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Determinants of oil palm smallholder farmers' adaptation strategy to climate change in Bengkulu, Indonesia

Determinantes de la estrategia de adaptación de los pequeños agricultores de palma aceitera al cambio climático en Bengkulu, Indonesia

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Abstract: Bengkulu is one of 10 provinces in Indonesia, which became a center of oil palm production. The aim of the study is to define how the determinant factors influence the oil palm smallholder farmer's adaptation strategies on climate change in Bengkulu Province, Indonesia. Binary logistic regression method was employed to clarify the independent variables that influence farmers' strategy adapted to climate change. Farmer experience and their household expenditure have the positive and significant effect on cropping diversification, while oil palm price has a positive influence in using land clearing without slash and burning. The factors that most influence the farmers' adaptation to climate change are farmer's cooperation membership and membership of farmer group for agricultural extension. Because of their education and experience, they are not an important determinant on strategies adapted to climate change, but the farmer's group for agricultural extension was very important in the adoption of comprehensive adaptation strategies to climate change, thus the understanding and skill of implementing strategies adapted to climate change among smallholder farmers needs improving by government extension agency. Therefore, ensuring access to information on climate change through extension agents is believed to create awareness and favorable conditions to adopt farming practices suited to climate change. It also means that improving the knowledge and skills of extension service personnel about climate change and adaptation strategies, and making the extension services more accessible to farmers is strongly recommended. For future

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work, new research involving more area with diversified ownership can be performed, not only smallholder farmer ownership but also private and state corporation ones. Moreover, the study about government action and policy for accelerating farmer's adaptation is important to be executed in the future.

Key-words: adaptation, climate change, oil palm, Indonesia, logit model.

Resumen: *Bengkulu es una de las 10 provincias de Indonesia, que se convirtió en un centro de producción de palma de aceite, donde las plantaciones de palma aceitera son la mayor superficie de tierra entre los cultivos de plantaciones en esta región. Este estudio tiene como objetivo específico determinar cómo influyen los factores determinantes en las estrategias de adaptación de los pequeños agricultores de palma aceitera sobre el cambio climático en la provincia de Bengkulu, Indonesia. Se empleó el método de regresión logística binaria para aclarar las variables independientes que influyen en la estrategia de los agricultores adaptada al cambio climático. La experiencia de los agricultores y el gasto de sus hogares tienen un efecto positivo y significativo en la diversificación de los cultivos, mientras que el precio de la palma aceitera influye positivamente en el uso del desmonte sin quemarse. Los factores que más influyen en la adaptación de los agricultores al cambio climático son la membresía de cooperación de los agricultores y la pertenencia al grupo de agricultores para la extensión agrícola. Debido a su educación y experiencia no son un determinante importante de las estrategias adaptadas al cambio climático, el grupo de agricultores para la extensión agrícola fue muy importante en la adopción de estrategias integrales de adaptación al cambio climático, así como la comprensión y habilidad de implementar estrategias adaptadas al clima el cambio entre los pequeños agricultores necesita mejorarse por medio de la agencia de extensión del gobierno. Por lo tanto, se cree que garantizar el acceso a la información sobre el cambio climático através de agentes de extensión crea conciencia y condiciones favorables para la adopción de prácticas agrícolas adecuadas al cambio climático. También significa que se recomienda encarecidamente mejorar el conocimiento y las habilidades del personal de servicios de extensión sobre el cambio climático y las estrategias de adaptación, y hacer que los servicios de extensión sean más accesibles para los agricultores. Para el trabajo futuro, se debe considerar la realización de una nueva investigación que involucre más áreas con propiedad diversificada, no solo la propiedad de los pequeños agricultores, sino también las empresas privadas y estatales. Además de eso, el estudio sobre la acción del gobierno y la política para acelerar la adaptación de los agricultores también es importante para ser ejecutado en el futuro.*

Palabras clave: adaptación, cambio climático, palma aceitera, Indonesia, modelo logit.

JEL Classification: Q1

1. Introduction

Over the years, large areas of primary and secondary forest have been cut or burned down to make way for oil palm plantations, particularly in Indonesia and Malaysia, the two countries that produce 80.5 percent of the world's palm oil. To tackle the many complex sociopolitical issues surrounding the industry, a variety of regulations, and campaigns have been developed by governments and non-governmental organizations (NGO) over the years attempting to create a more sustainable industry, partly in response to pressure from the environmental community (Ivancic & Koh, 2016).

