PROCEEDING

OF ISAE INTERNATIONAL SEMINAR BANDAR LAMPUNG AUGUST 10-12, 2017

"Strengthening Food and Feed Security and Energy Sustainability to Enhance Competitiveness"

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"Strengthening Food and Feed Security and Energy Sustainability to Enhance Competitiveness"

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COMPETITIVE AND SUSTAINABLE PRODUCTION OF COCOA IN TANGGAMUS, LAMPUNG PROVINCE, INDONESIA

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ABSTRACT

Lampung province is the 7th largest cocoa producers in Indonesia where 18,906 ha of them situated in Tanggamus Regency. This regency was the major producer of both coffee and cocoa. In the last 13 years, the coffee growing area decreased by 11.61% and its production decreased by 24.01%, meanwhile the cocoa growing area and its production increased by 400%. This study was aimed to explore the competitiveness and weakness factors of sustainable cocoa production in Tanggamus. The survey was taken at two sub-district of Tanggamus Regency which purposively sampled based on different land suitability. Field survey, interview, and focused group discussion were conducted in 2016-2017. Feasibility study was done in Bulok Sub-district using a total of 60 family samples.The finding showed that cocoa farming was more competitive than coffee farming for the following reasons: higher price (in 2008-2015 cocoa price was 20.12% higher than coffee price), higher farm income (Rp 12,808,551 compared to Rp 6,583,484) and higher ratio R/C (1.85 compared to 1.48). Beside coffee, cocoa land areas with moderate suitability and good market access could out compete the usage of land for other cash crops including fruits and vegetables that usually having high price. Nonetheless, the sustainability of cocoa production in Tanggamus faced some weaknesses i.e. low availability of high yielding planting materials and that resistant to pest and diseases, high incidence of pest and disease in the field, obstacles of replanting or rejuvenating old and less productive cocoa stands, variability of bean production, and low quality of unfermented bean and improperly drying.

Keywords : cocoa, coffee, competitive, production, sustainable

I. INTRODUCTION

Cocoa is important trade commodity of Indonesia, with export volume of cocoa bean in 2015 of 350,750 ton and value of 1,316 million US$. Lampung province is the 7th largest producers of cocoa in Indonesia, having 73,531 hectares of cocoa plantation, including in Tanggamus Regency with 18,906 ha. Lampung province is also the 2nd largest producers of coffee in Indonesia. Tanggamus has 17,919 ha of smallholder coffee plantation [1]. In Lampung, cocoa plantations were situated in 100-600 m above sea level [2] where coffee also planted.

There were a dynamic of land use in Tanggamus between coffee (as a traditional commodity) and cocoa. In the last 13 years, coffee area decreased by 11.61% and production decreased by 24.01%, meanwhile cocoa area and production increased 400% (Table 1). Some farmers converted coffee plantation to cocoa plantation meanwhile others remained to plant coffee

Expansion of Indonesia cocoa planted area especially smallholder plantation increased significantly since 1987. Due to scarcity of forest area to plant cocoa, cocoa plantations were superimposed or diversified with other industrial crops such as coffee, coconut, rubber, and banana [2]. Among expansive commodities such as cocoa, rubber, and oil palm, some coffee plantations were survive. Plantations dynamic based planting period of replanting and new planting showed competitiveness of cocoa encouraged by the market [5].

Along with the vast development of new cocoa areas, the recent production and productivity of cocoa in Indonesia continues to a significant decline that threaten the sustainability of cocoa production. The decline in the quality and yield were influenced by many factors, among others, the attacks of infectious diseases and pests such

as cocoa fruit borer *Conophomorpha cramerella*, plant materials, post-harvest and farming systems [6]. This research aimed to study (1) competitiveness of cocoa farming compare to coffee farming and (2) factors indicating sustainable cocoa production particularly in Tanggamus, Lampung, Indonesia.

