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Composition, Structure, and Carbon Stock of Tree in the System: Teak-Based Agroforestry in Gemawang Wonogiri Village

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Abstract

Background: The teak-based agroforestry system in Gemawang Wonogiri Village has the potential for various types of constituent tree vegetation that can act as carbon stock stores. This research was conducted considering the limited research on teak-based agroforestry systems, especially in the Wonogiri area. This study aims to provide information on tree vegetation's composition, structure, and diversity and determine the potential carbon stocks of tree vegetation standing in teak-based agroforestry systems. **Methods:** The research method used a 20 x 20 m^2 plot of 1 ha, and the plots were placed using a *purposive sampling approach.* **Results:** Found nine species of tree vegetation from 8 families with 271 individuals ha^{-1}. The species of teak tree *(Tectona grandis)* has the highest INP of 81.56 %. The Diversity Index is moderate, with a value of 1.79, and the Dominance Index is low at 0.21. The amount of carbon stored in tree stands is 45.71 MgC ha^{-1}. **Conclusions:** This research can give information and points of reference about the structure and composition of stands in agroforestry systems and their potential to store carbon stocks. The research data is useful for the community as a source of information regarding the condition of the agroforestry area in Gemawang Village so that they can make optimal use of the area by developing suitable vegetation.

Keywords: Agroforestry; Carbon; Diversity; Trees

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Introduction

Currently, the problem for people in areas close to forests is converting forest land into agricultural areas. Forest areas are maintained as soil protectors from erosion and as forest cover, which acts as an absorber of carbon dioxide. The conversion of forest functions to non-forest areas causes the loss of tree vegetation, which impacts soil stability due to erosion (Bella & Rahayu, 2021). Many forest land uses are currently developed through agroforestry systems to use land sustainably and increase ecological carrying capacity (Fitri et al., 2018). Agroforestry uses land by combining crops and trees integrated with one area.

Vegetation undergoes the process of photosynthesis to produce carbon reserves. The carbon stock in vegetation is about 47 % of the vegetation biomass. Tree biomass is calculated by calculating the wood's specific gravity and the trunk's diameter at breast height or 1.3 meters above ground level (Susila & Apriliani, 2019). Tree vegetation has a long life cycle and can store the highest carbon reserves (Maryadi & Linda, 2019). There are two types of agroforestry, namely simple agroforestry and complex agroforestry. Simple agroforestry comprises seasonal crops such as corn, papaya, and banana and forest plants such as teak or coconut. At the same time, complex agroforestry uses a fairly large area of land, namely 0.5 ha to 1 ha, with the constituent components of palawija, mango,

cocoa, and teak trees. Teak (*Tectona grandis*) is one of the tree species that make up the agroforestry system. Teaks can survive in both humid and dry conditions. Generally, teak trees reach a height of 9 to 11 meters (Husein et al., 2022). Most teak trees are developed in tropical climate forests with rainfall of 1200 to 1300 mm/year and humidity of 60 % to 80 % (Jannah et al., 2022). Teak is a commercial plant because the wood has a high selling value and is included in the durable and robust class II woods (Rahmawati et al., 2019).

One of the plantations that apply the agroforestry pattern is a plantation located in Gemawang Village, Ngadirojo District, Wonogiri Regency. The community utilizes the land by planting cashew trees with other vegetation, especially tree vegetation with a diameter of more than 20 cm, such as teak, cocoa, mahogany, and jackfruit. The agroforestry system is managed to improve people's welfare, especially in areas around forests, by paying attention to preserving natural resources (Agu et al., 2022). Vegetation has a significant influence on the environment, including playing a role in supplying organic matter, N fixation, improving soil physical properties, improving soil biological processes, and acting as a store of carbon reserves (Evizal et al., 2012).

