According to Hidayat (2014), an inverted "J" curve, commonly observed in tropical rainforests, suggests effective tree regeneration. However, variations in species dominance and natural selection can limit the survival of individuals in certain diameter classes. The success of vegetation in a particular area depends on physical, biotic, and chemical environmental factors (Krebs 1994; Darmawati et al. 2021). Species' relative dominance is influenced by density and diameter (Darmawati et al. 2021).

Forest management contributes to increased carbon sequestration, influencing carbon changes in forest ecosystems (Karki et al. 2016). Tropical forests act as major carbon sinks, storing up to 40% of global carbon stocks compared to other ecosystems (Maxwell et al. 2019; Pratiwi et al. 2022). Biomass estimation provides insights into carbon content in vegetation, with higher-density trees contributing to greater biomass and carbon stocks (Nur et al. 2022). This study showed a total carbon value of 107.22 tons per hectare and a biomass value of 228.35 tons per hectare (Table 5), higher than agroforestry system study area of Santhyami et al. (2018) in West Sumatra.

Carbon stock varies across ecosystems and species due to factors such as tree height, diameter, and wood-specific gravity (Joshi et al. 2023). Species diversity and carbon stock are interconnected, reflecting that carbon management and biodiversity conservation can occur simultaneously (Assaye and Asrat 2016). Agroforestry systems may offer advantages over natural forests in carbon sequestration due to easier establishment and enforcement of property rights (Santhyami et al. 2018).

Data on species composition, stand structure, and carbon stock can support forest management in the Wana Lestari Karang Sidemen Community Forest (HKm). These insights are crucial for conservation planning, monitoring forest health, assessing carbon storage for climate change mitigation, and developing sustainable management strategies. In conclusion, HKm Wana Lestari contains 63 plant species with 12631 individuals per hectare. Coffee (*C. robusta*) dominates, while bayur (*P. javanicum*), durian (*D. zibethinus*), cocoa (*T. cacao*), and waru (*H. tiliaceus*) are abundant. The diversity index (H') ranges from 0.40 to 2.29 (moderate), and the stand structure comprises four canopy strata (A, B, C, and D) without an inverted "J" curve. Total carbon reserves are 107.22 tons per hectare, with a biomass of 228.35 tons per hectare, indicating potential for climate change mitigation through increased carbon stocks.

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