Responding to this pressure, Indonesia, the biggest palm oil world producer, launched mitigation actions on climate change by smallholder farmers in 2010 (Agency for Agricultural Research and Development, 2010). Oil palm plantations, with total area of 11,672,861 hectares, are the largest plantation in Indonesia (Agricultural Statistics, 2016). 40.8 percent of this total oil palm area in Indonesia, or 4,763,797 hectares, were smallholder farmers' ownership (Tree Crop Estate Statistics of Indonesia, 2016). Thus, when the oil palm smallholder farmers have a high capability of adapting to climate change, they will highly contribute to the success of the launched program.

Farmer's behavior adapted to climate change refers to how farmers commit acts for adjusting or changing their farming activities to minimize the negative or to optimize the positive impact of climate change (Tripathi & Mishra, 2017; Füssel, 2007). Adaptation is intangible intrinsic properties of farmer households that actually depends on many specific factors (Rurinda et al., 2014; Vervoort et al., 2014). This adaptation can be either anticipatory or reactive strategy over time (Smit & Wandel, 2006). The strategy was categorized as spontaneity if the farmer took this strategy passively without anticipating and planning as response climate change. Contrarily, if the adaptation strategy arises as planning and anticipation against the effect of climate change so that such adaptations were categorized as a planned adaptation. Climate change adaptation research at the farm level will provide an understanding of specific adaptation strategies and their impacts (Below et al., 2012). The farmer's strategies adapted to climate change at the farm level have been studied by researchers in Indonesia, but generally those studies are conducted in cereal and horticulture crops farming (Widiyanti & Dittmann, 2014; Sukma, 2012; Kurniawati, 2011; Permana, 2013; Siburian, 2009; Candradijaya, 2015; Sukartini & Solihin, 2013; Festiani, 2011), while a similar study to palm oil farming has not been carried out yet. So the study of how oil palm smallholders take strategies adapted to climate change is important to be executed.

This study was executed and located in the Bengkulu for three important reasons: First, based on empirical evidence (Houdian et al., 2014) that showed the amount of carbon dioxide (CO_2) in the province of Bengkulu in 2013 was as much as 913.21 thousand tons and it may increase to 9835.61 thousand tons in 2030, or there will be a 15 percent growth annually. As we know, CO_2 is an essential element that produce the greenhouse effect, one kind of main emitted gases responsible for climate change. Second, the research was showing that palm oil plantation had high growth per year in the four districts of smallholders' production center in province of Bengkulu: 49.38 percent, 52.34 percent, 32.14 percent and 17.43 percent for Muko-Muko, Bengkulu Utara, Seluma and South Bengkulu, respectively (Ardana et al., 2014). Third, Bengkulu is one of 10 provinces in Indonesia, which became a center of oil palm production, where the area is the largest among those plantation crops in Bengkulu. Besides that, from the area classification based on land ownership of oil palm plantations in the province of Bengkulu, the smallholder ownership area (195.213 ha) is the largest (Tree Crop Estate Statistics of Indonesia, 2016).

Understanding the factors that determine the behavior of climate change adaptation in the farming level is important because it helps creating policies that can facilitate the adaptation process to be implemented on a larger scale than individual households or community level (Wood et al., 2014). Therefore, this study specifically aims to determine how the determinant factors influence the smallholder farmer's adaptation strategies on climate change, and to analyze the marginal effect magnitude of those determinants. This study is expected to enrich the understanding of socio-economic researchers about how smallholder farmers adapt to climate change, especially for oil palm farming.