Many studies have examined agroforestry systems, one of which compared carbon stocks for cocoa rubber, cocoa-multistate, cocoa-coconut, and cocoa grown in monoculture. The results showed that most carbon-absorbing vegetation was non-cocoa, 86-96 % (Santhyami et al., 2018). Other studies also compared carbon stocks in agroforestry, primary, and secondary forests. The total carbon storage in the woods is 1,869.73 kg ha^{-1}, 2,618.32 kg ha^{-1}, and 1,460.91 kg ha^{-1}. The amount of carbon storage is affected by the density and diameter of the constituent trees (Luth & Setiyono, 2019).

Gemawang Village has large plantations with many different plants set up in an agroforestry system. But there isn't a lot of research on how these agroforestry systems store carbon or how many different kinds of plants they have. This study aims to provide information on the composition, structure, and diversity of tree vegetation making up teak-based agroforestry systems and to determine the potential of standing carbon stocks of tree vegetation in teak-based agroforestry systems. The research results are expected to be helpful and provide information about tree vegetation and the potential for carbon storage in agroforestry systems for readers and the surrounding community to optimize their management.

Methods

Time and Place and Research

This research was conducted for four months, from December 2022 to March 2023. The research location was in Gemawang Village, Ngadirojo District, Wonogiri Regency, Central Java, which is located at coordinates 70° 32' – 80° 15' South Latitude and 1100° 41' – 1110° 18' East Longitude. The topographical condition of Gemawang Village is limestone hills, where most of the land is dry, covering an area of 9,325.556 ha. The research location is located on a teak-based agroforestry plantation in Gemawang Village (Figure 1).

Tools and materials

The tool used in this research is GPS Essentials to get plot coordinates—a thermohygrometer and soil tester to measure abiotic factors. Roll a meter to measure the circumference of a tree as high as DBH (1.3 m). The materials used in this study were tree vegetation in the agroforestry system in Gemawang Village.

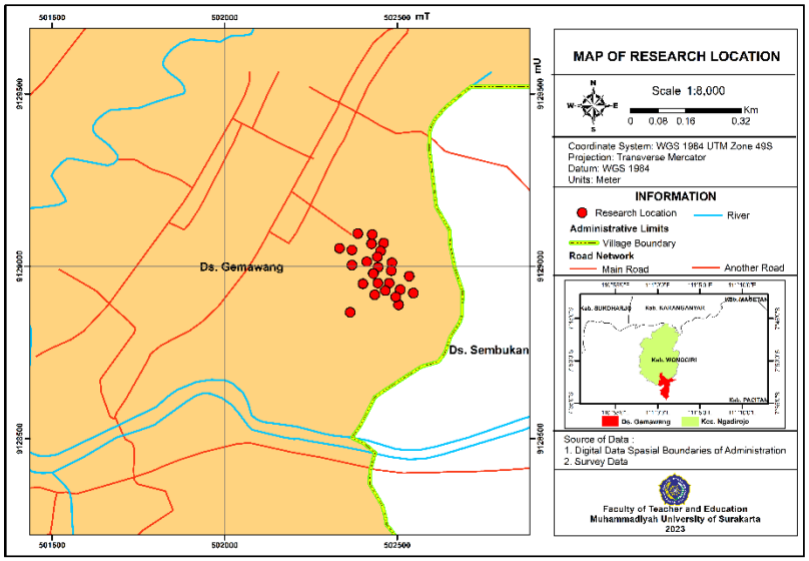

Figure 1. Research location

Data Collection

This research is a type of quantitative research based on measurement results (Djaali, 2020). The technique used is a survey by looking at the study site's physical conditions, including the existing tree vegetation, to determine the structure and composition of tree vegetation species. The data in this study are primary and secondary. Preliminary data include species names and abiotic factors such as temperature, humidity, soil pH, and soil moisture. Secondary data consists of vegetation analysis to determine the structure and composition of tree vegetation and estimate carbon stocks using allometric formulas.

