Artículos

Adaptation Strategy to Climate Change Among White Pepper Smallholder Farmers in Bangka-Belitung, Indonesia*

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Abstract:

This study aimed to determine the effect of the socio-economic factors on climate change adaptation strategy of white pepper farmers in Bangka-Belitung Province, Indonesia. West Bangka Regency was chosen as a research site because this area is one of the main white pepper growing-areas. Then, 70 samples of white pepper farmers were randomly selected. The cross-sectional primary data were collected through interviews directly with farmers in the research location using a list of questions in the questionnaire previously served by the researcher. The logit regression model was used to analyze factors influencing the farmers' adaptation to climate change. This research suggested the following: 1) government programmes related to accelerating the implementation of climate change adaptation should be prioritized to female farmers and 2) knowledge and technical skills of extension agents at a local level, related to implementing climate change adaptation strategies, must be increased as well as materials regarding the implementation of climate change adaptation should be part of the agricultural extension syllabus for white pepper farmers.

Keywords: adaptation, strategy, climate change, logit model, white pepper, smallholder farmer, Bangka-Belitung.

Estrategia de adaptación al cambio climático en pequeños agricultores de Bangka-Belitung, Indonesia

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Resumen:

El objetivo de este estudio es determinar el efecto de los factores socioeconómicos sobre la estrategia de adaptación al cambio climático entre los agricultores de pimienta blanca en la provincia de Bangka-Belitung, Indonesia. Se escogió West Bangka Regency como el sitio de investigación porque esta área es una de las principales áreas de producción de pimienta blanca. Luego se seleccionaron aleatoriamente 70 muestras de agricultores de pimienta blanca. Se recogieron datos primarios transversalmente a través de entrevistas hechas directamente con los agricultores en el sitio de investigación, usando una lista de preguntas en un cuestionario provisto por el investigador. Se usó el modelo de regresión logística para analizar los factores que influyen en la adaptación de los agricultores al cambio climático. Esta investigación sugirió lo siguiente: 1) los programas gubernamentales relacionados con acelerar la implementación de la adaptación al cambio climático deben ser priorizados para las mujeres agricultores; y 2) se deben aumentar el conocimiento y la destreza técnica del agente de extensión a nivel local, relacionados con la implementación de estrategias de adaptación al cambio climático y también los materiales sobre la implementación de la estrategia de adaptación al cambio climático deben ser parte de currículo de extensión agrícola para los agricultores de pimienta blanca.

Palabras clave: adaptación, estrategia, cambio climático, modelo de regresión logística, pimienta blanca, pequeño agricultor, Bangka-Belitung.

Climate change phenomena have a dwindling effect on agricultural activities (Ehiakpor et al., 2016). The same phenomenon also occurs in the production of Bangka-Belitung's white pepper. The yield data of this commodity in Bangka-Belitung province showed a fluctuating trend and declined sharply over the past five years. In 2011 the yield of white pepper was 1,830 kg per ha, and then its yield decreased sharply to 1,555 kg per ha by 2015 (figure 1).