2. Methodology

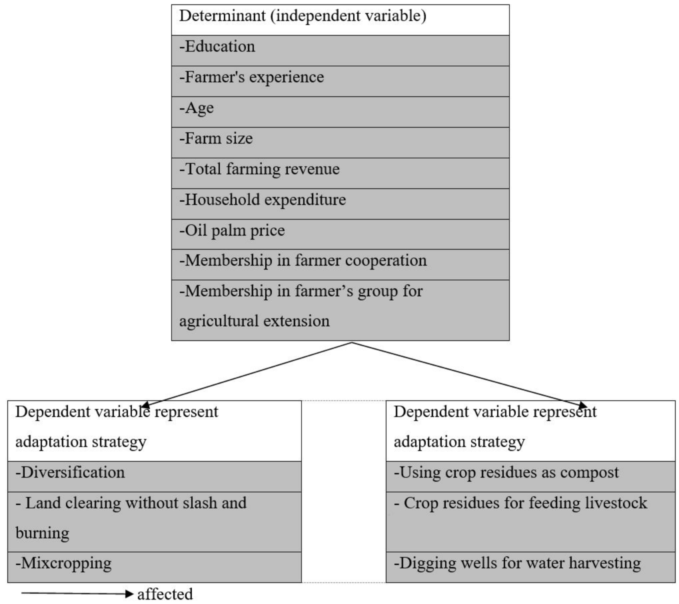
2.1. Research framework

Research framework of this study can be seen in Figure 1. By referring to previous studies and field investigation about farmer behavior that can be classified as the adapted strategy to climate change, we have identified six behaviors or farmer's activities, which were suitable as adapted strategies of oil palm smallholder farmers in Bengkulu. Those activities are diversification of farming (Barbier et al., 2009; Below et al., 2012; Yegbemey et al., 2013; Li et al., 2013; Bryan et al., 2013; Jianjun et al., 2015; Singh et al., 2016; Yu, 2016; Sukma, 2012; Permana, 2013; Rurinda et al., 2014; Elum et al., 2017; Tambo, 2016; Ehiakpor et al., 2016), land clearing without slash and burning (Tomich et al.,1998), mix cropping (Deressa et al., 2009; Gebrehiwot & Van Der Veen, 2013; Alauddin & Sarker, 2014; Widiyanti & Dittmann, 2014; Jianjun et al., 2015; Tripathi & Mishra, 2017; Truelove et al., 2015; Tambo, 2016; Abid et al., 2016; Singh et al., 2016; Nguyen et al., 2016; Li et al., 2017; Ehiakpor et al., 2016), using crop residues as compost (Barbier et al., 2009; Bhaktikul, 2012), crop residues for feeding livestock (Rurinda et al., 2014; Tambo, 2016), and digging wells for water harvesting (Sukma, 2012; Udmale et al., 2014; Widiyanti & Dittmann, 2014; Swe et al., 2015). Therefore, the details of the independent variables and their alleged effect on the dependent variable can be seen in Table 1.

2.2. Sampling and data collection methods

This study was executed from October to November 2015 in the districts of Bengkulu Utara and Muko-muko. The research locations were determined deliberately

Figure 1. Framework to estimate the impact of determinants (independent variables) on farmer's climate change adaptation strategies (dependent variables).



Source: The authors.

Table 1. Description of independent variables used in binary logistic regression analysis

Independent variable	Measurement and unit	Expected effect	Research referred
Expenditure	Household expenditure in IDR (Indonesian currency)	+	Deressa et al. (2009); Sahu & Mishra (2013); Gebrehiwot & Van Der Veen (2013); Jianjun et al. (2015); and Abid et al. (2016)
		-	Menike & Arachchi (2016)
Farm size	Farm size in hectare	+	Gebrehiwot & Van Der Veen (2013); Alauddin & Sarker (2014); and Jianjun et al. (2015)
		-	Candradijaya (2015)
Oil palm farming total revenue	Total revenue of household's farmer from oil palm farming in IDR (Indonesian currency)	+	Deressa et al. (2009); Sahu & Mishra (2013); Gebrehiwot & Van Der Veen (2013); Pires & Cunha (2014); Jianjun et al. (2015) and Abid et al. (2016)
		-	Menike & Arachchi (2016)
Oil palm price	Price per kilogram in IDR per kilogram	+	Asset and wealth of households are also needed to facilitate the adoption of adaptation strategies cause of being needed for adequate capital. (Carter & Barrett, 2006). Thus, the allegedly higher oil palm price means the greater farmer's income, thus further enabling farmers to invest in climate change activities.
Age	Age of farmer in years	+	Deressa et al. (2009); Gebrehiwot & Van Der Veen (2013); Pires & Cunha (2014); and Candradijaya (2015)
		-	Roco et al. (2014)
Experience	Number of years in oil palm farming	+	Festiani (2011); Bryan et al. (2013); Roco et al. (2014); and Jianjun et al. (2015)
Education	1 if Senior high school and above and otherwise=0	+	Deressa et al. (2009); Kurniawati (2011); Yegbemey et al. (2013); Alauddin & Sarker (2014); Jianjun et al. (2015); Menike & Arachchi (2016); and Abid et al. (2016)
Farmer cooperation membership	Membership in farmer cooperation if yes = 1 and no=0	+	Ehiakpor et al. (2016);
		-	Bryan et al. (2013)
Membership in farmer's group for agricultural extension	Membership in farmer's group for agricultural extension if yes = 1 and no=0	+	Deressa et al. (2009); Below et al. (2012); Bryan et al. (2013); Yegbemey et al. (2013); Gebrehiwot & Van Der Veen (2013); and Tambo (2016)

