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Important factors affecting production and marketing in a cocoa supply chain

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Abstract: A sustainable cocoa production needs a solid supply chain and its possible interventions. Therefore, this research aimed to analyze the main factors in sustainable cocoa production and marketing, focusing on farmers as the core stakeholders in the cocoa supply chain. This research used a quantitative survey method. The data was collected using a questionnaire that asked questions about the production of cocoa beans, ranging from cocoa cultivation to post-harvest and marketing. To achieve the research objectives, confirmatory factor analysis and probit regression were used. The results show that the availability of seeds, applying chemical and organic fertilizers, use of pesticides, and farming capital were the main factors in cocoa cultivation. The use of organic fertilizers offered the biggest contribution, followed by chemical fertilizers and farming capital. Water content and cleanliness of cocoa beans were the main factor of post-harvest. Supplier attributes, such as education, access to extension, farming experience, off-farm, access to credit, and access to production inputs, affected the sale of cocoa beans to marketing outlets.

Keywords: Cocoa seeds, Organic fertilizers, Chemical fertilizers, Pesticides, Farming capital, Cocoa cultivation, Post-harvest.
Abbreviations: CC_Cocoa Cultivation; CFA_Confirmatory Factor Analysis; PH_Post-harvest; X1_Availability of cocoa seeds; X2_Use of chemical fertilizers; X3_Use of organic fertilizers; X4_Use of pesticides; X5_Farming capital; X6_Water content of cocoa beans; X7_Cleanliness cocoa beans.

Introduction

In Indonesia, cocoa is a very important commercial crop for millions of farmers and the Indonesian national economy (FAO, 2020). Cocoa is grown in cultivation systems with various ecological complexities (Jacobi et al., 2013; Muhardi and Effendy, 2017). However, productivity and quality of cocoa beans have continued to decrease lately, which has caused Indonesia's ranking to drop to fifth in the world (Effendy et al., 2019). This was due to pest attacks and diseases, increasing age of the crop, less professional land management, and limited farmers' skills (Effendy et al., 2013; Effendy, 2015; Effendy and Antara, 2015).
Cocoa production is only one part of the supply chain, with several other sectors still needing to interact before it becomes chocolate (the final product). Other sectors are the agricultural input industry (such as seeds, fertilizers), local buyers (traders), processors, transporters, the packaging industry, retailers, and end consumers (Camargo and Nham-tumbo 2016).
Traders have traditionally played an important role in marketing cocoa beans. They enjoyed very high profit margins so that the price at the farmer's level became low (Sisfahyuni et al., 2011; Abubakar et al., 2013). This would cause the cocoa supply chain in the marketing department to be less than optimal (Hasibuan et al., 2015; Herawati et al., 2015). The supply chain was the life cycle of a product. Its activities included input procurement, production processes, product storage, distribution, and commercialization (Garcia-Alcaraz et al., 2017). To be sustainable, a supply chain must find an optimal long-term balance between economic, social, and environmental problems (Fay 2012; Borel-Saladin and Turok 2013).
One of the main consequences of globalization and business liberalization is the entry into the local retail sector of multinational companies with various supply chain management practices (Arumugam et al., 2010). This has proven to change market structure, competition, buyer-supplier relations, price levels to consumers and producers, marketing efficiency, product growth, and innovation. Several impacts were observed in developing countries, such as the intermediary marginalization of small markets and farmers as well as lower prices for both farmers and producers. The diffusion of supply chain management demanded high-quality products, but smallholders had not been able to meet these requirements (Arumugam et al., 2010).
Based on this, integration was needed along the supply chain from primary production to the final product (such as chocolate). There were still many stakeholders, such as retailers and consumers, who did not know the impact of the production system and procurement on the field; therefore, they often submitted demands that could not yet be fulfilled by farmers. Thus, it was important to think of supply chain interventions to encourage sustainable products to meet the needs of various people, especially farmers, who were the core stakeholders in the chain.
This research aimed to analyze the factors that played an important role in the production and marketing of sustainable cocoa. The results could be used to inform factors that could be considered in the sustainability of cocoa production and help to inform policy directions, investment, and other future decisions that could contribute to sustainable development.

Result and discussion

Description of research variables

The description of surveyed research variables of the cocoa farmers is presented in Table 1.