Table 1. Planted areal and production of coffee and cocoa in Tanggamus

Year	Coffee		Cocoa	
	Areal (ha)	Production (t)	Areal (ha)	Production (t)
2002	51,814	40,242	3,774	2,079
2006	54,185	45,064	14,017	7,180
2009	54,256	45,342	14,314	7,180
2010	53,706	45,310	15,194	7,195
2012	53,105	44,639	17,081	7,404
2015	45,798	30,578	18,906	10,216

Source: BPS Kabupaten Tanggamus [7]

II. MATERIALS AND METHODS

The site of this survey covered two sub-districts of Tanggamus Regency which purposively sampled representing different land suitability for cocoa and coffee and village development indices. Bulok represented a remote, mountainous, less population sub-district with low village development indices where cocoa plantation is the main farming system followed by coffee plantation. Sumberejo represented a good access, more populated sub-district with high village development indices where cocoa is only secondary crop among many others such as coffee, fruits and vegetables.

Table 2. The characteristics of study site

Characteristics	Bulok	Sumberejo
Land area (km²)[7]	51.68	56.77
Topography	Sloping (medium gradient mountain)	Sloping (medium gradient hill)
Altitude (m above sea level)	400-500	600-700
Population density (person/km²)	405.3	576.3
Land suitability for cocoa [8]	S3 – N	S2-S3
Land suitability for coffee	S3 – N	S2-S3
Soil classification [8]	Dystropepts, hapludults	Dystropepts, humitropepts, tropaquepts
Cocoa farming type	Smallholder plantation, cocoa is the main crop	Home-garden, cocoa is secondary crop
Cocoa land area (ha)	0.5-2.0	0.01-1.5

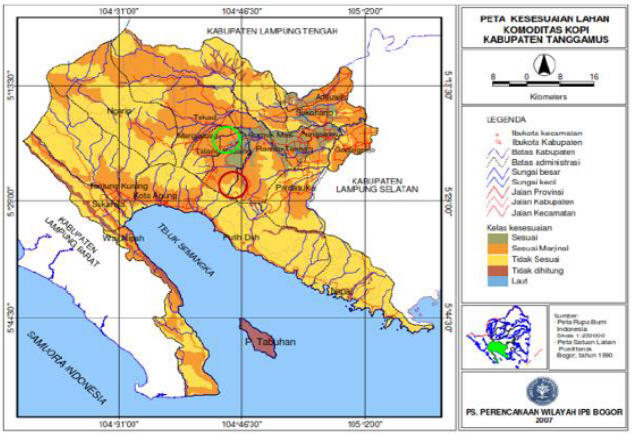

Fig. 1. Map of coffee land suitability in Bulok (red marked) and Sumberejo (green marked)[8]

Land suitability of Bulok is not suitable – marginally suitable for cocoa and coffee. Land suitability of Sumberejo is marginally suitable – moderately suitable for cocoa and coffee (Table 2, Fig. 1-2). Field survey, interview, and focused group discussion (FGD) was conducted in 2016-2017. Feasibility study was conducted in Bulok Sub-

district using 60 family samples from 30 of each cocoa and coffee farmers. Data were analysed using financial feasibility analysis and SWOT analysis.

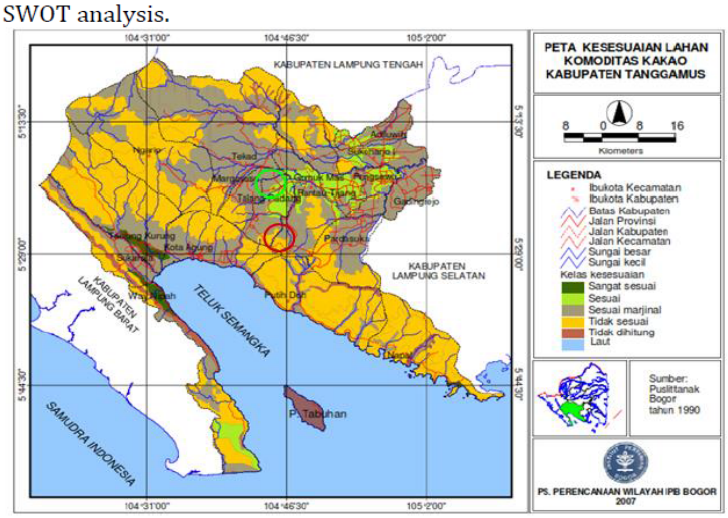

Fig. 2. Map of cocoa land suitability in Bulok (red marked) and Sumberejo (green marked)[8]

