Sustainability of cocoa production in Indonesia

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Abstract

The objective of this study was to present empirical evidence about the sustainability of cocoa farming in Indonesia and how decisions are made in producing cocoa beans. This study used a survey method involving a questionnaire for collecting data. The results showed that the sustainability of cocoa farming was determined by weak sustainable ecological factors (46.07%), moderately sustainable socioeconomic factors (54.43%), moderately sustainable technological factors (55.95%), moderately sustainable factors that help farmers in cocoa farming (59.60%), and weak sustainable factors in cocoa farming families' futures (47.52%). To increase the sustainability of cocoa farming, the current study found that farmer education, cocoa crop rejuvenation, cocoa pest and disease control, cleanliness and quality of cocoa beans, cocoa productivity, institutions, extension, technology, credit availability, and stability of cocoa bean prices are the most important factors to be improved.

Keywords: Sustainability, cocoa beans, ecological factors, socioeconomic factors, technological factors.
Abbreviations: CBP_cocoa black pod; CPB_cocoa pod borer; EF_ecological factors; FF_factors of cocoa farming families' future; EIR_eastern Indonesia Region; FH_factors that help farmers in cocoa farming; MDS_multi dimensional scaling; RMS_root mean square; SF_socioeconomic factors; TF_technological factors.

Introduction

In 2002, cocoa plantations provided employment and source of income for around 900 thousand family heads of farmers, mostly in Eastern Indonesia Region (EIR). They also provided the largest foreign exchange contribution to the three plantation sub-sectors after rubber and palm oil, presenting a value of US $ 701 million (Ministry of Industry, 2007). Indonesia was the 3rd largest cocoa producing country in the world after Ivory Coast and Ghana (Effendy et al., 2013; Effendy, 2015). However, in 2018, cocoa productivity greatly decreased, causing Indonesia to fall to 5th place after Côte d'Ivoire, Ghana, Ecuador, and Nigeria (Effendy et al., 2019). The decrease in cocoa productivity has been a result of pests and diseases, in combination with the advanced maturity of plants as they have become older (Effendy et al., 2013; Nurhidaya et al., 2015; Effendy, 2015). In addition to decreasing productivity, the quality of cocoa beans was low and farming was inefficient, decreasing cocoa farming income (Effendy and Antara, 2015; Effendy, 2018a).
Presence of disease, pests, low productivity and low cocoa farming income persuade farmers to convert the function of cocoa land to other crops such as coffee and pepper, disrupting the sustainability of cocoa farming in Indonesia.

Applying sustainability in agriculture has gained popularity since the Brundtland report in 1987 (Akcaoz and Kizilay, 2009). Interest in the concept has grown largely because of low agricultural income and pest/disease attacks, leading to large impacts on agricultural output, farmers' welfare, and overall environmental problems (Giannoccaro and Berbel, 2014; Muhardi and Effendy, 2017). This means it is important to determine the extent to which certain farming systems are sustainable or not (Van calker et al., 2005; Akcaoz and Kizilay, 2009). In general, agricultural sustainability concerns economic, social and ecological sustainability (Shearman 1990; Heinen 1994; Hansen 1996). According to Akcaoz and Kizilay (2009), there have been various problems in the economic and social sustainability of cow's milk activities, such as price instability, organizational structure, animal diseases, cleanliness and quality, low productivity, high unit production costs, marketing problems, lack of government support, and low level of education among farmers.
The findings of Adamišin et al. (2017) showed that sustainability of agricultural economic performance is determined by production factors such as labor, capital and natural resources. In addition, agricultural entrepreneurs also

need subjective assumptions such as imagination, ambition, willingness to bear risks, organizational skills, and better management. This was consistent with the results of the study of Olson et al. (2008), which showed that 87% of company sustainability depends on the work of senior management and only 13% depended on external factors. According to Adamišin et al. (2015), effective management of agricultural entities could be a good inspiration for these companies. Validated effective elements in management could be applied to agricultural entities, so that they could contribute to higher economic performance.

In accordance with the attention that is currently being paid to sustainability in agriculture, we became interested in analyzing the sustainability of cocoa farming in Central Sulawesi, Indonesia. The objective of this study was to present empirical evidence on the sustainability of cocoa farming in Indonesia, as well as how decisions were made in the production of cocoa beans.