Source: The authors.

with the consideration that the two districts are the highest oil palm production areas in the province of Bengkulu, where the growth of oil palm land per year for Bengkulu Utara and Muko-muko are 52.34 percent and 49.38 percent, respectively (Ardana et al., 2014). Then, we randomly selected 47 smallholder farmers in Bengkulu Utara and 82 in Mukomuko as our samples. The total sample was 129 smallholder oil palm farmers. The cross-section primary data was collected through interviewed directly with farmers in the study sites using a list of questions (questionnaire), which had been served by the researchers.

2.3. Logit model

In addition, binary logistic regression method was employed to clarify the independent variables that influence farmers' strategy adapted to climate change. According to Tesfahunegn et al. (2016), this regression analysis is useful for predicting the discrete outcome of the dichotomous dependent variable from independent variables that may be continuous, discrete, and dichotomous or a combination of these. In this study, the dependent variable is dichotomous variable with value 1 or 0 if a farmer is being adapted (1) or not being adapted (0) to climate change (Table 2).

The binary logistic regression function estimated the likelihood of the effects of the independent variables on the dependent variable (Thomas, 1996) is described as:

$$Ln\left(\frac{P}{1-P}\right)\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \; .... \beta_k X_k \qquad (1)$$

The value of *P/(1-P)* is called the odds (likelihoods) ratio, if *P* is the probability for farmers' being adapted to climate change activity, then (1-*P*) represents the probability of not being implemented climate change activity; β_0 is the intercept, β_1, β_2 … and β_i are regression coefficients of the independent variables of X_1, X2 … and X_k. If the value of the odds ratio is higher than 1, the likelihood of the effect of the independent variable on the dependent variable is increased (positive relationship), odds ratio value of one indicates no relationship and a value less than one indicates the negative relationship.

Table 2. Description of variables that used in the research

List of variable	Position	Mean	Std. Dev.	Measurement and unit
Diversification	Dependent variable	0.34	0.475	Dummy, value 1 for diversified farming and 0 for otherwise
Land clearing without slash and burning	Dependent variable	0.41	0.493	Dummy, value 1 if farmer is doing land clearing without slash and burning and 0 if otherwise
Mixcropping	Dependent variable	0.55	0.499	Dummy, value 1 if farmer is doing mix cropping and 0 if otherwise
Using crop residues as compost	Dependent variable	0.32	0.47	Dummy, value 1 if using crop residues as compost and 0 if otherwise
Crop residues for feeding livestock	Dependent variable	0.17	0.377	Dummy, value 1 if crop residues for feeding livestock and 0 if otherwise
Digging well for water harvesting	Dependent variable	0.44	0.498	Dummy, value =1 if digging well for water harvesting and 0 if otherwise
Expenditure	Independent	2516166	2318069	Continous
Farm size	Independent variable	2.86	3.36	Continous
Oil palm farming total revenue	Independent variable	5357726	16659770	Continous
Oil palm price	Independent variable	797.37	93.93	Continous
Age	Independent variable	42.93	11.52	Continous
Farmer's experience	Independent variable	13.29	8.29	Continous
Education	Independent variable	0.67	0.47	Dummy, value 1 if high senior school and above and 0 if otherwise
Farmer cooperation membership	Independent variable	0.31	0.46	Dummy, value 1 if member of farmer cooperation and 0 if otherwise
Membership in farmer's group for agricultural extension	Independent variable	0.81	0.39	Dummy, membership in farmer's group for agricultural extension if yes = 1 and no=0

Source: Owned survey data (2015).

Likelihood ratio test to be employed to assess goodness of fit of the model (Thomas, 1996). In order to test the null hypothesis that all the slope coefficients are simultaneously equal to zero, the equivalent of the F test in the linear regression model is the likelihood ratio (LR) statistic. Given the null hypothesis, the LR statistic follows the $\chi 2$ distribution with df equal to the number of explanatory variables (Gujarati, 2004).