III. RESULTS AND DISCUSSION

A. *Land Use Shift*

Basically coffee plantation of smallholders were the main farming system in Tanggamus including in Bulok and Sumberejo Sub-district. However alternative crops were developed driven by good price and demand. In Bulok Sub-district, some coffee land uses were shifted to cocoa by full conversion (coffee cleared to plant cocoa) or inter-planting coffee with cocoa. If cocoa trees were inter-planted at close spaced (3-4 m), coffee trees were gradually died due to light and nutrient competition with cocoa. In Sumberejo more coffee land uses were shifted to banana or papaya that offer higher income. Cocoa trees were planted at home-garden and at plantation as mixed crops. Farmers prefer to plant coffee inside Sumberejo Sub-district and as well outside sub-district closed to forest area.

Table 3. Land use share in Bulok and Sumberejo

Land use	Bulok (ha)	Sumberejo (ha)
Coffee	2,252	1,647
Cocoa	2,615	148
Black pepper	733	284
Coconut	539	594
Snake fruit	35	400
Mango	286	286
Durian	1,095	823
Banana	1,132	3,880
Papaya	60	3,811
Upland field	1005	1036

B. *Cocoa Price*

Farmers' decision to plant cocoa were driven by high price and high productivity of cocoa plantation. In average of 2008-2015 cocoa price was 20.12% higher than coffee price (Fig. 3). However, prices were volatile. FGD results noted that in 2017 cocoa and coffee price become closer that farmers remain to plant coffee. Coffee farmers concluded that coffee farming has low risk (price, pest and disease) yet low farming expenses (Table 4). Cocoa farmers noted that beside high price, bean yield may reach 1-2 ton/ha when cocoa plantations were under proper manage (mainly fertilizing, pruning, sanitation) and pods were bearing along the year with enough rainfall. Cocoa trees were prone to long dry season that makes leaves drop followed by high incidence of black pod disease. In contrast, coffee trees were prone to long wet season that makes failure of flowering and fruiting. Coffee flowers and fruits dropped when rainfall was accessed especially at night rainfall. FGD concluded that both coffee and cocoa were prone to extreme rainfall due to climate change.

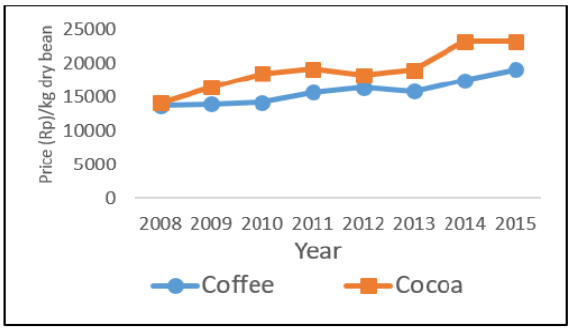

Fig. 3. Dynamic of cocoa and coffee price in 2008-2015 (Source: Directorate General of Estate Crops [1])

Table 4. Reasons of coffee change or not change to cocoa

Satisfaction Factors	Coffee not to change to cocoa (% farmers, n=30)	Coffee change to cocoa (%farmers, n=30)
Coffee farmer		
Farming risk is lower	53.33	
Farming expenses is lower	33.33	
Influence of other farmers	13.33	
Total	100	
Cocoa farmer		
Cocoa has higher price		53.33
Harvesting along the year		33.33
Farming expenses is lower		10.00
Influence of other farmers		3.33
Total		100

C. Farming Income

Structure of cost and income of coffee and cocoa farming showed on Table 5. Cocoa farmers applied more manure, fertilizers (particularly urea and NPK compound), and herbicide than coffee farmers. Fertilizers were applied 2-3 times a year, at early and end of wet season to induce growth (after dry season) and bearing (before dry season). Cocoa plants were managed more intensive in term of manure, chemical, and labour resulted in higher production cost. However, due to higher yield productivity and higher price, cocoa farming generated higher revenue and farm income. In fact cocoa farming offered higher financial feasibility. Some farmers changed their coffee plantation to cocoa plantation hopefully to get higher income.