Results and Discussion

The results of the analysis using Rapco-Central Sulawesi method (Rapid Appraisal for Cocoa on Central Sulawesi) showed that the sustainability index of ecological factors was 46.07% (weakly sustainable); socioeconomic factors of farmers was 54.43% (moderately sustainable), technological factors was 55.95% (moderately sustainable), factors that help farmers in cocoa farming was 59.60% (moderately sustainable), and factors of cocoa farming families' future was 47.52% (weakly sustainable). Each of the factors and attributes are sensitive and require improvement for sustainability. The value of each factor that affected the sustainability of cocoa farming is presented as follows.

Ecological factors

Ecological factors that affected the sustainability of cocoa farming consists of 10 attributes, namely (1) land suitability and agro-climate for cocoa plants, (2) land and environmental management, (3) use of cacao beans, (4) cocoa productivity, (5) the quality of cocoa beans produced, (6) the use of organic material as fertilizer, (7) the age of the cocoa plant, (8) cocoa pod borer (CPB) pest attack, (9) attack of cocoa black pod (CBP) disease, (10) attack of pests and diseases other than CPB and CBP. We analyzed these attributes using the Rapco-Central Sulawesi method.

The analysis results of the Rapco-Central Sulawesi method show that the effect of ecological factors on the sustainability of cocoa farming (MDS sustainability index) was 46.07% (weakly sustainable) with stress value = 0.137 and R^2 = 0.944. Stress value 0.137 < 0.25 and the value of R^2 = 0.944 shows that the model using these attributes explained 94.40% of the existing models. The Monte Carlo sustainability index was 45.54%, when compared to MDS. There was a difference of 0.53%, which is certainly smaller than 1.0, showing that the model was in a condition of the goodness of fit (Kavanagh and Pitcher, 2004).

Leverage analysis results show that the ecological factors that became the main levers in the sustainability of cocoa farming were (1) the age of cocoa plants, (2) the use of organic materials, (3) CPB attack, and (4) land and environmental management (Fig 1). Increasing the sustainability status of cocoa farming in the future relies on addressing these attributes.

The age of the cocoa plant was the most sensitive attribute. The results of the field survey show that the age of cocoa plants ranged from 7 to 29 years, averaging 18 years. Cocoa plants that were old have started to decrease in productivity (Gugere et al., 2016), while at the same time pests and diseases more easily attacked them. Cocoa yield productivity also tended to decrease as farmers were less optimal in cocoa land and environment management, including pruning, fertilizing, eradicating pests and diseases. Pests and diseases that predominantly attacked cocoa were CPB and CBP. Organic fertilizer uses also require consideration because it could affect the production and quality of cocoa beans (Effendy and Antara, 2015; Effendy et al., 2019). Cocoa productivity ranged from 250 to 1375 kg/ha/year dry beans with an average of 706 kg/ha/year. Genetically, cocoa production has the potential to reach 1800 to 2750 kg/ha (DPDJP., 2009). To increase the productivity and sustainability index of cocoa farming, ecological factors need to be addressed, including rejuvenating cocoa plants, controlling pests and diseases more intensively, use of organic fertilizers, land and the environment management, and using superior seeds resistant to pests and diseases that also have high productivity.

Socioeconomic factors

Socioeconomic factors affecting cocoa farming sustainability consist of 12 attributes, namely (1) level of formal education of farmers, (2) scale of cocoa farming, (3) cocoa farming experience, (4) family participation in cocoa farming, (5) level of labor absorption from cocoa farming, (6) cocoa farming income, (7) farming income other than cocoa, (8) income outside agriculture, (9) market access, (10) dependence on foreign market prices, (11) the size of farmer households, and finally (12) the age of the cocoa farming manager. We analyzed these attributes using the Rapco-Central Sulawesi method.

The analysis results of the Rapco-Central Sulawesi show that the effect of socioeconomic factors on the sustainability of cocoa farming (MDS sustainability index) was 54.43% (moderately sustainable) with stress value = 0.149 and R^2 = 0.921. Stress value 0.149 < 0.25 and the value of R^2 = 0.921 shows that the model using these attributes explained 92.21% of the existing models. The Monte Carlo sustainability index was 54.431%, when compared to MDS. There was a difference of 0.001% and this was smaller than 1.0, indicating that the model was in a condition of the goodness of fit (Kavanagh and Pitcher, 2004).