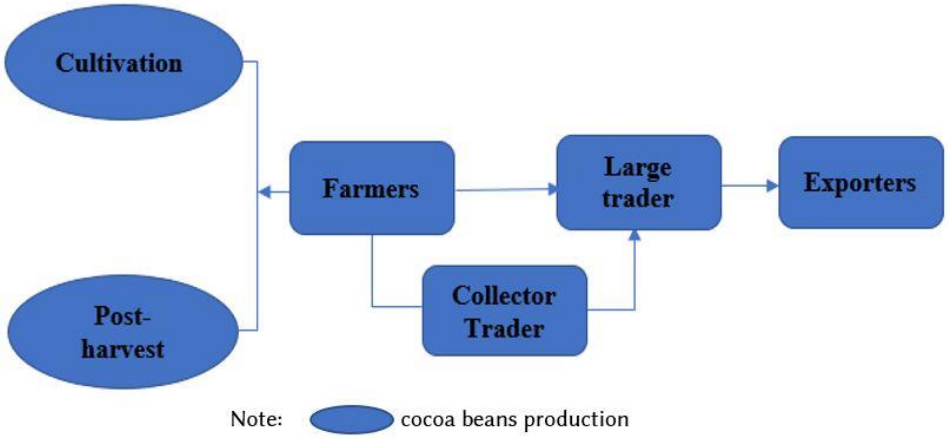

Fig 1. Cocoa beans supply chain in central Sulawesi.

The availability of cocoa seeds, the use of chemical fertilizers, organic materials, and pesticides had a score of less than 4. This indicates the use of these materials by cocoa farmers was still below standard. Farmers' inability to prepare production inputs is due to the of lack capital. Limited capital makes it difficult for farmers to access quality production facilities, resulting in low-quality cocoa beans (Ariningsih et al., 2021). Likewise, the quality of cocoa beans produced was still low, which can be seen from the water content and cleanliness of cocoa beans. The use of chemical and organic fertilizers has been proven to increase the availability of nutrients in the soil and improve the physical and chemical properties of the soil, which in turn increases cocoa production as well as the use of superior seeds (Agussalim, 2016; Kotten et al., 2023). In marketing phase of cocoa beans, 71% of farmers sell their products to large traders, while the rest sell to the collector traders. In the marketing context, the dominance of sales to wholesalers indicates the dependence of farmers on certain marketing chains, which can affect their selling prices and income (Siregar and Siregar, 2013). The education level of farmers was mostly the completion of only primary school and access to extension was less than 5 times per year, but the experience in cocoa farming was quite high. Low levels of farmer education and minimal access to agricultural extension hinder the adoption of better cultivation practices (Effendy et al., 2019). To earn more household income, cocoa farmers also worked off-farm (73%). In cocoa beans marketing, 67% of farmers had access to money credit and 50% got production input credit, which has been encouraging to choose marketing outlets.

Cocoa beans supply chain

The supply chain is a product flow that involves several parties in fulfilling customer orders (Hassini et al., 2012). It is emphasized that more than one decision-maker is involved in the supply chain. This also happened in the cocoa beans supply chain in Central Sulawesi (Fig 1).

Fig. 1. shows that in the upstream part, the production of cocoa beans was carried out by smallholders who sold cocoa beans either through collector traders or directly to large traders. Large traders sold it to multinational exporters such as PT-Olam Indonesia and PT- Cargill Indonesia. Multinational cocoa traders then sold it to a cocoa mill manufacturer (grinder) that turned it to liquid cocoa. In the downstream industry, liquid cocoa was then processed and manufactured into final products such as food, chocolate, and cosmetics.

This supply chain shows that smallholders played an important role in the production of cocoa beans. However, smallholders received only a small part of the sale price of cocoa beans (Sisfahyuni et al., 2011; Abubakar et al., 2013) due to various factors, including the unequal trade relations and the decreasing cocoa productivity due to pests and diseases (Effendy et al., 2013; Effendy, 2015; Effendy and Antara, 2015). In addition, it was rare for smallholders to be organized and have information and strong bargaining power on the cocoa price trends in the market (Hasibuan et al., 2015; Herawati et al., 2015). Smallholders often sold cocoa beans at prices dictated by traders.

In the production of cocoa beans, smallholders were in an unfavorable position. They could not determine the various factors that affected this business. Smallholders depended on seeds, chemical fertilizers, and pesticides that they had to buy. They were also subject to the volatility of uncertain cocoa beans prices, as well as vulnerability due to cocoa pests and diseases, thus creating poverty for many smallholders involved in growing cocoa. In some areas of Central Sulawesi, smallholders no longer depended on cocoa for their livelihood. Some combined it with working as farm laborers. In turn, this had other consequences. When the current cocoa crisis occurred because of various pests and diseases and weak bargaining power over prices, some smallholders had to sell their land, change its function, or even abandon their land.