D. Cocoa replanting

Farmers had changed their plantation to cocoa, but good agriculture practices for cocoa has not adopted yet. About 20% of cocoa trees were in age 15-19 years old that need to be rejuvenated. Moreover about 23% of cocoa trees were more than 20 years old that need to be replanted or rejuvenated. Farmers could manage old coffee tree to be cut, to be replanted or changed to another plant (Fig. 4, coffee tree data of 15-19 years old was drop due to conversion), or to be rejuvenated by clonal grafting. Coffee plantations usually had good performance of pruning and grafting. In other hand farmers let old cocoa tree to grow older and higher with minimal pruning. Not much farmers pruned their cocoa trees and cloned it by side grafting or top grafting.

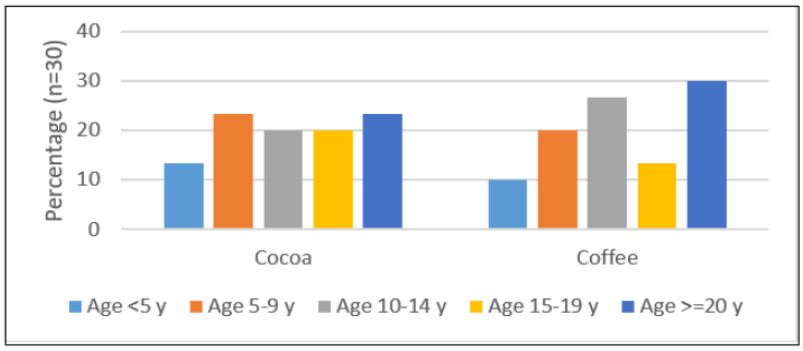

Fig. 4, Age structure of coffee and cocoa plantation

Table 5. Comparing cost and income of coffee and cocoa farming (ha^{-1})

Variables	Coffee		Cocoa	
	No.	Value (Rp)	No.	Value (Rp)
A. Farm expenses				
1. Fertilizer				
Manure (kg)	643	965,000	936	1,403,846
Urea/ZA (kg)	97	242,130	205	507.052
NPK compound (kg)	78	233,333	186	450,000
TSP/SP36 (kg)	122	330,556	103	256,410
2. Pesticide				
Herbicide (l)	5	237,197	9.6	440,346
Fungicide	0	0	0	0
3. Non family labour (cash)	75.4	3,015,604	79.8	3,192,145
4. Harvesting transport		130,119		178,887
5. Hulling		338,304		0
6. Land tax		6,578		6,000
7. Levy		0		35,000
Total (A)		5,498,821		6,469,686
B. Accounted cost				
1. Family labour	16	643,178	49	1,944,701
2. Land rent (ha-1)		2,000,000		2,000,000
3. Depreciation cost		13,825		20,938
Total (B)		2,657,003		3,965,639
C. Production cost (A+B)		8,155,824		10,435,325
D. Dry bean yield (kg)	680		903	
E. Revenue		12,082,305		19,278,237
R/C		1.481		1.847
Farm income (E-A)		6,583,484		12,808,551
Net income (E-C)		3,926,481		8,842,912

Table 6 showed cost of replanting or new planting cocoa and coffee tree per hectare of land area. Cost of planting cocoa in first year was not very much higher than of planting coffee. However cost of cocoa seedlings was more expensive and high yielding planting materials were sometime not available. For smallholders it was a big money to invest in 3-4 years before cocoa plantations generating income. Cocoa farmers land tenure were small, only less than 2 hectares. Farmers tended to delay replanting old cocoa plantation. Without rejuvenation, old cocoa trees (> 20 years old) produced low yield. Moreover, as cocoa trees become older, labour inputs for pruning, shade management, and pest and disease control begin to decline to very low levels as reported by Curry *et al.* [9].

Table 6. Replanting/new planting cost of coffee and cocoa plantation (ha^{-1})

Cost variables	Unit	Coffee		Cocoa	
		No.	Value (Rp)	No.	Value (Rp)
1. Land clearing	Man day				
Felling		25	1,250,000	20	1,000,000
Cutting and stacking		6	300,000	7	350,000
2. Tillage	Man day				
Hoeing 1		12	600,000	14	700,000
Hoeing 2		10	500,000	10	500,000
3. Seedling	polybag	2,650	2,650,000	1,165	4,660,000
4. Planting					
Manure	ton	4	1,200,000	2	600,000
Holing and planting	Man day	10	500,000	5	250,000
5. Maintenance					
Hand weeding (3x)	Man day	36	1,800,000	36	1,800,000
Herbicide(1x)	litter	3	300,000	3	300,000
Herbicide spraying	Man day	1	50,000	1	50,000
Fertilizer Urea, Phonska (3x)	kg	200	500,000	200	500,000
Fertilizer application	Man day	12	600,000	9	450,000
Total cost			6,903,350		7,463,700