Leverage analysis results showed that the socioeconomic factors that were primary levers in the sustainability of cocoa farming were (1) dependence on foreign market prices, (2) cocoa farming income, (3) family participation in cocoa farming, and (4) farming income other than cocoa, (Fig 2). Focusing on these attributes could allow the region to improve the sustainability status of cocoa farming going forward.

Based on the analysis results, community cocoa farming in Central Sulawesi was quite profitable. Unfortunately, competitiveness of cocoa from this region was low because it was not supported by the quality of the results due to less optimal cultivation and postharvest treatments (Effendy,

2018a). Therefore, cultivation and postharvest technologies require improvement to increase productivity and quality of cocoa yields (Effendy et al., 2019). The price of cocoa beans in Indonesia relies on the world cocoa market price. Quality cocoa beans gain higher prices. Therefore, to increase the index and sustainability status of cocoa farming, it is also necessary to improve these sensitive attributes through implementing better cocoa cultivation technology, post-harvest, and marketing access.

Technological factors

The current study found that technological factors affecting the sustainability of cocoa farming were six-fold: (1) knowledge of cocoa cultivation, (2) level of technological mastery, (3) cacao crop pruning action, (4) fertilizing action, (5) cocoa pest and disease control action, (6) availability of the result processing industry. We analyzed these attributes through the Rapco-Central Sulawesi method.

The results of the Rapco-Central Sulawesi analysis showed the effect of technological factors on the sustainability of cocoa farming (sustainability index) was 55.95% (moderately sustainable) with stress value = 0.163 and R^2 = 0.910. Stress value 0.163 < 0.25 and the value of R^2 = 0.910 shows that the model using these attributes explained 91.00% of the existing model. The Monte Carlo sustainability index was 56.70%, when compared to MDS. There was a difference of 0.75% and this was smaller than 1.0, showing the model was in a condition of the goodness of fit (Kavanagh and Pitcher, 2004).

Leverage analysis showed that the technological factors that became the main levers in the sustainability of cocoa farming were (1) pest and disease control action, (2) level of technological mastery, (3) knowledge of cocoa cultivation, and (4) availability of the result processing industry (Fig 3). Observing and acting to optimize such attributes would increase the sustainability status of cocoa farming in the future.

The level of technological mastery remains relatively low, largely owing to the level of education of farmers, who on average, have attained only junior high school or lower. This makes it difficult for farmers to receive or seek information on cocoa farming technology. Poor technological mastery has caused farmers to be unable to combat attacks of pests and diseases on their cocoa plants, leading to low productivity. Therefore, to increase the index and sustainability status of cocoa farming, it is necessary to improve these sensitive attributes (among others) by means of more intensive agricultural extension and training. Likewise, it is necessary to improve the frequency, content, and quality of extension program (Effendy et al., 2013; Effendy et al., 2019).

Factors that help farmers in cocoa farming

There are 6 factors assisting farmers in cocoa farming and thereby affecting its sustainability: (1) the extension program, (2) loans when needed, (3) government support, (4) participation in farmer cooperatives, (5) suppliers of agricultural inputs, and (6) farmer groups. We used the Rapco-Central Sulawesi method to analyze these attributes.

The analysis results of the Rapco-Central Sulawesi method show the factors that help farmers for sustainability of cocoa

farming (sustainability index) by 59.60% (moderately sustainable) with stress value = 0.167 and R^2 = 0.9096. Stress value 0.167 < 0.25 and the value of R^2 = 0.9096 shows that the model using these attributes explained 90.96% of existing models. The Monte Carlo sustainability index was 60.30%, when compared to MDS. There was a difference of 0.70% and this was smaller than 1.0, showing the model is in a condition of the goodness of fit (Kavanagh and Pitcher, 2004).

The leverage analysis results show that the main levers in cocoa farming sustainability were (1) could get a loan when needed, (2) farmer groups, (3) government support, and (4) extension programs (Fig 4). Addressing these 6 attributes could increase the sustainability status of cocoa farming.

