

# Plant Diversity in Various Agroforestry System Based on Cocoa in Pasaman, West Sumatra

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**Abstract**— In Sumatra, cocoa has been cultivated by small holders in diverse agroforestry systems. But recently, companion shade trees are being removed in hopes of reaching higher cocoa yield. This study tests a hypothesis, that high cocoa productivity is compatible with shade and diversity if farmers apply good cocoa management. The study was conducted throughout 2018 in Sontang village, Pasaman district, West Sumatra. We aimed to compare cocoa yield, tree diversity, and ethnobotanical value in 3 shade management systems (low/medium/high). Twelve 20 x 20 m plots were sampled random ly under each shade, resulting in 36 plots covering 1.44 ha. Plant diversity was measured by species inventories and usefulness was determined based on ethnobotanical interviews. The medium shade also showed the highest crop diversity and highest usefulness. The study concludes that the medium shade harbors suitable level of tree diversity with a positive impact on cocoa yield. We recommend training farmers in cocoa management while sustaining medium shade as a productive, useful and bio diverse system.

**Keywords**— Cocoa, Agroforestry System.

## I. INTRODUCTION

Cacao (*Theobroma cacao* L.) is an estate crop commodity that has been growing rapidly and has an important role in the national economy, especially as a employment provider, the main source of income for the majority of the population in some provinces, as well as the third largest foreign exchange supply after rubber and palm oil. According to Dampa (2003), cocoa is the prior commodity of the estate agency based on the following considerations: a) biologically, cocoa require a shade trees that make them suitable to be developed under other plants, and also make this commodity as a new alternative income for farmers b) economically, cocoa including the commodity that could produces yield in medium term period than others annual crops; c) in terms of price, cocoa bean is one of the most profitable product, d) in the way of cultivation, cocoa doesn't require an appropriate technology on farming practise, so that it would be suitable to be cultivated by smallholder farmers.

Cocoa plantations developed through agroforestry systems and then managed properly will ensure the continuity of the structure and ecological processes in it. Interactions between ecosystem structure allows for a variety of ecological processes, including biomass production and nutrient cycling (nutrient cycle). Cocoa-based agroforestry systems can provide a range of ecosystem services (ecosystem services), among others, contribute to maintaining the organic matter content of the soil, thereby improving soil fertility (Mendez., 2006), minimize erosion, preventing the development of pests and diseases, and reduce the weed population. Mixing plants in a cropping system greatly affect nutrient cycles that occur in an ecosystem.

Based on the above it is necessary to investigate the level of plant diversity contained in the model farm management cocoa agroforestry good (simple shade) and complex (multi-level) that have an impact on the productivity of cocoa compared to systems plantation management in non agroforestry (monoculture)

## II. MATERIAL AND METHOD

This study was performed using comparative survey. Implementation of the survey begins from field observations (cacao agroforestry with various systems), making the coordinates of the garden, the determination of sample plots and observations as well as the selection of the cocoa farmers to be used as subjects in this study. Determination and election observation plots cocoa farmers carried out by random sampling. Observation of the diversity of plants is done by counting all the species of plants and the number of individuals of each species in research plots. To determine the species diversity calculated using diversity index of Shannon-Wiener (Kent and Paddy, 1992; Smith and Wilson, 1996; Spellerberg and Fedor, 2003).

$$H' = - \sum_{i=1}^N (p_i) (\ln p_i)$$

H' = Shannon Wiener Index

N = the total number of species to-i

Pi = The proportion of species to-i

**Kriteria levels of biodiversity are:**

relatively high when  $H > 3.5$ , while if  $H = 1.5$  to  $3.5$  and lower when  $H < 1.5$

### III. DISCUSSION

#### Plant diversity in cacao agroforestry system

Agroforestry is important for the habitat of various species of plants, animals and a variety of beneficial microorganisms, so as to conserve biodiversity in an ecosystem. Agroforestry can increase the biodiversity, in the absence of agroforestry may have a lot of species that are extinct. A landscape dominated by intensive farming still requires the presence of many natural species, especially those related to biodiversity in the soil (Hairiah et al., 2002). In addition, agroforestry can provide a useful

contribution to the economy is agricultural land, as agroforestry can be a useful place to stay, for example pollinators, predators of agricultural pests.