Research Procedure

The first step to collecting information on temperature, air humidity, soil pH, and soil moisture is to measure abiotic factors. The next stage is the experimental method to determine the research plots, and the placement of the fields is carried out using the purposive sampling method. Determining plot area using the *species-area curve* method with an initial lot measuring 20 x 20 m2 for tree stands (Sufyan, 2018). The initial plot area was 400 $m^{2,}$ and the type of tree vegetation found was recorded, then the room was doubled to 800 $m^{2,}$ and the second area was doubled until no new species were added (Solihat, 2022). Community forests managed in agroforestry have a minimum size of 0.25 ha (Widayanti et al., 2020). So in this study, we used an agroforestry system on land with a minimum area of 0.25 ha to achieve a maximum size of 1 ha and a total of 25 research plots.

Data Analysis

The Important Value Index (INP) comes from relative density (KR), relative frequency (FR), and relative dominance (DR) (Kusmana, 2017). The Dominance Index (D) is based on the Simpson index, and the Diversity Index (H') uses Shannon-Wiener (Odum, 1993). The amount of biomass is based on the specific gravity of the wood taken from *db.worldagroforestry.org (Wood Density Database),* and potential carbon stocks in standing stands were calculated using the Allometric Ketterings equation (Ketterings et al., 2001)

Result

Structure and Composition Vegetation

Based on observations of environmental conditions in a teak-based agroforestry system in Gemawang Village in December 2022.

Table 1. Abiotic Factors in Teak-Based Agroforestry System

No	Parameter	∑ Average
1	Temperature	27.1 °C
2	Humidity air	77 %
3	Humidity of soil	50 %
4	Soil pH	5.5

In the teak-based agroforestry system in Gemawang Village, nine types of tree-level vegetation were found in the study plots.

Table 2. Analysis of Vegetation in Teak-Based Agroforestry System

No	Family	Species	KR	FR	DR	INP
1	Lamiaceae	*Tectona grandis*	28.78	23.08	29.70	81.56
2	Anacardiaceae	*Anacardium occidentale*	30.63	17.95	27.55	76.13
3	Sterculiaceae	*Theobroma cacao*	13.65	10.26	11.14	35.05
4	Leguminose	*Albizia chinensis*	9.59	11.54	10.66	31.80
5	Moraceae	*Artocarpus heterophyllus*	5.90	12.82	9.20	27.92
6	Meliaceae	*Swietenia macrophylla*	3.32	7.69	4.04	15.05
7	Fabaceae	*Leucaena leucocephala*	2.95	7.69	3.37	14.01
8	Fabaceae	*Gliricidia sepium*	2.95	5.13	2.32	10.40
9	Arecaceae	*Cocos nucifera*	2.21	3.85	2.02	8.08
Total			100	100	100	300

Based on the Important Value Index (INP), *Tectona grandis* has the highest value, 81.56 %. So, the tree vegetation is the most dominant type at the study site.

Tree Vegetation Diversity

Vegetasi, The most common tree vegetation in each study plot, was teak (*Tectona grandis*), and the rarest tree vegetation in the study plots was coconut (*Cocos nucifera*) and other tree vegetation.

Table 3. Diversity and Dominance in Teak-Based Agroforestry System

No	Species	Total	H'	D
1	*Tectona grandis*	78	0.36	0.0828
2	*Anacardium occidentale*	83	0.36	0.0938
3	*Theobroma cacao*	37	0.27	0.0186
4	*Albizia chinensis*	26	0.22	0.0092
5	*Artocarpus heterophyllus*	16	0.17	0.0035
6	*Swietenia macrophylla*	9	0.11	0.0011
7	*Leucaena leucocephala*	8	0.10	0.0009
8	*Gliricidia sepium*	8	0.10	0.0009
9	*Cocos nucifera*	6	0.08	0.0005
Total		271	1.79	0.2113

The Diversity Index was obtained with a value of 1.79, which indicated a moderate level of species diversity, and a Dominance Index of 0.2113, which indicated a low level of species abundance.

Potential Carbon Stocks of Tree Vegetation

The calculation of carbon stock for each type of tree vegetation in a teak-based agroforestry system is presented in Table 4.