Farmer groups in Central Sulawesi are better developed, but not optimally, leading to their inability to help their members in terms of the availability of agricultural inputs. According to farmers, the availability of agricultural inputs was very important in cocoa farming. Agricultural inputs, such as fertilizer, greatly affect cocoa production (Effendy, 2018b). In farmer groups, cooperation between members could encourage more efficient use of resources. Farming efficiency could reduce production costs and thereby increase profit margins (Effendy et al., 2019). Farmer groups could also be a means of technological innovation diffusion and knowledge (Stockbridge et al., 2003; Nuryanti and Swastika, 2011).

Farmers showed themselves to be in sore need of financial institutions such as banks and cooperatives. The results of interviews with farmers indicated that they had difficulty acquiring financial loans, which forms a significant barrier to preparing production inputs. Government support was highly expected in the availability of facilities and infrastructure in rural areas so that farmers could meet their needs.

Factors affecting future of cocoa farming families

Factors affecting future of cocoa farming families and sustainability of cocoa farming consist of 8 attributes, namely (1) agricultural education programs for young people, (2) availability of home credit services, (3) increases in educational opportunities, (4) improvement of infrastructure (roads, telecommunications, etc.), (5) increasing the availability of employment outside agriculture, (6) providing support in the event of a natural disaster (earthquakes, floods, landslides, etc.), (7) guaranteeing cocoa beans prices, (8) increases in credit availability. We used the Rapco-Central Sulawesi method to analyze these attributes.

The analysis using Rapco-Central Sulawesi method show factors that affect the future of cocoa farming families and sustainability of cocoa farming (sustainability index) was 47.52% (weakly sustainable) with stress value = 0.178 and R^2 = 0.8791. Stress value 0.178 < 0.25 and the value of R^2 = 0.8791 shows that the model using these attributes explained 87.91% of the existing models. The Monte Carlo sustainability index was 47.58%, and when compared to MDS there was a difference of 0.059%, smaller than 1.0. This shows that the model is in a condition of goodness of fit (Kavanagh and Pitcher, 2004).

Leverage analysis results show that the main levers in the sustainability of cocoa farming were (1) increasing credit availability, (2) guaranteeing cocoa beans, (3) providing support in the event of natural disasters (earthquakes, floods,

Table 1. Factors and attributes that tended to affect the sustainability of cocoa farming.

| Factors	Attributes	Symbol
Ecological factors	(1) land suitability and agro-climate	EF1
	(2) land and environmental management	EF2
	(3) use of cacao beans	EF3
	(4) cocoa productivity	EF4
	(5) the quality of cocoa beans produced	EF5
	(6) the use of organic material as fertilizer	EF6
	(7) the age of the cocoa plant	EF7
	(8) cocoa pod borer (CPB) pest attack	EF8
	(9) attack of cocoa black pod (CBP) disease	EF9
	(10) attack of pests and diseases other than CPB and CBP	EF10
Socioeconomic Factors	(1) formal education of farmers	SF1
	(2) scale of cocoa farming	SF2
	(3) cocoa farming experience	SF3
	(4) family participation in cocoa farming	SF4
	(5) labor absorption from cocoa farming	SF5
	(6) cocoa farming income	SF6
	(7) farming income other than cocoa	SF7
	(8) income outside agriculture	SF8
	(9) market access	SF9
	(10) dependence on foreign market prices	SF10
	(11) the size of farmer households	SF11
	(12) the age of the cocoa farming manager	SF12
Technological factors	(1) knowledge of cocoa cultivation	TF1
	(2) level of technological mastery	TF2
	(3) cacao crop pruning action	TF3
	(4) fertilizing action	TF4
	(5) cocoa pest and disease control action	TF5
	(6) availability of the result processing industry	TF6
Factors that help farmers in cocoa farming	(1) extension program	FH1
	(2) could get a loan when needed	FH2
	(3) government support	FH3
	(4) participation in farmer cooperatives	FH4
	(5) suppliers of agricultural inputs	FH5
	(6) farmer groups	FH6
Factors of cocoa farming families' future	(1) agricultural education program for young people	FF1
	(2) availability of home credit services	FF2
	(3) increase educational opportunities	FF3
	(4) increasing infrastructure	FF4
	(5) availability of employment outside agriculture	FF5
	(6) providing support in the event of a natural disaster	FF6
	(7) give guarantees the of cocoa beans price	FF7
	(8) increase in credit availability	FF8
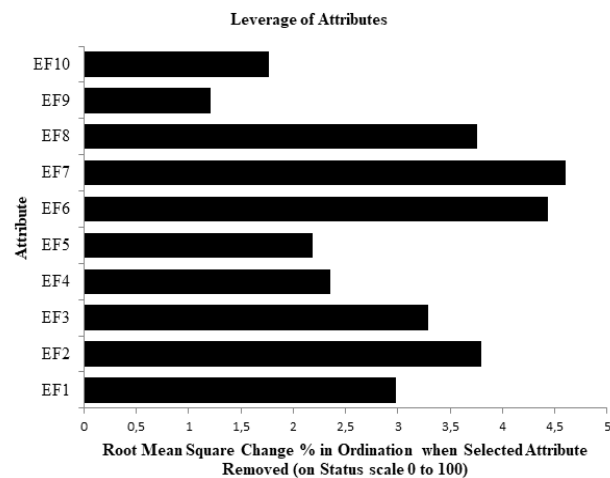
Fig 1. Leverage (sensitivity) analysis results of ecological factors.