E. Cocoa Multiple Cropping

Fig. 5 showed cocoa and coffee farmers land tenure. Having small scale cocoa plantation usually less than 2 hectare, 100% of sampling farmers practiced mixed planting. It was the way to manage the risk and to increase farm income. The risk of cocoa farming were including price fluctuation and yield drop due to pests, diseases, and long dry season.

Smallholder cocoa plantations were characterized by intercropping cocoa with variety of plants and shading trees. It makes smallholder cocoa plantations usually had high biodiversity [2]. When farmers wish to diversify their sources of income and maximize their land use they can intercrop their cocoa land in spite of monoculture plantation. Snoeck [10] reported that intercropping rubber-cocoa and was significantly more profitable than other associations with rubber tree until the 12th year.

We could found varieties of plant associated with cocoa trees in smallholder plantation including fruits, spices, and others. Banana, durian, and black pepper were the most commonly planted with cocoa in the area. Bananas had been planted since the establishment of cocoa plantation, functioning as shading plants and also as income generating. As cocoa trees canopy closed, banana partly eradicated and some clump were left. Banana clumps were thinned to leave a single tree and single ratoon tree.

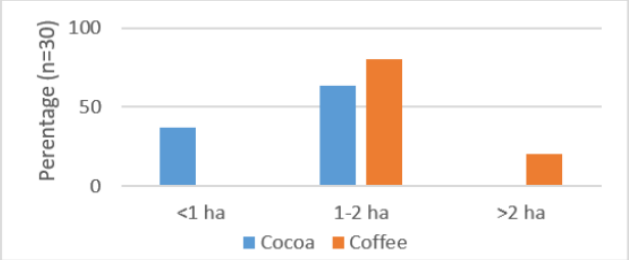

Fig. 5. Cocoa and coffee farmers land tenure

Intercropping cocoa with banana significantly increased the yield of cocoa due structure effect of cocoa – banana [11]. In a degraded cocoa plantation with a long history of intensive fertilization, inter-planting with banana and shade trees had positive effects on cocoa yield probably linked with the creation of an environment that improves cocoa crop physiology and reduces pressure of pests and diseases [12]. Shading also beneficial as an adaptation measure for cocoa plantation to climate change [13].

Table 7. Farming income from multiple cropping

Variables	Coffee multiple cropping	Cocoa multiple cropping
Intercrops (frequency, n=30)	Banana (23), Durio (16), black pepper (19), *Parkia speciosa* (14), coconut (3)	Banana (17), Durio (11), black pepper (10), *Parkia speciosa* (7), clove (3), *Lansium domesticum* (2), long pepper (1), coconut (1), mangosteen (1)
Revenue (Rp)	6,320,611	4,475,790
Farm expenses (Rp)	560,541	504,910
Farm income (Rp)	5,760,070	3,970,880
Farm income percentage to cocoa (%)	87.5	31.0

Black pepper was commonly intercropped with cocoa at the middle of the cocoa rows using Gliricidia sepium as standard. Durian trees were planted commonly at the border of the land. The multiple crops in cocoa farming generated income of 31% to income from cocoa bean. The multiple crops in coffee farming could generated higher income (Table 7), especially for coffee – black pepper multiple cropping due to high price of black pepper. Gross [14] concluded that diversification of crops is an important strategy allowing cocoa and coffee farmers to reduce their exposure to climate and other risks. This measure would not be difficult to implement, as it could be based on a return to more traditional, diverse farming methods that were common before intensification and monoculture were adopted. Jagoret *et al.* [15] reported that input-intensive system (based on the monoculture of selected hybrids) to increase cocoa production has reached its limitation including agronomic, socio-economic and environmental. In poly-culture cocoa plantation where cocoa trees were planted with others association trees, yield might reach 1,100 kg of cocoa per hectare and cocoa trees had longer lifespan.