In this study, the diversity of plants is counted in 3 pengelolalao system cocoa plantations, namely cocoa farm run complex agroforestry systems, cacao agroforestry systems managed by simple and cocoa plantations managed by non-agroforestry system. The diversity of crops is calculated with an inventory of all kinds of useful plants that exist in the cocoa farm then also calculated the index of diversity and species richness index, in order to know the level of diversity of each cocoa farm management systems.

Table 1. Diversity of species of plants in various cocoa farm management system

#### a. Plant diversity in general

No.	Local name	Latin name	Plot Type		
			AF.Komplek	AF.Sederhana	Non.AF
1	areca nut	<i>Areca cathecu L.</i>	34	10	8
2	Rubber	<i>haveabrasiliensis</i>	25	11	0
3	tuba root	<i>Derris elliptica.</i>	4	0	8
4	Chili	<i>Frustences Capsicum L.</i>	48	108	67
5	petai	<i>Parkiaspeciosa</i>	2	2	0
6	betel Forest	<i>Piper aduncum L.</i>	1	2	2
8	Papaya	<i>Carica papaya L.</i>	14	11	21
9	Langsat	<i>Lansiumdomesticum</i>	8	3	0
10	Durian	<i>Duriozibethinus</i>	17	9	3
11	Lime	<i>Citrus aurantifolia</i>	4	0	0
12	Avocado	<i>Perseaamericana</i>	3	6	0
13	Ginger	<i>Zingiberofficinale</i>	5	3	2
14	Banana	<i>Musa paradisiaca</i>	55	76	26
15	JambuBol	<i>Syzygiummalaccense L</i>	3	0	0
16	acid Sundai	<i>Citrus hystrix</i>	1	0	0
17	Turmeric	<i>Curcuma longa L.</i>	12	0	0
18	Mango	<i>Mangiferaindica L.</i>	1	1	0
19	Gliricidia	<i>Gliricidiasepium</i>	10	12	4
20	Sijungkat	<i>Lactuca sativa</i>	6	58	5
21	Rice-rice	<i>Sauropusandrogynus</i>	17	21	4
22	Ranti	<i>Solanumamericanum</i>	1	1	6
23	jengkol	<i>Archidendronpauciflorum</i>	2	1	0
24	Coffee	<i>Coffearobusta</i>	5	2	6
25	Sweet shoots	<i>Manihot esculenta</i>	53	69	4

No.	Local name	Latin name	Plot Type		
			AF.Komplek	AF.Sederhana	Non.AF
26	Rimbang	<i>Solanumtorvum</i>	4	9	2

27	galangal	<i>Alpinia galanga L.</i>	6	3	7
28	Cinnamon	<i>Cinnamomum burmannii</i>	6	0	0
29	Dab-dab	<i>Erythrina Sp</i>	1	0	0
30	Moringa	<i>Moringa oleifera</i>	0	1	1
31	Taro	<i>Colocasia esculenta L.</i>	0	6	0
32	Pepper	<i>Piper nigrum L.</i>	0	1	0
33	rambutan	<i>Nephelium lappaceum L.</i>	0	1	0
34	Serai	<i>Cymbopogon citratus</i>	0	10	0
35	Lime	<i>Citrus hystrix</i>	0	1	2
36	Pineapple	<i>Ananas comosus L.</i>	0	0	0
37	petai china	<i>Leucaena leucocephala</i>	0	0	1
38	sugar palm	<i>Arenga pinnata</i>	0	0	2
<b>Total</b>			<b>17</b>	<b>32</b>	<b>15</b>