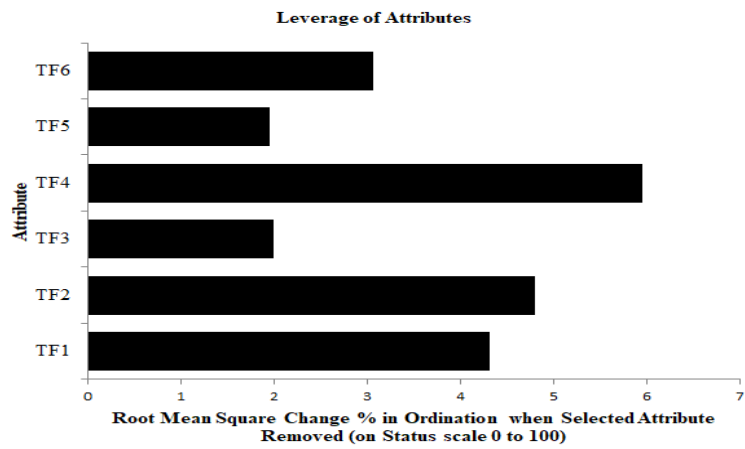**Fig 2.** Leverage (sensitivity) analysis results of socioeconomic factors.

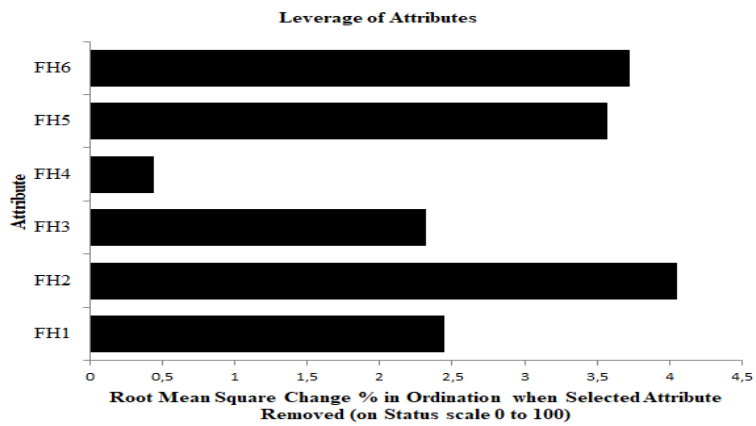**Fig 3.** Leverage (sensitivity) analysis results of technological factors.

Fig 4. Leverage (sensitivity) analysis results of factors that help farmers.
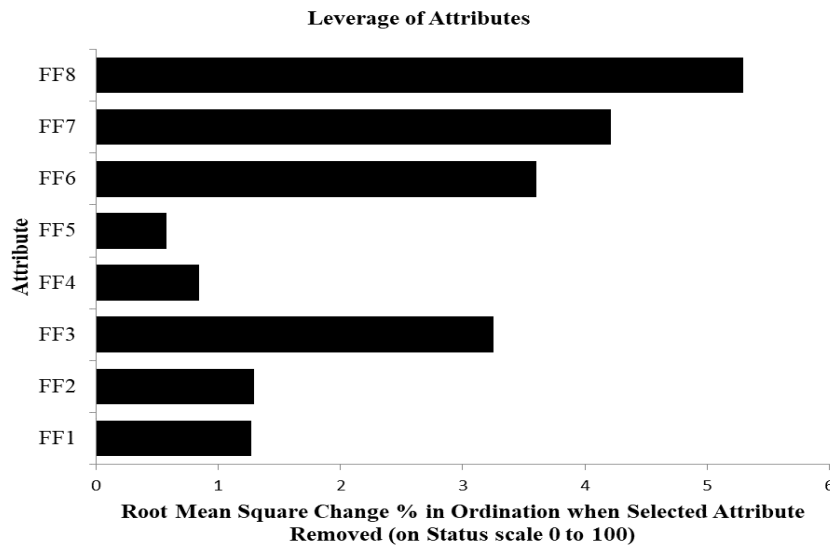
Leverage of Attributes