Based on the owned survey, there were six adaptation strategies employed by smallholder farmers in research locations; therefore, those dependent variables of strategies adapted to climate change as the qualitative binary variable that takes value = 1 for those farmers who undertake these activities and 0 for otherwise (Table 2).

3. Results and discussion

3.1. Overview of oil palm smallholder farmer adaptation to climate change

Farmer's knowledge and understanding of climate change were very limited. It could be seen from the data that 100 percent of the smallholder farmer's sample could not explain what meaning climate change is. Nevertheless, it was not necessarily inferred that farmers were not adapting and mitigating climate change. Climate change adaptation at the farm level may take the form of an action or a certain action as strategies adapted to climate change, even though they could not explicitly identify what they did as a form of adaptation and mitigation on climate change (Bhaktikul, 2012).

Smallholder farmers adaptation is essential in mitigating the potential impacts of climate variability. Jiri et al. (2015) argued that the vulnerability of smallholder farmers would continually increase without adaptation. Based on the owned survey, it was identified that there were six adaptation strategies that were employed by smallholder farmers in research locations, as can be seen in Table 3.

Farm diversification is undertaken to reduce losses due to the failure of one farming cause of extreme climates. Most smallholder farmers did not take diversification strategy, only 33.3 percent of those smallholder farmers who did this adapted strategy. The pattern of farming diversification which was undertaken by smallholder farmers can be seen in Table 4.

Table 3. Palm oil smallholder farmer's strategies adapted to climate change at farm level (n=129)

Strategy Adapted	Yes		No	
	Frequency	Percentage	Frequency	Percentage
Diversification	43	33.3	86	66.7
Land clearing without slash and burning	52	40.31	77	59.69
Mixcropping	71	55.03	58	44.97
Using crop residues as compost	42	32.56	87	67.44
Crop residues for feeding livestock	22	17.05	107	82.94
Digging well for water harvesting	57	44.18	72	55.81

Source: Owned survey data (2015).

Table 4. Pattern of farming diversifications was undertaken by smallholder farmers in Bengkulu

Diversification Pattern	Frequency	Percentage
Oil palm + rice	2	1.55
Oil Palm + rubber	23	17.82
Oil palm +cattle	3	2.32
Oil palm+ freshwater fish	1	0.77
Oil palm + rubber+ cattle	13	10.07
Oil palm +cattle + thorny palm + freshwater aquaculture	1	0.77
Total	43	33.3

Source: Owned survey data (2015).

The most common diversification pattern undertaken by the farmers was, as Suckall et al. (2014) mentioned, that farmer diversified their activities for reasons: 1) anticipation in case there was a risk in main commodity if farm production was down and its price fell and 2) increase the income of farming households. For such reasons, there were 40 farmers applying diversified farming not only planted oil palm but also to grow other crops, such as rubber, thorny palm and cattle. Another form of diversification was using short-growth-period crops. Only three farmers who took this strategy diversified. They planted short-growth-period crops, like rice and freshwater fish, to guarantee their harvest because of their coincidence with the rainy season. Such strategy also was found by (Li et al., 2015).

Land clearing are activities that are carried out by the farmer to prepare the area ready for planting to support plant growth and facilitate the management of the farming land. Land clearing behavior that reflects a negative impact on the climate change is by slash and burning (Tomich et al., 1998). Thus, if the smallholder farmers were doing land clearing without slash and burning then that behavior is categorized as a strategy adapted to climate change.

It was known that the majority of oil palm smallholder farmer in Bengkulu took land clearing by slash and burning (59.69 percent). There were many reasons why smallholder farmers took land clearing by slash and burning, namely making soil easier to plant (6.97 percent), the fastest way for land preparation (5.42 percent), make soil more fertile (3.11 percent), the clearest land for planting (15.51 percent) and without reason (21.71 percent), respectively (Table 5).

Generally, mixed cropping has been the most important strategy adapted to climate change. It has been affirmed by 55.03 percent of the oil palm smallholder's farmers in the Bengkulu (Table 3). Generally, oil palm is noted as a mixed crop or an intercrop at the early stage (usually from 1 to 4 years). Farmers in most cases plant maize, tubers and pulses together with the oil palm tree.

Farmer activity that convert agricultural residues to compost can be viewed as an adapted strategy on climate change because this action is categorized as an implementation of conservation agriculture (Bhaktikul, 2012). Only 32.56 percent of oil palm smallholder farmers were discovered to had had undertaken this adaptation strategy (Table 3).