Table 4. Biomass and Carbon Stock in Teak-Based Agroforestry System

Species	Total Biomass		Jumlah Stok Karbon	
	Average (Tons Ind^{-1})	Biomassa Area^{-1} (Tons ha^{-1})	Average (MgC Ind^{-1})	Carbon Area^{-1} (MgC ha^{-1})
Tectona grandis	0.45	34.95	0.21	16.08
Anacardium occidentale	0.28	22.99	0.13	10.57
Artocarpus heterophyllus	0.67	10.72	0.31	4.93
Albizia chinensis	0.34	8.95	0.16	4.12
Theobroma cacao	0.22	8.31	0.10	3.82
Swietenia macrophylla	0.49	4.37	0.22	2.01
Albizia chinensis	0.34	8.95	0.16	4.12
Leucaena leucocephala	0.53	4.26	0.24	1.96
Gliricidia sepium	0.35	2.77	0.16	1.27
Cocos nucifera	0.41	2.28	018	0.95
Total	3.74	99.6	1.71	45.71

The amount of biomass in a teak-based agroforestry system covering an area of 1 ha is 99.6 tons ha^{-1}, while the amount of carbon stock is 45.71 MgC ha^{-1}.

Discussion

The results of the research show that there are nine types of tree vegetation from 8 families, including cashew (*Anacardium occidentale*), teak (*Tectona grandis*), jackfruit (*Artocarpus heterophyllus*), cocoa (*Theobroma cacao*), mahogany (*Swietenia macrophylla*), sengon (*Albizia chinensis*), lamtoro (*Leucaena leucocephala*), gamal (*Gliricidia sepium*), and coconut (*Cocos nucifera*). The species *Tectona grandis* has the highest Importance Value Index (INP) value of 81.56 %, followed by *Anacardium occidentale* with a value of 76.13 %. This shows that the species with the highest INP are the most influential in a community (Basrowi et al., 2018). She was supported by the opinion (Sosilawaty, 2020), which states that plants with the highest index are plant species that are most dominant and have a high level of dominance in a community. Although the number of *Anacardium occidentale* species was higher than that of *Tectona grandis*, the INP of *Tectona grandis* was higher because *Tectona grandis* vegetation dominated the study plots. Based on (Hidayat, 2018), species with a higher abundance than other species are caused by these species being dominant at the research station and spreading across all stations.

The dominance index value in this teak-based agroforestry system is 0.21, so the dominance index is in the low category. The species with the highest dominance index is *Anacardium occidentale*. This can be influenced by environmental conditions that support *Anacardium occidentale* growth (Suhadi, 2007). This is by the environmental conditions in the study area, where the abiotic factor has been measured in Table 1, namely the air temperature of 27.1^{o}C. The dominance index in the low category shows that the diversity of species occupying this habitat has a balanced opportunity to maintain species growth and remain sustainable (Febriana et al., 2022). Table 1 shows measurements of environmental conditions in a teak-based agroforestry system in Gemawang Village. Based on the measurements in this area, the pH is 5.5, which indicates the soil conditions tend to be acidic. This soil condition is suitable for tree vegetation that has adaptability or can adapt to environmental needs, such as the *Tectona grandis* species. Areas, where Tectona grandis grows generally have soil with a medium texture and a pH of 4.5 - 6.5 (Amalia et al., 2022).

The physiological processes of individuals in a community are influenced by surrounding factors such as environmental factors, both physical and chemical. Different temperatures affect each vegetation's growth because of the various stages of development in each vegetation as needed, so it can't determine the optimum temperature (Arisandy &

Triyanti, 2020). Air humidity in the research area is 77 %, while soil moisture is 50 %. Research (Pratama et al., 2021) states that air humidity for vegetation growth is between 70-90 %, and the optimum soil moisture suitable for vegetation growth is 50-80 %. Based on this, the environmental conditions in the teak-based agroforestry system in Gemawang Village are ideal for growing the constituent vegetation in the agroforestry system. *Anacardium occidentale* is suitable to develop in areas with an air humidity of 70-80 % and has a humidity tolerance of 60-70 % (Saragih & Yadi, 1994).