Fig 5. Leverage (sensitivity) analysis results of factors of cocoa farming families' futures.

landslides, etc.), and (4) increasing educational opportunities (Fig 5). Increasing the sustainability status of cocoa farming in the future may rely on consulting these attributes. Financial institutions such as banks were already available in Central Sulawesi, but the availability of credit services for farmers in rural areas remains poor. This means that such institutions are still unable to help farmer families in terms of the finance. According to farmers, the availability of credit services is very important for home loans and the availability of agricultural inputs. In addition, credit services are useful for increasing opportunities for higher education among farmer's children. Education helps farmers make the right decisions in farming, including using resources more efficiently and implementing more effective methods (Singha et al., 2012; Abdullah and Samah, 2013).

Government support in the event of a natural disaster greatly helps farmers to continue productivity. Interviews with farmers revealed that they were greatly helped by government assistance in improving infrastructure, such as roads and telecommunications, especially with reference to the natural disaster on September 28, 2018 in Palu. Besides that, they also look forward to government assistance in stabilizing cocoa prices.

Materials and Methods

Research areas

The current study conducted a cocoa farming sustainability survey in Central Sulawesi Province, Indonesia. Primary data collection used a questionnaire with a Likert scale starting from 0 (very low) to 5 (very high). Sampling used a simple random method. The sample entailed 320 cocoa farmers. The study occurred from March to May 2019, with sampling carried out randomly in the villages of Berdikari and Rahmat (represented Sigi District), while the villages of Sidole and Tanampedagi represented the Parigi Moutong District.

Analysis method

The analytical method involved Multi-Dimensional Scaling (MDS) called Rapfish. We modified this method into the Rapid Appraisal for Cocoa on Central Sulawesi, expressing results in the form of an index and sustainability status. The results to obtain from the application of this method were attributes that were sensitive to the index and the sustainability status of cocoa farming. Table 1 exhibits the factors and attributes analyzed in the sustainability of cocoa farming.

The index categories and the sustainability status of cocoa farming studied have an interval of 0 to 100 percent as follows.

0.00 - 25 bad category (non-sustainable)
25.01 - 50.00 weakly category (weakly sustainable)
50.01 - 75.00 moderately category (moderately sustainable)
75.01 - 100 good category (sustainable)

Leverage analysis, Monte Carlo analysis, Stress value determination and coefficient of determination (R^2) were also done in MDS analysis. Leverage analysis (sensitivity analysis) was done to find out which attributes were considered to have a strong effect on improving the sustainability status of cocoa farming. Attributes that have a strong effect were seen in the change of Root Mean Square (RMS) ordinance on the X-axis. The greater the change in RMS, the more sensitive the role of these attributes to the improvement of sustainability status. Monte Carlo analysis was used to assess the MDS output if the difference between the Monte Carlo index and MDS was less than 1 showing that the cocoa farming sustainability index status value corresponded to a 95 percent confidence interval. Stress value and coefficient of determination (R^2) functioned to know the suitability of the MDS model if the stress value was smaller than 0.25 and the coefficient of determination (R^2) closed to 1 showed the goodness of fit (Kavanagh and Pitcher, 2004).

Conclusion

This study has identified several problems in the sustainability of cocoa farming such as farmers' education remaining low, the old age of cocoa plants, cocoa pests and diseases, cleanliness and quality of cocoa beans, low productivity, institutions, extension, technology, production costs, credit availability, and price instability of cocoa beans. The research findings support this argument, namely (a) weakly sustainable ecological factors (46,07%), (b) moderately sustainable socioeconomic factors (54,43%), (c) moderately sustainable technological factors (55,95%), (d) factors that help farmers in cocoa farming which were moderately sustainable (59,60%), and finally (e) weakly sustainable factors of cocoa farming families' futures (47,52%).