Using oil palm plant residues to feed cattle could be categorized as an strategy adapted to climate change because such behavior could improve farm efficiency due to the use of sewage oil palm farm as a production factor of other farming (cattle) and minimized risk of agribusiness failure due to climate change (Rurinda et al., 2014). Table 3 shows that only 17.05 percent of oil palm smallholder farmers in Bengkulu used their oil palm residues to be used as cattle feeding.

Digging wells for water harvesting was categorized as an action that reflected farmers' adaptation on climate change (Sukma, 2012; Udmale et al., 2014; Widiyanti & Dittmann, 2014; Swe et al., 2015) because the implementation of such activity meant farmers adopt a kind of conservation agriculture and land management technologies to improve plant resistance to drought. Surveyed data showed that 44.18 percent of the number of smallholder farmers who took this strategy (Table 3).

3.2. Factors affected adaptation strategies to climate change

Before taking the statistical test about the influence of independent variables on the dependent variable, firstly it had been taken the correlation test among

Table 5. The reasons for land clearing by slash and burning

No	Reasons for burning	Frequency	Percentage
1	Cheapest cost	9	6.97
2	Make soil easier to plant	9	6.97
3	The fastest way for land preparation	7	5.42
4	The clearest land for planting	20	15.51
5	Make soil more fertile	4	3.11
6	Without reason	28	21.71
	Total	77	59.69

Source: Own survey data (2015).

independent variables which would include in the logit model. If there was a high correlation between the two independent variables, it meant both variables should not be within the same single equation to prevent the presence of multicollinearity (Gujarati, 2004; Thomas, 1996). Correlation among independent variables can be seen in Table 6. The result showed only farm size and oil palm farming total revenue are highly correlated, with the value of correlation coefficient of 0.74. Thus, these two variables cannot be included in the same single equation of logit model as an independent variable.

All equations of strategy adapted logit model had the best criteria closeness of fit. The likelihood ratio statistic ($\chi 2$) showed that five models from six strategies adapted model were found to be significant at 1 percent and one model was significant at 5 percent probability level (Table 7). It was implied that the models had a strong explanatory power. It can be seen also the direction of the influence of the independent variables on the dependent variable of each strategy adapted logit model. Table 8 showed a marginal effect or the actual magnitude of change of each independent variable on its dependent variable. Marginal effect is a measurement of the expected change in the probability of a particular adaptation strategy chosen with respect to a unit change in the explanatory variables. Gujarati (2004) said that to measure marginal effect or the actual magnitude of change of each independent variable on dependent variable by taking the antilog of the jth slope coefficient (in case there was more than one regressor in the model), subtract 1 from it and multiply the result by 100, then we will get the percent change in the odds for a unit increase in the k*th* independent variable.

Expenditure significantly influences adaptation in using crop diversification only at 1 percent probability level. The findings of the marginal effects from the logit model show that household expenditure had positive and significant statistically impact on using crop diversification. The value of the marginal effect (Table 8) showed that a unit increased in household expenditure resulted in an increase of the small probability (less than 0.01 percent) in using crop diversification as the adapted strategy for climate change. This result is the same as the finding of Ardana et al. (2014), which the more smallholder farmer household expands their costs, the more they need to expand their source of income so that the more they need crop diversification strategy.

Table 6. Correlation coefficient among independent variables

Correlation	Expenditure	Farm size	Total revenue	Price	Age	Experience	Education (dummy)	Farmer cooperation membership (dummy)	Membership in agricultural extension group (dummy)	District (dummy)
Expenditure	1.000000									
Farm size	0.350751	1.000000								
Total revenue	0.216339	0.740825	1.000000							
Price	0.058354	0.119542	0.039127	1.000000						
Age	0.077893	0.0129	-0.091882	-0.177058	1.000000					
Experience	0.030784	-0.02183	-0.059991	-0.195816	0.631945	1.000000				
Education (dummy)	0.115128	0.165337	0.112305	0.153307	-0.428116	-0.313449	1.000000			
Farmer cooperation membership (dummy)	-0.039142	-0.11298	-0.025278	-0.000930	0.116117	0.252224	0.011851	1.00000		
Membership in agricultural extension group (dummy)	0.090488	-0.29005	-0.225426	0.000663	0.063400	0.130492	-0.084515	0.2343	1.000000	
District (dummy)	-0.002301	-0.05832	0.012988	-0.230483	0.320018	0.374995	-0.011390	0.4327	-0.134770	1.00000

Source: Own Survey data (2015).