F. Sustainable Cocoa Production

About 53% of cocoa farmer sample was above 40 years old (Fig. 6). It was better than those of coffee farmers that 100% was above 40 years old. It seemed that being a farmer of cocoa or coffee plantation was not attractive for youth. During FGD no youth really willing to be cocoa farmers. They preferred to go to city and work as factory

labour. If they failed living in the city, they might back home and work as a farmer, replacing their father take care of cocoa orchard.

Table 8 showed SWOT analysis for sustainable production in the studied area. The strengths were mainly related to competitiveness of cocoa compare to coffee which is the main plantation in Tanggamus. Cocoa trees might be grown at marginal land suitability in a broad farming system including monoculture and poly-culture plantation and home garden. Cocoa productivity and price might be higher that generated higher farm income. It might drive land use shift from coffee to cocoa plantation. However, during FGD we found some weakness for sustainable cocoa production. Whenever price of other competitor commodity was rise (for example black pepper price increased in 2015-2016 and coffee price increasing in 2017), farmers would convert cocoa planted area to other crops. In India region, strengths and weakness for sustainable cocoa supply have been reported by Beg et al [16].

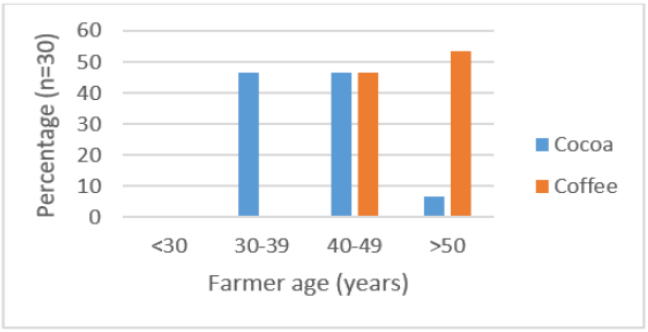

Fig. 6. Percent age distribution among cocoa and coffee farmer

High yielding cocoa planting materials were available mostly for every farmer groups. However local varieties and clones were commonly planted because its seedling price was lower. Farmers had experience that selected local variety could produce high yield. Unfortunately, unlike in coffee farming, pruning, grafting, rejuvenating, replanting were not commonly practiced yet in cocoa farming. Farmers produced unfermented cocoa bean with high water content. In rainy season, sun-drying take longer time to meet standard water content of dry bean unless cocoa bean became mouldy and black.

Table 8. SWOT for sustainable cocoa production

Production sustainability	Indicators	Factors
Strength	Agronomy & economy	Planted as home garden, plantation, or mixed cropping, adaptive to marginal suitability, fruiting along the year, simple post-harvesting, higher productivity, price, and farm income (compared to coffee)
	Environment	High trees coverage and tree biodiversity, minimum chemical applied
	Social	High farmer satisfaction of cocoa farming, easy to manage, easy to sell
Weakness	Agronomy & economy	Planting local and low yield clones, less pruning, less farm sanitation, high incidence of pests and diseases, less rejuvenation/ rehabilitation/re-planting, fluctuating yield 400-900 kg/ha, low quality cocoa bean (non-fermented, not proper sun drying), small scale smallholder plantations made less efficient handling and processing, pod peal waste was still rarely used for goat feeding.
	Environment	Commonly planted at marginal land suitability, applied intensive fertilizer and herbicide, terracing was not commonly built, farmers prefer to burn litter ground cover to prevent outbreak of black pod disease
	Social	Small land tenure, living in less developed village, age of more 40 years old, not much youth eager to be cocoa farmer
Opportunities		There are programs of sustainable cocoa initiatives, programs of society forest, adoption of new varieties and clones with high yield, pests and diseases resistance, price incentives for fermented and high quality bean, price incentive for organic cocoa, processing to other cocoa product, processing and marketing organized by cooperatives, empowering and investing in small holder cocoa farming
Threats		Fluctuating and decreasing cocoa price, climatic condition due to climate change, land use shifting to other competitive plants, long chain of marketing

IV. CONCLUSION

In Tanggamus Lampung Province cocoa farming was more competitive than coffee farming for the following reasons: (1) higher price (in 2008-2015 cocoa price was 20.12% higher than coffee price), (2) higher farm income (Rp 12,808,551 compared to Rp 6,583,484) and (3) higher ratio R/C (1.85 compared to 1.48). Beside coffee, cocoa land areas with moderate suitability and good market access could out compete the usage of land for other cash crops including fruits and vegetables that usually having high price. The sustainability of cocoa production in Tanggamus faced some weaknesses i.e: (1) low availability of high yielding planting materials and that resistant to pest and diseases, high incidence of pest and disease in the field, (2) obstacles of replanting or rejuvenating old and less productive cocoa stands, (3) variability of bean production due to climatic situation, (4) producing low quality cocoa bean including no fermentation, mouldy bean and high water content, (5) small scale smallholder plantations made less efficient handling and processing, (6) youth generation had little interested in cocoa farming.