Cocoa beans production

Fig. 1. shows that smallholders played an important role in the cocoa supply chain and as those who produced cocoa beans. There were two processes in the production of cocoa beans, namely cocoa cultivation and post-harvest. Cocoa cultivation and post-harvest were affected by several factors and the results of the estimation as shown in Table 2.

The evaluation of the CFA (Confirmatory Factor Analysis) model was based on several index criteria listed in Table 1 and there were at least two fit index combinations (Chen et al., 2008; Fan et al., 2016). The analysis results (Table 2) indicate that the CFA model of cocoa beans production overall provided an acceptable match with the data (goodness of fit). In the latent variable of cocoa cultivation, there were five manifest variables (indicators), namely, the availability of seeds, the use of chemical fertilizers, the use of organic fertilizers, the use of pesticides, and farming capital with a factor loadings value being greater than 0.50. This shows that the five indicators could explain the existence of latent variables of cocoa cultivation. Indicators of the use of organic fertilizers that provided the largest contribution in explaining the latent variables of cocoa cultivation were then followed by indicators of the use of chemical fertilizers and farming capital.

The use of organic fertilizers could improve the chemical, physical, and biological properties of the soil so that it could increase soil fertility (Bot and Benites, 2005). According to Leifeld and Fuhrer (2010) and Ladha et al. (2011), organic matter could increase C and N content and preserve ecosystems. Unlike chemical fertilizers, which provided only one to several types of nutrients, organic fertilizers had an important role in improving the physical, chemical, and biological properties of the soil. Although the nutrient content of organic fertilizers was relatively low, their role in the chemical properties of the soil far exceeded that of chemical fertilizers. The organic fertilizers were provided macronutrients (such as N, P, K, and S) and micronutrients (such as Zn, Cu, and Mo) to the soil and increased soil cation exchange capacity (Bot and Benites 2005). The role of organic fertilizers on soil physical properties included improving soil structure, soil pore size distribution, and reducing soil temperature fluctuations. The role of organic

Table 1. Description of research variables.

Variables	Units	Mean	Std. Deviation
Availability of cocoa seeds	Liker	3.73	1.07
Use of chemical fertilizers	Liker	3.63	1.25
Use of organic fertilizers	Liker	3.67	1.18
Use of pesticides	Liker	3.91	1.08
Farming capital	Liker	3.69	1.15
Water content of cocoa beans	Liker	3.18	1.31
Cleanliness cocoa beans	Liker	2.77	1.32
cocoa beans marketing	dummy	0.71	0.45
education level of household head	Liker	2.82	1.06
access to agricultural extension	number	4.44	1.60
cocoa farming experience	year	11.62	5.90
off farm	dummy	0.73	0.44
access to credit	dummy	0.67	0.47
access to production inputs	dummy	0.50	0.50

Table 2. Parameters estimation of the cocoa beans production measurement model.

Measurement Model	λ	t	R2	ε	Value
Cocoa Cultivation (CC)					
X1	0.75**	15.18	0.57	0.43	
X2	0.79**	16.38	0.63	0.37	
X3	0.85**	18.06	0.72	0.28	
X4	0.72**	14.25	0.52	0.48	
X5	0.79**	16.26	0.62	0.38	
Post-Harvest (PH)					
X6	0.86**	14.60	0.73	0.27	
X7	0.84**	14.34	0.70	0.30	
Goodness of fit index					
Chi Square					14.79
p					0.32
RMSEA					0.02
CFI					1.00
GFI					0.99
AGFI					0.97

Table 3. Estimation of factors that affected the decisions of smallholders in cocoa beans marketing

Variables	Coefficient	Standard error	P value
Intercept	-7.89		
Z_1	2.81**	0.55	0.00
Z_2	0.58**	0.23	0.01
Z_3	0.64**	0.22	0.00
Z_4	0.09*	0.05	0.09
Z_5	2.23**	0.47	0.00
Z_6	1.30**	0.44	0.00
Log likelihood	-24.77		
LR chi2	336.19		
Prob > chi^2			0.00
Pseudo R2	0.87		

Note: ** significant at α 5%, * significant at α 10%.