Table 7. Parameter estimation of the logit model of adaptation strategy (n=129)

Independent variables	Dependent variables											
	Diversification		Land clearing without slash-burn		Mixcropping		Crop residues as compost		Crop residues for feeding livestock		Digging wells for water harvesting	
	coefficient	Prob.	coefficient	Prob.	coefficient	Prob.	coefficient	Prob.	coefficient	Prob.	coefficient	Prob.
Expenditure	8.45E-07***	0.0038	-1.85E-07	0.164	-6.29E-08	0.425	5.9E-08	0.557	-4.84E-08	0.764	6.55E-08	0.589
Farm size	-	-			-	-	-0.1161	0.142	-	-	0.02285	0.765
Total revenue from palm oil farming	2.15E-08	0.2632	2.72E-08	0.581	-	-	-	-	-			
Palm oil price	-0.0057	0.2728	0.0059**	0.019			0.0043*	0.072	0.0017	0.593	-0.0040	0.108
Age	-0.0539	0.2878	-0.0161	0.503	-0.0102	0.532	0.0155	0.542	-0.0414	0.233	0.0032	0.909
Experience	0.1371**	0.0377	-0.0459	0.226	-	-	-0.0138	0.705	0.0246	0.623	-0.0220	0.597
Education (dummy)[a]	-0.0124	0.9903	-0537	0.912	-	-	0.3879	0.466	0.2368	0.751	0.7539	0.222
Membership in farmer cooperation [b]	0.9276	0.4045	0.9495*	0.074	0.5540	0.185	1.6839***	0.041	2.6284***	0.001	0.7004	0.328
Membership in agricultural extension group (dummy) [c]	-0.3484	0.7550	-1.2281**	0.033	1.2522***	0.013	-1.5933**	0.0101	0.9826	0.378	2.1728***	0.009
District (dummy)[d]	6.6188***	0.0000	-0.4187	0.449	-	-	-1.9237***	0.0027	-3.3081***	0.002	-4.0586***	0.000
Constant	-1.3693	0.7527	-2.6410	0.239	-0.3878	0.632	-3.3950	0.137	-2.6360	0.418	2.4325	0.324
LR Statistic	120.3992***		27.5896***		10.9141**	0.027	26.04***		36.2195***		66.1462***	
Prob (LR Statistic)	0.000000		0.0011		0.0275		0.002		0.000016		0.000000	

***, **, * are significant at 1, 5 and 10% probability level, respectively [a] Dummy, 1 = senior high school and above and 0 = otherwise [b] Dummy, 1 = member of farmer cooperation and 0= otherwise [c] Dummy, 1= member of agricultural extension group and 0= otherwise [d] Dummy, 1= for Bengkulu Utara district and 0 for Muko-muko district

Table 8. Marginal effect or percent change in the odds of dependent variable for a unit increase in the each its dependent variable (n=129)

Independent variables	Dependent variables					
	Diversification	Land clearing without slash-burn	Mix cropping	Crop residues as compost	Crop residues for feeding livestock	Digging well for water harvesting
	Marginal effect	Marginal effect	Marginal effect	Marginal effect	Marginal effect	Marginal effect
Expenditure	8.45E-05***	-1.85E-05	-6.29E-06	5.9E-06	-4.84E-06	6.55E-06
Farm size	-		-	-10.961382	-	2.3113061
Total revenue from oil palm farming	2.15E-06	2.72E-06	-	-		
Oil palm price	-0.5683	0.5917**		0.4309258*	0.1701446	-0.3992011
Age	-5.2473	-1.5971	-1.0148156	1.5620748	-4.0554725	0.3205125
Experience	14.6942**	-4.4862		-1.3705217	2.4905076	-2.1759765

***, **, * are significant at 1, 5 and 10% probability level, respectively Marginal effect = $(e^{\beta_i}-1)*100\%$

Oil palm price significantly influences adaptation using land clearing without slash and burning at 5 percent probability level. The findings of the marginal effects from the logit model showed that when a unit of oil palm price went up, then the probability of adoption land clearing without slash and burning would rise 0.59 percent. The higher the price of oil palm, the greater the income of farmers. When some of the income is saved, then it will raise the asset and capital of farmers. Carter & Barrett (2006) said that the greater the farmer's asset, the higher is their ability to invest in the activities related to climate change adaptation. This evidence indicates that when oil palm price increase, it shall trigger smallholder farmer adopt land clearing without slash and burning.