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REFERENCES

[1] Directorate General of Estate Crops. Tree Crop Estate Statistics of Indonesia 2014-2016 Cocoa. Ministry of Agriculture. Jakarta. 2016.
[2] R. Evizal, Sumaryo, N. Sa'diyah, J. Prasetyo, F.E. Prasmatiwi, I. Nurmayasari. Farm performance and problem area of cocoa plantation in Lampung Province, Indonesia. Conference Proceeding the USR International Seminar on Food Security. p. 193-205. 2016.
[3] M. Wessel and P.M.F. Quist-Wessel. Cocoa production in West Africa, a review and analysis of recent development. NJAS-Wageningen Journal of Life Science 74-75: 1-7. 2015.
[4] E.A. Ellis, K.A. Baerenklau, R. Marcos-Martinez, E. Chavez. Land use/land cover change dynamics and drivers in a low-grade marginal coffee growing region of Veracruz, Mexico. Agroforest Syst 80:61-84. 2010.
[5] F. Ruf. Diversification of cocoa farms in Cote d'Ivore: Complementary of and competition from rubber rent. In: F. Ruf and G. Schroth (eds). Economics and Ecology of Diversification. DOI 10.1007/978-94-017-7294-5_2. 2015.
[6] Rubiyo and Siswanto. Peningkatan produksi dan pengembangan kakao (Theobroma cacao L.) di Indonesia. Buletin RISTRI 3(1): 33-48. 2012.
[7] BPS KabupatenTanggamus. Tanggamus Dalam Angka. Kota Agung. 2016.
[8] PS Perencanaan Wilayah IPB Bogor. Peta Kesesuaian Lahan Komoditas Kopi dan Kakao Kabupaten Tanggamus. Bogor. 2007.
[9] G.N. Curry, G. Koczberski, J. Lummani, R. Nailina, E. Peter, G. McNally, O. Kuaimba. A bridge too far? The in*fl*uence of socio-cultural values on the adaptation responses of smallholders to a devastating pest outbreak in cocoa. Global Environmental Change 35:1-11. 2015.
[10] D. Snoeck, R. Lacote, J. Keli, A. Doumbia, T. Chapuset, P. Jagoret, E. Gohet. 2013. Association of hevea with other tree crops can be more profitable than hevea monocrop during first 12 years. Industrial Crops and Products 43: 578-586. 2013.
[11] O. Deheuvels, J. Avelino, E. Somarriba. Vegetation structure and productivity in cocoa-based agroforestry systems in Talamanca, Costa Rica. Agriculture, Ecosystems and Environment 149: 181-188. 2012.
[12] W. Vanhove, N. Vanhoudt, P. van Damme. Effect of shade tree planting and soil management on rehabilitation success of a 22-year-old degraded cocoa (*Theobroma cacao* L.) plantation. Agriculture, Ecosystems and Environment 219: 14-25. 2016.
[13] G. Schroth, P. Laderach, A.I. Martinez-Valle, C. Bunn, L. Jassogne. Vulnerability to climate change of cocoa in West Africa: Patterns, opportunities and limits to adaptation. Science of the Total Environment 556: 231-241. 2016.
[14] M. Gross. Coffee and chocolate in danger. Currant Biology 24(11): 503-506. 2014.
[15] P. Jagoret, O. Deheuvels, and P. Bastide. Sustainable cocoa production learning from agroforestry. Perspective Ecological Intensification (27): 1-4. 2014.
[16] M.S. Beg, A. Ahmad, K. Jan, K. Bashir. Status, supply chain and processing of cocoa - A review. Trends in Food Science and Technology 66: 108-116. 2017