fertilizers on soil biological properties was as a source of energy and food for micro and soil mesofauna, such as earthworms, termites, and collembola, so that the increased activity of soil organisms could increase nutrient availability, soil nutrient cycles, and pore formation of soil micro and macro. In addition, stable organic matter (humus) functions to: (1) increase fertilizers efficiency; (2) extend the time of N utilization; (3) increase plant nutrient uptake, especially P and Ca; (4) reduce the risk of pest attacks and plant diseases with the balance of nutrient functions in the soil; (5) buffer Salinity in the soil; and (6) act as a catalyst to increase the status of C in the soil (Brady and Weil, 2002). Some research results show that organic fertilizers could affect the efficiency of the use of production inputs s to increase agricultural productivity and quality (LI et al., 2008; Krasachat, 2012; Effendy and Antara 2015; Effendy et al., 2019). Thus, the use of chemical fertilizers that were not balanced with the provision of organic fertilizers could damage soil structure and reduce soil biological activity.

Fertilizer was the main factor to increase cocoa productivity, but smallholders used less fertilizer in their farming. This was attributed to the lack of smallholder's capital (Effendy et al., 2018), which was the third important indicator affecting cocoa cultivation. Capital obtained from credit allowed farmers to obtain production inputs such as quality seeds, fertilizers, and pesticides so that productivity tended to increase (Abu et al 2011; Gbigbi 2011; Khan and Ali, 2013; Effendy et al., 2019). The seed was the fourth indicator that needed to be considered in cocoa cultivation. It was widely available, but new and better varieties needed to be developed. The available cocoa seeding systems, such as seeds, grafting, cuttings, high-yielding somatic embryogenesis, and disease resistance, had to be affordable by smallholders. Some research results (Fuwa 2007; da Silva Dias 2010; Effendy et al., 2019) show that superior varieties had the potential to increase economic efficiency which could increase farmers' incomes. Superior varieties often have advantages in terms of crop productivity, resistance to pests and diseases, and tolerance to climate change. A study by Nearti et al. (2023) showed that adopting superior varieties contributed significantly to increased productivity in the agricultural sector, which ultimately increased household income and food security. In addition, superior varieties can also reduce production costs through efficient use of inputs such as

Table 4. Goodness of fit index for the CFA model.

Goodness of fit	Cut-off Value
p of Chi-square test (χ^2)	> 0.05
Root mean square error of approximation (RMSEA)	< 0.06
Comparative fit index (CFI)	> 0.94
Goodness-of-fit index (GFI)	> 0.90
AGFI	> 0.90
factor loadings (λ)	> 0.50
measurement error (ε) or	< 0.51
R^2	>0.70

Source: (Fan and Sivo 2005; Hair et al., 2010; Barrett 2007; Ryu 2011).

Table 5. Latent Variable and Research Indicators.

Latent Variable	Manifest variable (indicator)	Symbol
Cocoa cultivation (CC)	1. Availability of cocoa seeds	X1
	2. Use of chemical fertilizers	X2
	3. Use of organic fertilizers	X3
	4. Use of pesticides	X4
	5. Farming capital	X5
Post-harvest (PH)	1. Water content of cocoa beans	X6
	2. Cleanliness cocoa beans	X7

fertilizers and pesticides (Cassman et al., 2003), further strengthening the economic benefits for farmers. The use of pesticides was also an important factor in cocoa cultivation if plants were attacked by pests and diseases. Chemical or biological pesticides were important to fight and control cocoa pests, such as insects, fungi, weeds, and diseases such as cocoa black pod disease.

There were two indicators of post-harvest latent variables, namely, water content and cleanliness of cocoa beans, with factor loadings values being greater than 0.50. This shows that indicators of water content and cleanliness of cocoa beans could explain the existence of cocoa post-harvest latent variables. Both indicators made a major contribution in explaining the cocoa post-harvest latent variable. Water content and cleanliness of cocoa beans predominantly determine the quality of the product. The low quality of cocoa beans would cause a discount in the selling price (Suryana et al., 2007) so that the income of the smallholders decreased which affected the purchase of the next production input.

The decision of smallholders in cocoa beans marketing

The results of the probit model on the factors that affected smallholders in cocoa beans marketing are presented in Table 3. Table 3 shows the results of probit regression models estimation for the decision of smallholders in cocoa beans marketing. The conclusion was that the decision of smallholders in cocoa beans marketing was positively and significantly related to the level of education, access to extension, farming experience, off-farm, access to credit, and access to production inputs. The education level of farmers could increase the likelihood of selling cocoa beans to large traders. This result is consistent with several previous studies (Mojaverian et al., 2014; Muthini et al., 2017; Bannor and Sharma, 2017; Bannor et al., 2019) confirming that the level of education had a positive effect on the choice of marketing outlets.