b. Shade tree Diversity

No.	Latin name	species	Σ Individuals	Σ Individuals	Σ Individu
1	<i>Areca catechu L.</i>	areca nut	34	10	8
2	<i>haveabrsiliensis</i>	Rubber	25	11	0
3	<i>Parkia speciose</i>	petai	2	2	0
4	<i>Carica papaya L.</i>	Papaya	14	11	21
5	<i>Lansium domesticum</i>	Langsat	8	3	0
6	<i>Duriozibethinus</i>	Durian	17	9	3
7	<i>Persea Americana</i>	Avocado	3	6	0
8	<i>Musa paradisiaca</i>	Banana	55	76	26
9	<i>Syzygium malaccense L</i>	Jambu Bol	3	0	0
10	<i>Mangifera indica L.</i>	Mango	1	1	0
11	<i>Gliricidia sepium</i>	Gliricidia	10	12	4
12	<i>Archidendron pauciflorum</i>	jengkol	2	1	0
13	<i>Coffea robusta</i>	Coffee	5	2	6
14	<i>Cinnamomum burmannii</i>	Cinnamon	6	0	0
15	<i>Erythrina Sp</i>	Dab-dab	1	0	0

No.	Latin name	species	Σ Individuals	Σ Individuals	Σ Individu
17	<i>Leucaena leucocephala</i>	petai china	0	0	1
16	<i>Nephelium lappaceum L.</i>	rambutan	0	1	0
18	<i>Arenga pinnata</i>	sugar palm	0	0	2
<b>Total</b>			<b>186</b>	<b>145</b>	<b>71</b>

Based on Table 1 above it can be seen that the diversity of plants determined in the system agroforestry cocoa in Nagari Sontang, Padang District include 342 individual plants of 28 species found in the system agroforestry complex, followed by 436 total individual plants of 27 species found in simple agroforestry system and the latter with 189 total individual plants of 20 species of plants are found in non-agroforestry systems of cacao (Figure 1).

From the above it can be concluded that the total of individual plants is highest in the system agroforestry

simple (436 individual plants), compared to a system of agroforestry complex (342 individual plants), this was due to the system of agroforestry simple overgrown with various kinds of crops and wild plants under the cocoa plant vegetation or cover crops. The high degree of shade in complex agroforestry system can reduce the diversity of undergrowth. While the total of the lowest individual plants contained in the non-agroforestry system as many as 189 people because it is dominated by a few shade trees and seasonal plants under the cocoa plant vegetation.