While the calculation of the diversity index Shanon-Wiener (H') shows a level of species diversity of 1.79, based on Table 3, the level of species diversity in this teak-based agroforestry system is included in the medium category, which is between 1<H>3. The medium type indicates that the growth of tree vegetation in this agroforestry area is heading to a sound stage. Species diversity in a community is a parameter to determine whether a species can maintain its stability against disturbances in that habitat (Doudi et al., 2020). This is supported by research (Santhyami et al., 2020), which states that the cocoa-coconut agroforestry system in Pariaman, West Sumatra, has a medium category diversity index of 1.02.

Table 4 shows the biomass and carbon stock amount using the allometric Ketterings formula for estimating carbon in branched tree stands. The calculation results show that the amount of biomass per area is 99.6 tons ha^{-1} with a total average of 3.74 tons $individual^{-1}$. Meanwhile, the amount of carbon stored per area is 45.71 MgC ha^{-1} with an average total of 1.71 MgC $individual^{-1}$. In the agroforestry area of 1 ha in Gemawang Village, the largest carbon stock storage tree is Tectona grandis, with a total biomass per area of 34.95 tons $ha^{-1,}$ and the amount of carbon stored is 16.08 MgC ha^{-1}. The amount of biomass and carbon stock in different stands can be affected by the presence of different tree species. In addition, it is influenced by various factors such as stem diameter, density, and diversity of tree vegetation types (Istiqomah et al., 2022). The various types of tree vegetation in agroforestry systems produce relatively larger carbon stocks than areas with similar vegetation or monocultures. The amount of carbon stored depends on the ability of vegetation to absorb CO^2 in the environment through photosynthesis. This research is by (Santhyami et al., 2018), who compared carbon storage in cocoa-rubber, cocoa-multi-strata agroforestry, cocoa-coconut, and monoculture cocoa. The highest carbon storage in cocoa-coconut agroforestry was 103.42 MgC ha^{-1}, while the lowest was in cocoa grown in monoculture, 10 MgC ha^{-1}.

This research can provide information about the structure, composition, and potential of stands in agroforestry systems to store carbon stocks. Besides that, it can be used as a reference in ecology and environmental research. The information contained therein regarding ecological conditions in teak-based agroforestry systems is beneficial for the community to optimally utilize the area by considering ecological conditions and suitable vegetation to develop in the area so that can manage the land in the agroforestry system in Gemawang Village and provide sustainable benefits. Further research is needed regarding the structure and composition of the agroforestry system's sapling, seedling, and sapling levels based on teak in Gemawang Village.

Conclusions

Based on research that has been conducted on teak-based agroforestry systems in Gemawang Wonogiri Village, the environmental conditions in the area are classified as suitable for its constituent vegetation, such as cashew (*Anacardium occidentale*), teak (*Tectona grandis*), jackfruit (*Artocarpus heterophyllus*), cocoa (*Theobroma cacao*), mahogany (*Swietenia macrophylla*), sengon (*Albizia chinensis*), lamtoro (*Leucaena leucocephala*), gamal (*Gliricidia sepium*), and coconut (*Cocos nucifera*). The species diversity index was moderate at 1.79 with a low dominance of 0.21. The species *Tectona grandis* has the highest Importance Value Index (81.56 %). The amount of carbon stock stored in this agroforestry system is 45.71 MgC $ha^{-1,}$ with the *Tectona grandis* species having the highest reserve storage of other constituent vegetation, 16.08 MgC ha^{-1}.

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Declaration statement

The authors reported no potential conflict of interest.

References

Agu, Y. P. E. S., Pareira, M. S., & Boybana, K. M. (2022). IDENTIFIKASI MODEL AGROFORESTRI TRADISIONAL PADA WILAYAH DATARAN RENDAH KABUPATEN TIMOR TENGAH UTARA. *Jurnal Pertanian Agros*, *24*(2).