Access to agricultural extension affected farmers in their preferred outlet choice of cocoa marketing. This result is consistent with research conducted by Laven (2007), Lundstedt and Pärssinen (2009), and Bannor et al., 2019. The Indonesian government provides extension services for cocoa farmers, which has encouraged most farmers to sell cocoa beans to large traders.

The experience of farmers in farming was positively related to the choice of marketing outlets, by which those with higher experience tended to sell cocoa beans to large traders. This result is consistent with the finding of Bannor et al. (2019), reporting that increasing experience in cocoa farming could increase opportunities for farmers to sell to large companies. This was because collector traders bought cocoa beans at prices that varied according to the water content and the price was lower than that of large traders.

Farmers who had off-farm work tended to sell cocoa beans to large traders. This was related to the additional income of a farmer from off-farm work. This additional income served as a buffer for farmers to choose more profitable marketing outlets. This result is congruent with the findings of Iton (2017) and Bannor et al. (2019) that increasing income reduces the possibility of choosing less profitable marketing channels.

Access to credit affected farmers to sell cocoa beans to large traders. Large traders tended to give credit to farmers to help them to meet their needs and other costs (Kyomugisha et al., 2017). With credit, farmers could buy inputs for their farming (Abu et al 2011; Effendy et al., 2019). The availability of production inputs tended to affect farmers to sell cocoa beans to large traders. The procurement of production inputs was usually associated with the credit available to farmers.

Materials and Methods

Research design and data collection

The research was conducted in the Regency of Sigi and Poso. This location was randomly selected from 5 regencies in Central Sulawesi that had a production over 10,000 tons of cocoa (Regency of Banggai, Poso, Donggala, Parigi Moutong, and Sigi). We randomly selected 320 cocoa farming operations that were already in production. Data collection used a questionnaire, whereas respondents were asked to answer questions about the production of cocoa beans, ranging from cocoa cultivation, post-harvest, and marketing.

Questionnaires for factors that were important in the production of cocoa beans were designed using a Likert scale, in which the value (1) shows that the activity is very low and the highest value (7) means that the activity is very high. Questions for factors that affected the marketing of cocoa beans were structured and closed. Finally, we analyzed the factors that played an important role in the production of cocoa beans by using confirmatory factor analysis (CFA). To analyze the factors that affected the marketing of cocoa beans, we used probit regression.

Statistical analysis

Descriptive statistics were used to analyze descriptive research variables. For the confirmatory factor analysis (CFA) we used the Lisrel program. The CFA model was said to be goodness of fit, if it meets the following requirements (Table 4).

The variables analyzed in this research are listed in Table 5.

There are only two choices of cocoa beans marketing by smallholders, namely to collectors or large traders. This could be estimated by using a discrete choice model, one of these models is probit regression. The dependent variable of this model is a

dummy variable equal to 1 if a farmer chooses to sell to a large trader and 0 if the other. This model has been used in many studies (Giannoccaro and Berbel, 2014; Wade et al., 2016; Ghimire et al., 2017; Effendy et al., 2019; Jan, 2020; Nonvide, 2020) to estimate the adoption of agricultural technology packages.

If the dependent variable Y has only two results (1 and 0) which are affected by the independent variable Z, the probit model can be stated as follows:

$$P_i = F(Y_i) = F(\beta_0 + \beta_1 Z_{1i}) \quad (1)$$

where P_i shows the probability and F shows the cumulative normally distributed function. Because the probit probability model is related to the cumulative normal probability function, a simple probit probability model can be written as follows:

$$Y_i = \beta_0 + \beta_i Z_{1i} + \varepsilon_i \quad (2)$$

To get an estimate from the Yi index, we could use the inverse of cumulative normal function, thus obtained:

$$Y_i = F^{-1}(P_i) = \beta_0 + \beta_i Z_{1i} + \varepsilon_i \quad (3)$$

Probit regression was used to analyze the factors that affected smallholders in cocoa beans marketing. The Probit model in this research is.

$$Y = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \varepsilon \quad (4)$$