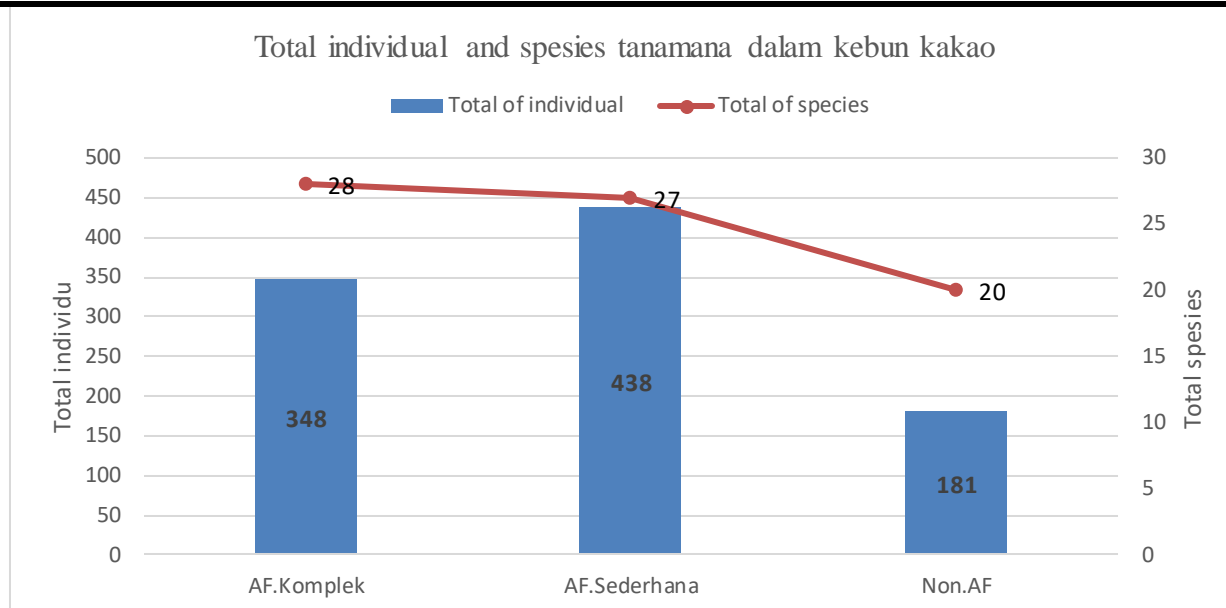


Fig.1: Diagram of plant species diversity in cacao

The index of plant diversity depends the number of individuals of the species that are present in a system. In Figure 2 below tetera that the highest diversity index contained in the simple agroforestry system that is equal to 2.02, followed by a complex agroforestry system with diversity index value of 1.93. Non agroforestry garden systems have the lowest diversity index is 1.56. Mangurran (1998) explains that the Diversity Index ( $H'$ ) is highly correlated with species richness (number of individuals of each species) at a specific location, but is also influenced by the distribution of species abundance. The higher the index value  $H'$ , the higher the plant biodiversity, ecosystem productivity, pressures on ecosystems and ecosystem stability.

The low index of diversity of systems in non-farm management of agroforestry is because the system is only dominated the sidelines a few plants that are generally only as limiting as areca gardens (*Areca cathecu L.*), and some herbaceous habitus plants like

papaya (*Carica papaya L.*), banana (*Musa paradisiaca*) and some herbaceous plants such as moringa habitus (*Moringa oleifera*) and Gliricidia (*Gliricidia sepium*). Setiarno (1998) states that an area dominated by certain types then the area has a low species diversity and in the community the interaction between species is low.

Wealth index type depending on the number of species found in an area / ecosystem. In figure 2 shows that the highest number of plant species is dominated by a complex system of agroforestry as many as 28 species, followed by a simple agroforestry systems and last as many as 27 species of 20 species on non-agroforestry system. The higher the number of species in an ecosystem, the more tinggu also index the species richness of plants, it can be seen in Figure 4 below where the wealth index is highest plant species in complex agroforestry system amounted to 4.24 and in the simple agroforestry system amounted to 4, 06, while the non-agroforestry system 3,23.

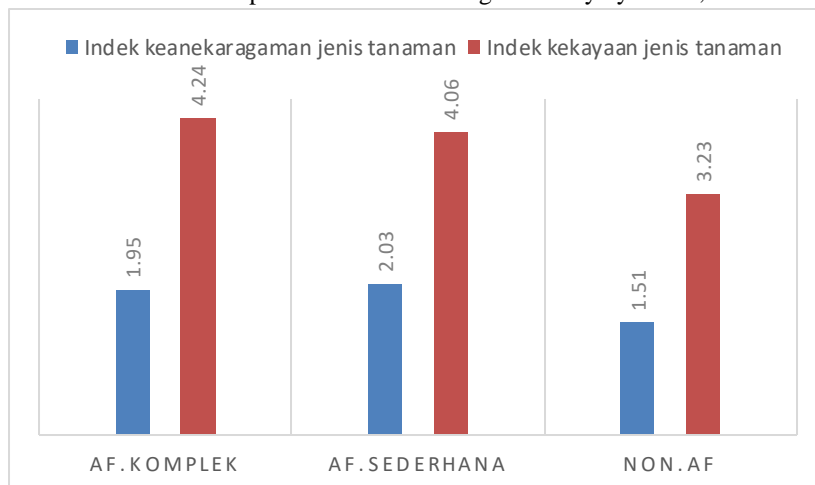


Fig.2: The index of diversity and richness of plant species in the cocoa farm

Richness is the number of types (species) in a community. The more the number of species is found, the index is also getting bigger fortune. Margalef richness index, divide the number of species by natural logarithm function which indicates that the increase of the number of species varies inversely with the number of individuals. It also shows that it is usually in a community / ecosystem has many species will have the least amount of individuals in each species.

#### **IV. CONCLUSION**

Based on experiments that have been conducted found some conclusions that

1. The highest plant diversity index of 2.03 as found in complex agroforestry systems, while the highest species richness index of 4.24 found in simple agroforestry systems
2. Farm management system with diversity cocoa agroforestry cover crops can provide environmental services (ecosystem services) to the development of the cocoa plant.

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