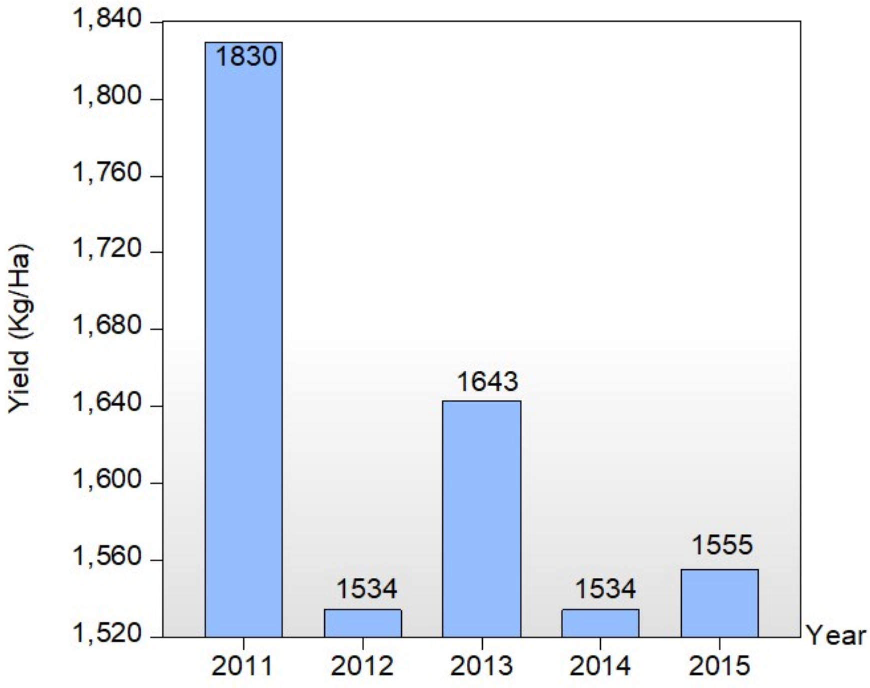

FIGURE 1.
White pepper yield in the Bangka-Belitung Province (kg/ha)
Source: Ministry of Agriculture Republic of Indonesia (2016)

According to Abid et al. (2016), farmers have understood climate change from climate-related risks that they have felt such as soil problems, events including more weeds, droughts, and floods. Two types of climate-related risks that become the determining factors of the white pepper yield decrease in Bangka-Belitung province according to the Agricultural Ministry of the Republic of Indonesia are drought and foot rot. Both diseases caused by the pathogenic fungus (Nasir, 2013).

Farmer's behavior for climate change adaptation refers to how farmers are committed with acts for arranging or modifying their farming activities to minimize the disadvantage or to optimize the benefits of climate change (Füssel, 2007; Tripathi & Mishra, 2017). Adaptation is an inexplicit intrinsic property of farmer households that really depends on many specific determinants (Rurinda et al., 2014). This adaptation can be either an anticipatory or reactive strategy over the time (Smit & Wandel, 2006). The strategy was classified as spontaneity if the farmer took this tactic passively without anticipating and planning as a response to climate change. On the contrary, if the adaptation strategy arises as planning and anticipation actions against the effect of climate change, then such adaptations are categorized as a planned adaptation.

Climate change adaptation research at the farm level will provide an understanding of specific adapted strategies to climate change and their impacts (Below et al., 2012). The farmer's adapted strategies to climate change at the farm level have been studied by researchers in Indonesia but generally, those studies are conducted on cereal and horticulture crops farming (Kurniawati, 2011; Festiani, 2011; Sukartini & Solihin, 2013;Widiyanti & Dittmann, 2014; Candradijaya, 2015), while a similar study on white pepper farming has not been performed yet.

So, it is quite important to conduct the study on how white pepper farmers take adapted strategies to climate change. Understanding the factors that influence the behavior of climate change adaptation at the farming level is important not only for helping to formulate policies that can facilitate the adaptation process on a larger scale rather than in individual households or at the community level (Wood et al., 2014), but also enriching the scientific understanding of socio-economic researchers about how smallholder farmers adapt to climate change, especially in white pepper farming.

Methodology

Adaptation to climate change at farm level according to Bhaktikul (2012) includes all activities aimed at anticipating climate change either reducing the adverse impact or maximizing the positive impact of climate change on farming performance. The action that can be categorized as an anticipatory response to climate change is termed by Kassam and Friedrich (2012) as conservation agriculture. Conservation agriculture has three characteristics that farmers adopt simultaneously, namely: firstly, continuous minimum mechanical soil disturbance (minimum or zero tillage); secondly, permanent soil cover with crop residues or other types of organic materials); and thirdly, diversification of crop species grown in sequences (crop rotation) and/or associations.

Although farmers are not familiar with the term or concept of behavior that refers to climate change adaptation, they can be said to adapt to climate change when taking actions that are categorized as anticipatory measures against climate change such as minimizing economic risks and agricultural business failures or conservation actions that prevent further deterioration due to adverse effects of climate change. Actions or activities such as changing varieties into varieties more suited to the climate they faced, diversifying farming and sources of income in anticipation of risks (Bhaktikul, 2012) and implemented agricultural conservation (Kassam & Friedrich, 2012).