Y = dependent variable (1 = selling to large traders and 0 = other), β_0 = intercept, β_1-β_6 = coefficient of the independent variable, Z_1 - Z_6 = independent variable, ε = error term. The independent variable is defined as follows:

Z1 = education level of household head (liker),
Z2 = access to agricultural extension (number),
Z3 = cocoa farming experience (years),
Z4 = off farm (1 = off farm, 0 = other),
Z5 = access to credit (1 = money credit, 0 = other),
Z6 = access to production inputs (1 = production input, 0 = other),

Conclusion

Indicators of seed availability, use of chemical fertilizers, organic fertilizers, pesticides, and farming capital could explain the existence of latent variables of cocoa cultivation. Indicators of the use of organic fertilizers provided the largest contribution in explaining the latent variables of cocoa cultivation, followed by indicators of the use of chemical fertilizers and farming capital. Indicators of water content and cleanliness of cocoa beans contributed greatly in explaining cocoa post-harvest latent variables. Water content and cleanliness of cocoa beans especially determined the quality of the product. Supplier attributes (smallholders), such as education, access to extension, farming experience, off-farm, access to credit, and access to production inputs, positively and significantly affected the sale of cocoa beans to marketing outlets. In the sustainability of the cocoa bean supply chain, it was recommended to pay attention to the existence of indicators of the availability of seeds, chemical fertilizers, organic fertilizers, and pesticides to farmers. To achieve this, the government would need to promote soft credit to farmers so farmers could buy cocoa production inputs. In addition, because access to money credit and production inputs affected farmers in choosing marketing outlets, the companies that buy the products should try to mobilize resources to support these activities.

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References

Abu GA, Taangahar TE, Ekpebu ID (2011) Proximate determinants of farmers WTP (willingness to pay) for soil management information service in Benue State, Nigeria. African J Agri Res. 6 (17): 4057–4064. DOI: 10.5897/AJAR11.326

Abubakar I, Yantu MR, Asih DN (2013) Kinerja kelembagaan pemasaran kakao biji tingkat petani perdesaan Sulawesi Tengah: Kasus Desa Ampibabo Kecamatan Ampibabo Kabupaten Parigi Moutong. e-J. Agrotekbisnis. 1(1): 74–80.

Agussalim (2016) Efektivitas pupuk organik terhadap produktivitas tanaman kakao di Sulawesi Tenggara. Jurnal Pengkajian dan Pengembangan Teknologi Pertanian. 19(2): 67-176.

Ariningsih E, Purba HJ, Sinuraya JF, Septanti KS, Suharyono S (2021) Permasalahan dan Strategi Peningkatan Produksi dan Mutu Kakao Indonesia. Analisis Kebijakan Pertanian. 19(1): 89-108.

Arumugam N, Fatimah MA, Chiew EFC, Zainalabidin M (2010) Supply chain analysis of fresh fruits and vegetables (FFV): Prospects of contract farming. Agric Econ Czech. 56(9): 435–442.

Bannor RK, Oppong-Kyeremeh H, Atewene S (2019) Influence of non-price incentives on the choice of cocoa licensed buying companies by farmers in the Western North of Ghana. J Agribus Develop Emerging Econ. 9 (4): 402-418.

Bannor RK, Sharma M (2017) Determinants of the choice of marketing outlet among Kinnow farmers in Rajasthan State of India. Indian J Econ Develop. 13(1): 11-22.

Barrett P (2007) Structural equation modelling: Adjudging model fit. Perso and Indivi Differ. 42(5):815–824.

Borel-Saladin JM, Turok IN (2013) The green economy: incremental change or transformation? Envi Pol Gov. 23(4): 209–220.

Bot A, Benites J (2005) The importance of soil organic matter, key to drought-resistant soil and sustained food production. Food and Agriculture Organization of the United Nations.

Brady NC, Weil RR (2002) The Nature and Properties of Soils, 14th Edition. Pearson Education, Inc. Upper Saddle River, New Jersey.

Camargo M, Nhamtumbo I (2016) Towards Sustainable Chocolate: Greening the Cocoa Supply Chain. London, UK: IIED.

Cassman KG (2003) Agriculture-Related Science and Technology Priorities for Poverty Reduction and Sustainable Development in Developing Countries to 2020. Consultative Group on International Agricultural Research, UN Food and Agriculture Organization.