Amalia, E. R., Setyaningsih, L., & Meiganati, K. B. (2022). STRUKTUR, KOMPOSISI DAN POTENSI KAYU DI HUTAN RAKYAT DESA KATONGAN (STUDI KASUS: DI DESA KATONGAN, KECAMATAN NGLIPAR, KABUPATEN GUNUNG KIDUL, YOGYAKARTA). *In Conference on Innovation and Application of Science and Technology (CIASTECH)*, *5*(1).

Arisandy, D. A., & Triyanti, M. (2020). Keanekaragaman Jenis Vegetasi di Bukit Cogong Kabupaten Musi Rawas. *BIOEDUSAINS:Jurnal Pendidikan Biologi Dan Sains*, *3*(1), 40–49.https:/doi.org/10.31539/bioedusains.v3i1.1241

Basrowi, M., Hendra, M., & Hariani, N. (2018). KOMPOSISI DAN STRUKTUR POHON RIPARIAN DI SUNGAI KAHALA KABUPATEN KUTAI KARTANEGARA. *Jurnal Pro-Life*, *5*(3).

Bella, H. M., & Rahayu, S. (2021). Forest land-use changes to farmland in Berawang Village, Ketol Subdistrict, Aceh Tengah District. *Pros. SemNas. Peningkatan Mutu Pendidikan*, *2*(1), 88–91.

Djaali. (2020). *Metodologi Penelitian Kuantitatif*. Bumi Aksara.

Doudi, M., Rasnovi, S., & Dahlan, D. (2020). Keanekaragaman Vegetasi Di Kawasan Geotermal Gunung Seulawah Agam Kabupaten Aceh Besar. *Prosiding Seminar Nasional Biotik 2020*, 56–60.

Evizal, R., Prijambada, I. D., & Widada, J. (2012). Peranan Pohon Pelindung dalam Menentukan Produktivitas Kopi. *Jurnal Agrotopika*, *17*(2), 19–23.

Febriana, Dewantara, I., & Latifah, S. (2022). KEANEKARAGAMAN JENIS POHON DI HUTAN TEMBAWANG DUSUN TAHAJIAN DESA GOMBANG KECAMATAN SENGAH TEMILA KABUPATEN LANDAK. *Jurnal Hutan Lestari*, *10*(1).

Fitri, R., Tarigan, S. D., Sitorus, S. R. P., & Rachman, L. M. (2018). Perencanaan Penggunaan Lahan Untuk Pengembangan Agroforestri Di Das Ciliwung Hulu Provinsi Jawa Barat. *Tataloka*, *20*(2), 148. https://doi.org/10.14710/tataloka.20.2.148-159

Hidayat, M. (2018). Analisis Vegetasi Dan Keanekaragaman Tumbuhan Di Kawasan Manifestasi Geotermal Ie Suum Kecamatan Mesjid Raya Kabupaten Aceh Besar. *BIOTIK: Jurnal Ilmiah Biologi Teknologi Dan Kependidikan*, *5*(2), 114. https://doi.org/10.22373/biotik.v5i2.3019

Husein, N., Hastuti, N. R., & Budi, A. S. (2022). Karakteristik Sifat Fisik dan Anatomi Kayu Jati yang Tumbuh di Kalimantan Timur. *Jurnal Pendidikan Dan Konseling*, *4*(5).

Istiqomah, L., Laili, S., & Zayadi, H. (2022). Estimasi Karbon pada Tegakan Varietas Kopi Arabika (Coffea arabica) Di Lahan Agroforestri Precet Wilayah Resort Pemangkuan Hutan Wagir KPH Malang. *Jurnal Ilmiah SAINS ALAMI (Known Nature)*, *5*(1).

Jannah, I. A., Woesono, H. B., & Suhartati, T. (2022). Pendugaan Cadangan Karbon Diatas Permukaan Tanah pada Tegakan Jati (Tectona grandis) di KPH Yogyakarta BDH Paliyan RPH Menggoro. *Jurnal Kehutanan Papuasia*, *8*(1), 125–129.