References

Abdullah FA, Samah BA (2013) Factors Impinging Farmers' Use of Agriculture Technology. Asi Soc Sci. 9(3): 120-124.

Adamišin P, Kotulič R, Kravčáková Vozárová I, Vavrek R (2015) Natural climatic conditions as a determinant of productivity and economic efficiency of agricultural entities. Agric. Econ. – Czech, 61: 265–274.

Adamisin P, Kotulic R, Vozarova IK 2017 Legal form of agricultural entities as a factor in ensuring the sustainability of the economic performance of agriculture. Agric. Econ. – Czech, 63, 2017 (2): 80–92

Akcaoz H, Kizilay H (2009) Sustainability of dairyproduction in Turkey: A case study. Agric Econ -Czech. 55(1): 25–32.

DPDJP (2009) Handbook of cultivation technical of cocoa (Theobroma cacao L.). The Increasing Production Movement and National Cocoa Quality, Jakarta (In Indonesia).

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

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 of 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.

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

Effendy (2018a) Factors affecting variation of total factor productivity in cocoa farming in the Central Sulawesi, Indonesia. AJCS. 12(04): 655-660.

Effendy (2018b) Changes of technical efficiency and total factor productivity of cocoa farming in Indonesia. Bul J of Agric Sci. 24(4): 566–573.

Giannoccaro G, Berbel J (2014) Farmers' stated responses towards the chemicals use under the CAP liberalization. Agric. Econ.– Czech. 60(1): 9–20.

Gugere JK, Antara M, Alam MN (2016) Production and IncomeAnalysis of Cocoa Farmingin Tongoa Village, Palolo Sub District, Sigi Regency. J. Agroland 23(1): 1-10.

Hansen JW (1996). is agricultural sustainability a useful concept? Agric Syst. 50: 117– 143.

Heinen JT (1994) Emerging, diverging and converging paradigms on sustainable development. Inter J of Sust Develop and World Eco. 1: 22–33.

Kavanagh P, Pitcher TJ (2004) Implementing Microsoft Excel Sofware for Fish: A Technique for The Rapid Appraisal of Fisheries Status. University of British Columbia. Fisheries Centre Research Report 12 (2).

Ministry of Industry (2007) Overview of the Cocoa Industry (in Indonesia). https://www.google.co.id/?gws_rd=ssl#q=Asosiasi+Kakao+Indonesia+(2005).+Prospek+Agroindustri+Kakao+Indonesia+di+Pasaran+Dunia+Sampai+Dengan+2010. Accessed 23.7.2019.

Muhardi, Effendy (2017) Cocoa farming patterns for sustainability of Indonesia Lore Lindu National Park (LLNP). AJCS. 11(08), 917-924.

Nurhidaya, Antara M, Effendy (2015) Effect of production input to the quality of cocoa beans and income cocoa farming in palolo sub district sigi district. J. Agroland 22(3): 254 – 264.

Nuryanti S, Swastika DKS (2011) Roles of Farmers' Groups in Agricultural Technology Adoption. Forum Penelitian Agro Eko. 29(2): 115 – 128.

Olson MS, Van Bever D, Verry S (2008) When growth stalls. Harvard Business Review, 86: 51–62.

Shearman R (1990) The Meaning and Ethics of Sustainability. Envi Manag. 14(1): 1–8.

Singha AK, Baruah MJ, Bordoloi R, Dutta P, Saikia US (2012) Analysis on Influencing Factors of Technology Adoption of Different Land Based Enterprises of Farmers under Diversified Farming System. J of Agric Sci. 4(2): 139-146.

Stockbridge M, Andrew D, Jonathan K, Jamie M, Nigel P (2003) Farmer Organizations For Market Access: An International Review. https://assets.publishing.service.gov.uk/media/57a08cb140f0b6497400138e/R8275_040518_IntlRev_FO_MktAccss.pdf. Accessed 23.7.2019.

Van-Calker KJ, Berentsen PBM, Giesen GWJ, Huirne RBM (2005) Identifying and ranking attributes that determine sustainability in Dutch dairy farming. Agric and hum Val. 22(1): 53–63.