Chen F, Curran PJ, Bollen KA, Kirby J, Paxton P (2008) An empirical evaluation of the use of fixed cutoff points in RMSEA test statistic in structural equation models. Socio Meth Res. 36(4):462–494.

da Silva Dias JC (2010) Impact of improved vegetable cultivars in overcoming food insecurity. Euphytica. 176: 125–136.

Effendy (2015) Increasing of cocoa farmers household income with two stage least squares method. Mod Appl Sci. 9 (6): 120 – 127.

Effendy, Antara M (2015) Effect of input production against quality of cocoa beans. Ameri J Appl Sci. 12 (10): 709-713.

Effendy, Antara M, Rauf RA, Tangkesalu D, Christoporus, Pratama MF, Basir-Cyio M, Mahfudz, Zainuddin, Muhardi (2018) Evaluation of economic efficiency from smallholder cocoa investment in Indonesia: A case study in central Sulawesi province with tropical climate. Aust J Crop Sci. 12(12): 2004-2010.

Effendy, Hanani N, Setiawan B, Muhaimin AW (2013) Effect characteristics of farmers on the level of technology adoption side-grafting in cocoa farming at Sigi Regency-Indonesia. J Agri Sci. 5 (12): 72-77.

Effendy, Pratama MF, Rauf RA, Antara M, Basir-Cyio M, Mahfudz et al (2019) Factors influencing the efficiency of cocoa farms: A study to increase income in rural Indonesia. PLoS ONE. 14(4): e0214569. https://doi.org/10.1371/journal.pone.0214569

Fan X, Sivo SA (2005) Sensitivity of fit indexes to misspecified structural or measurement model components: rationale of two-index strategy revisited. Structural Equation Modeling: A Multi J. 12(3):343–367.

Fan Y, Chen J, Shirkey G, John R, Wu SR, Park H, Shao C (2016) Applications of structural equation modeling (SEM) in