Experience significantly influence only one kind of adaptation strategy namely crop diversification at 5 percent probability level. The value of marginal effects from the logit model (Table 8) shows that a unit increase of farmer's experience will raise the probability of using crop diversification in 14.69 percent. Referring Niles et al. (2013), events that are temporal, socially, or geographically close to farmers are more tangible results in a greater likelihood to adopt behaviors that help a farmer adapt to or mitigate the problem.

Factors that most affected farmers' adaptation to climate change are their involvement in local organizations at the farm level, which in this study is represented by two independent variables namely farmer's cooperation membership and membership in agricultural extension group, respectively.

Farmer's cooperation membership significantly influences adaptation using land clearing without burning at 10 percent probability level and using oil palm plant residues as both compost and cattle feed at 1 percent probability level, respectively. The coefficient of farmer's cooperation member take positive value means that the smallholder farmers who are the member a farmer's cooperation more adapted in using land clearing without slash and burning and using oil palm plant residues as both compost and cattle feed than those smallholder farmers who are not a member (Table 8).

This result is consistent with Ehiakpor et al. (2016) about the benefits of local agricultural organizations to improve farmers' ability to adapt to climate change. In the local farm organizations, farmers interact with many parties so that they can get the information, strategies, ways of cultivation, and how to reduce the risk of failure, including the risks that arise due to the problem of climate change.

Slightly different results were found on the influence of membership in the group for the agricultural extension on adaptation strategies. Although membership in farmers' group was statistically significant effect against the four strategies adapted, namely land clearing without slash and burning, mix cropping, using oil palm residues as compost and digging wells for water harvesting at 5 percent, 1 percent, 5 percent and 1 percent the probability level, respectively. The coefficient of membership in a group for agricultural extension was positive in two equations (mix cropping and digging wells for water harvesting equation). It means the smallholder farmers who are members of a farmer group for the agricultural extension are more adapted in using mix cropping and digging wells for water harvesting than those who are not members.

Meanwhile, the coefficient value of farmer group for agricultural extension is negative in the equation both land clearing without slash and burning and using oil palm residues as compost (Table 7). It means farmers who are not participating in farmer group for the agricultural extension are more adapted in using land clearing without slash and burning and using oil palm residues as compost than those who are participating. This result is a difference from for example with the result of the study of Ustriyana & Dewi (2017) which showed that access farmer to extensions correlates with the source of information and knowledge of sustainable agriculture, which later impacts their decision to adopt techniques of sustainable agriculture. Meanwhile, our research shows that farmers who are not participating in the agricultural extension group more adopt strategy adaptation than those farmers who involved in agricultural extension indicates most of the extension material that offered for the farmers not related to strategies adaptation on climate change.

District is the dummy variable. Its coefficient takes negative values and statistically significant meant that the farmers in Muko-muko adopt more a number of strategies adapted than those farmers in Bengkulu Utara, particularly in using oil palm residues as compost, crop residues for feeding livestock and digging wells for a water harvesting, respectively. Meanwhile, the coefficient of district, which has a positive and statistically significant value, means that smallholder farmers in Bengkulu Utara district have more diversification strategy than those in Muko-muko district. The coefficient of district in the equation of land clearing without slash and burning is not significant statistically. It means that smallholder farmers in Bengkulu Utara district do not differ from farmers in Muko-muko district in using land clearing without slash and burning.

4. Conclusions

Farmer experience and their household expenditure have the positive and significant effect on cropping diversification, while oil palm price has a positive influence in using land clearing without slash and burning. The factors that most influence the farmers' adaptation to climate change are farmer's cooperation membership and membership of farmer group for agricultural extension.

Because their education and experience are not an important determinant on strategies adapted to climate change, the farmer's group for agricultural extension was very important in the adoption of comprehensive adaptation strategies to climate change. Therefore, the understanding and skill of implementing strategies adapted to climate change among smallholder farmers needs improving by government extension agency. Therefore, ensuring access to information on climate change through extension agents is believed to create awareness and favorable conditions for the adoption of farming practices suited to climate change. It also means that improving the knowledge and skills of extension service personnel about climate change and adaptation strategies, and making the extension services more accessible to farmers are strongly recommended.

For future work, performing new research involving more area with diversified ownership needs to be considered: not only smallholder farmer ownership but also private and state corporation ones. Besides that, the study about government action and policy for accelerating farmer's adaptation is also important.

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