Ketterings, Q., Coe, R., Noordwijk, M. Van, Ambagau, Y., & Plam, C. (2001). Reducing Uncertain In The Use of Allometric Biomass Equation For Predicting Above Ground Tree Biomass in Mixed Secondary Forest. *Forest Ecology and Management*, *146*(1–3), 199–209.

Kusmana, C. (2017). *Metode Survey dan Interpretasi Data Vegetasi*. IPB Press.

Luth, F., & Setiyono, H. (2019). Kemampuan Agroforestri Berbasis Kopi (Coffea arabica) dalam Menyimpan Cadangan Karbon. *Jurnal Ilmiah Pertanian*, *7*(1).

Maryadi, A., & Linda, R. (2019). *DAN CADANGAN KARBON DI BEBERAPA TAMAN Waktu dan Tempat*. *8*, 73–80.

Odum, E. (1993). *Dasar-dasar Ekologi Edisi 3*. Gadjah Mada University Press.

Pratama, R., Jumari, J., & Utami, S. (2021). Komposisi dan Struktur Vegetasi Riparian Strata Pohon di Kawasan Wana Wisata Curug Semirang, Ungaran, Semarang, Jawa Tengah. *Bioma : Berkala Ilmiah Biologi*, *23*(2), 112–118.

https://doi.org/10.14710/bioma.23.2.112-118

Rahmawati, Nugroho, Y., & Prihatiningtyas, E. (2019). Identifikasi Kesehatan Tanaman Jati (Tectona Grandis Linn. F) di Kabupaten Banjar Kalimantan Selatan. *Jurnal Sylva Scienteae*, *02*(5), 949–956.

Santhyami, Basukriadi, A., Patria, M. P., & Abdulhadi, R. (2018). The comparison of aboveground C-stock between cocoa-based agroforestry system and cocoa monoculture practice in West Sumatra, Indonesia. *Biodiversitas*, *19*(2), 472–479. https://doi.org/10.13057/biodiv/d190214

Santhyami, Basukriadi, A., Patria, M. P., & Abdulhadi, R. (2020). TREE COMMUNITY COMPOSITION AND STRUCTURE OF CACAO (THEOBROMA CACAO L.) BASED AGROFORESTRY IN WEST SUMATERA, INDONESIA. *Bioeksperimen: Jurnal Penelitian Biologi*, *6*(1).

Saragih, Y. P., & Yadi, H. (1994). *Mete-Budi Daya Jambu Mete, Pengupasan Gelondong*. Penebar Swadaya.

Solihat, R. F. (2022). Analisis Vegetasi Perintis Lokal Di Lahan Bekas Tambang Pasir Kecamatan Cimalaka Kabupaten Sumedang. *Jurnal Belantara*, *5*(1), 34–44. https://doi.org/10.29303/jbl.v5i1.483

Sosilawaty. (2020). *Keanekaragaman Vegetasi Hutan dan Dinamika Hara di Ekosistem Daerah Aliran Sungai* (R. M. S. Putra (ed.)).

Sufyan, F. (2018). Analisis Vegetasi Tumbuhan Pantai Pada Kawasan Pariwisata Dan Nonpariwisata Di Pesisir Pantai Slopeng Sumenep Sebagai Sumber Belajar Biologi. *Skripsi*, 2018.

Suhadi, O. (2007). *Budi Daya Jambu Mete*. Azka Mulia Media.

Susila, R., & Apriliani, R. N. (2019). PENDUGAAN CADANGAN KARBON DI TAMAN HUTAN RAYA INTEN DEWATA. *Wanamukti*, *22*(2).

Widayanti, E., Bintoro, A., & Duryat. (2020). Struktur dan Komposisi Vegetasi Agroforest Pala (Myristica fragrans) di Kecamatan Sumberejo Kabupaten Tanggamus Lampung. *Jurnal Silvikultur Tropika*, *4*(1), 231.