ecological studies: an updated review. Eco Proc. 5(19): 1-12. DOI 10.1186/s13717-016-0063-3
FAO (2020). FAOSTAT online database. http://www.fao.org/faostat/en/#data
Fay M (2012) Inclusive Green Growth: The Pathway to Sustainable Development. Washington, DC: World Bank.
Fuwa N, Edmonds C, Banik P (2007) Are small-scale rice farmers in eastern India really inefficient? Examining the effects of micro-topography on technical efficiency estimates. Agri Eco. 36: 335–346.
Garcia-Alcaraz JL, Maldonado-Macias AA, Hernandez-Arellano JL, Blanco-Fernandez J, Jimenez-Macias E, Saenz- Diez Muro JC (2017) The impact of human resources on the agility, flexibility and performance of wine supply chains. Agric Econ Czech. 63: 175–184.
Gbigbi MT (2011) Economic efficiency of smallholder sweet potato producers in delta state, Nigeria: a case study of Ughelli south local government area. Res J Agric Bio Sci. 7: 163–168.
Ghimire R, Green GT, Paudel KP, Poudyal NC, Cordel HK (2017) Visitors' Preferences for Freshwater Amenity Characteristics: Implications from the U.S. Household Survey. J Agric Res Econ. 42(1):90–113.
Giannoccaro G, Berbel J (2014) Farmers' stated responses towards the chemicals use under the CAP liberalization. Agric Econ Czech. 60(1): 9–20.
Hair JF, Black WC, Babin BJ, Anderson RE (2010) Multivariate Data Analysis (7th Edition). Englewood Cliffs, NJ: Prentice Hall.
Hasibuan AB, Wahyudi A, Listyati D, Aunillah A, Ermiati, Herman M (2015). The role of farmers organization in optimizing supply chain performance and added value of cocoa: a case study in kolaka, southeast Sulawesi. J TIDP. 2(1): 1-12.
Hassini E, Surti C, Searcy C (2012) A literature review and a case study of sustainable supply chains with a focus on metrics. Int J Produc Econ. 140: 69–82.
Herawati, Rifin A, Tinaprilla N (2015) Performance and efficiency of cocoa beans supply chain in pasaman, West Sumatra. J TIDP. 2(1): 43–50.
Iton AC (2017) Do demographics predict shoppers' choice of retail outlet for roots and tubers in Trinidad and Tobago?. J Agribus Develop Emerg Econ. 7(3): 231-241.
Jacobi J, Schneider M, Bottazzi P, Pillco M, Calizaya P, Rist S (2013) Agroecosystem resilience and farmers' perceptions of climate change impacts on cocoa farms in Alto Beni, Bolivia. Renewable Agric Food Syst. 30(2): 170–183.
Jan I (2020) Socio-Economic Determinants of Farmers' Adoption of Rainwater Harvesting Systems in Semi-Arid Regions of Pakistan. J Agr Sci Tech. 22(2): 377-387.
Khan H, Ali F (2013) Measurement of productive efficiency of tomato growers in Peshawar, Pakistan. Agric Econ Czech. 59: 381–388.
Kotten BM, Jeksen J, Malado M (2023) Pemupukan Pada Tanaman Kakao (*Theobroma cacao* L) di Kelompok Tani Plea Puli Desa Bloro Kecamatan Nita. JIPM:Jurnal Informasi Pengabdian Masyarakat. 1(4): 68-73.
Krasachat W (2012) Organic production practices and technical inefficiency of durian farms in Thailand. Procedia Econ Finan. 3: 445 – 450.
Kyomugisha H, Mugisha J, Sebatta C (2017) Potential determinants of profits and market efficiency of potato market chains in Uganda. J Agribus Develop Emerg Econ. 7(1): 52-68.
Ladha JK, Reddy CK, Padre AT, Kessel CV (2011) Role of nitrogen fertilization in sustaining organic matter in cultivated soils. J Environ Quality. 40: 1756–1766.
Laven A (2007) Marketing reforms in Ghana's cocoa sector: partial liberalization, partial benefits. available at: www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/588.pdf (accessed 07 December 2019).
Leifeld J, Fuhrer J (2010) Organic farming and soil carbon sequestration: What do we really know about the benefits? Ambio. 39: 585–599.
Li X, Luo Y, Gao Q, Dong S, Yang X (2008) Farm Production Growth in the Upper and Middle Parts of the Yellow River Basin, China, During 1980-1 999. Agric Sci China. 7(3): 344-355.
Lundstedt H, Pärssinen S (2009) Cocoa is Ghana, Ghana is cocoa-evaluating reforms of the Ghanaian cocoa sector. available at: http://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=1511300&fileOId=1647134 (accessed 07 December 2019).
Mojaverian SM, Rasouli F, Hosseini-Yekani SA (2014) Citrus marketing channel strategy and its determinants in Mazandaran province of Iran: an application of nested logit model. J Agric Sci Tech. 16(7): 1469-1479.
Muhardi, Effendy (2017) Cocoa farming patterns for sustainability of Indonesia Lore Lindu National Park (LLNP). Aust J Crop Sci. 11(08):917-924.
Muthini DN, Nyikal RA, Otieno DJ (2017) Determinants of small-scale mango farmers market channel choices in Kenya: an application of the two-step Craggs estimation procedure. J Develop Agric Econ. 9(5): 111-120.
Nearti Y, Fachrudin B, Zuliansyah MA (2023) Komparasi Pendapatan Varietas Unggul Padi di Lahan Demonstration-Farm (DEMFARM). Jurnal Agribisnis Indonesia (Journal of Indonesian Agribusiness). 11(1): 205–219. https://doi.org/10.29244/jai.2023.11.1.205-219
Nonvide GMA (2020) Identification of Factors Affecting Adoption of Improved Rice Varieties among Smallholder Farmers in the Municipality of Malanville, Benin J Agr Sci Tech. 22(2): 305-316.
Ryu E (2011) Effects of skewness and kurtosis on normal-theory based maximum likelihood test statistic in multilevel structural equation modeling. Behav Res Methods. 43(4):1066–1074.
Siregar H, Siregar R (2013) Analisis Rantai Nilai dan Nilai Tambah Kakao Petani di Kecamatan Paya Bakong dan Kecamatan Pirak Timu Kabupaten Aceh Utara. Jurnal Agrisep. 14(1): 1-12.
Sisfahyuni, Saleh MS, Yantu MR (2011) Kelembagaan pemasaran kakao biji di tingkat petani Kabupaten Parigi Moutong Provinsi Sulawesi Tengah. Jurnal Agro Ekonomi. 29(2): 191–216.
Suryana A, Goenadi DH, Baon JB, Herman, Purwoto A (2007) Prospek dan Arah Pengembangan Agribisnis Kakao. Edisi Kedua. Badan Penelitian dan Pengembangan Pertanian Departemen Pertanian, Jakarta.
Wade T, Kurkalova L, Secchi S (2016) Modeling field-level conservation tillage adoption with aggregate choice data. J Agric Res Econ. 41(2):266-285.