The adaptation to climate change includes the behaviors as proposed by Rejekiningrum et al. (2011), namely: first, the use of crop varieties that are tolerant to extreme climates such as drought, extreme temperatures and flood; second, the diversification of farming and crop rotation to minimize losses due to farming failure caused by extreme climates; third, the application of land management technology to improve plant resistance to drought such as mulch, bio-pore and infiltration well; fourth, the development of water management technology, especially on drought-prone land, such as "embung" (small pool for water harvesting) and drip irrigation, and fifth, the development of a farmer's institutional system as a social safety network in case of commodities price shocks that make the farmer's revenues to fall drastically.

Based on activities of climate change adaptation strategies from several previous studies and having compared them to the farmer's actions in the research location, I found five farmer activities that can be classified as the adapted strategy to climate change for white pepper farming. Those activities are classified as dependent variables in the logit model herein, i.e., farming diversification, mixed cropping, using farming residues as compost, building wells for water harvesting, and using organic fertilizer. The details of the factors or independent variables and their alleged effect on each dependent variable can be seen in table 1.

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

Independent variable	Measurement and unit	Expected effect	Reference Researches
Farming total revenues	In IDR (Indonesian currency)	+	Abid et al. (2016)
		-	Menike & Arachchi (2016)
Age	Farmer's age in years	+	Candradijaya (2015)
		-	Roco et al. (2014)
Gender	1 if male, and otherwise = 0	+	Tambo (2016)
Experience	Number of years in white pepper farming	+	Festiani (2011)
Education	The value is 1 if senior high school and above, and otherwise = 0	+	Alauddin & Sarker (2014)
Membership in farmer cooperative	Membership in farmer cooperative 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	+	Tambo (2016)
Membership in other rural organization	Membership in other rural organization if yes = 1 and no = 0	+	Ehiakpor et al. (2016)
Price	Price per kilogram in IDR per kilogram	+	The allegedly higher price means the greater farmer's asset and wealth, thus further enabling farmers to invest in climate change activities (Carter & Barrett, 2006).

Source: own source

Sampling and data collection methods

West Bangka Regency was chosen as a research site because this area is a producer of *Muntok white pepper*, a brand name of white pepper prominently exported from the island of Bangka since the Dutch colonial era. Seventy-seven samples of white pepper farmers were randomly selected. The cross-sectional primary data were collected by interviewing directly the farmers in the study sites using a list of questions in the questionnaire previously served by the researcher.

Logit regression model

The analytical tool used to analyze factors influencing adaptation of white pepper farmers to climate change is the logit regression model approach. The model is formulated as follows (Gujarati, 2004):

$$P_i = F(Zi) = (\beta_0 + \beta_1 X_i) = \frac{1}{1+e^{-z}} = \frac{1}{1+e^{-(\beta 0 + \beta 1 Xi)}} \tag{1}$$

where:
Pi = the probability that farmer will make the choice of adaptation strategy to climate change
β_0 = intercept
βi = regression coefficient
Xi = the *i*th of the independent variable
Both sides of equation (1) are multiplied by $1 + e^{-zi}$ to obtain:

$$(1 + e^{-zi})P_i = 1 \tag{2}$$

If equation (2) is divided by Pi and then subtracted 1, the following equation is obtained:

$$e^{-zi} = \frac{1}{Pi} - 1 = \frac{1-Pi}{Pi} \tag{3a}$$

Or could be represented as follow:

$$e^{zi} = \frac{Pi}{1-Pi} \tag{3b}$$

Equation (3) is transformed into a natural logarithmic model, and then the following equation is obtained:

$$Z_i = \ln \frac{Pi}{1-Pi} \tag{4}$$

Because ln e^{zi} = Z_i, then equation (4) can be represented as follows:

$$Z_i = \ln \frac{P_i}{1-P_i} = \beta_0 + \beta_i X_i \quad (5)$$

Equation 5 is well known as a logit model.

Farmer adaptation strategies to climate change are positioned as qualitative binary dependent variables where the value is 1 if the farmer implemented this strategy and 0 if he/she did not implemented it. In this study those variables were approximated from the probability (Pi) of the five adapted strategies as follows: 1) Farming diversification, 2) mixed cropping, 3) using farming residues as compost, 4) building wells for water harvesting and 5) using organic fertilizer.

The independent variables (Xi) in this study are age, gender of farmers, farming experience, white pepper price, household expenditure, total income of farmers from all his/her farming business, cooperative membership, farmer group membership, and other rural organization membership and educational status. However, there were additional considerations related to the econometrical reason for placing independent variables in the logit regression equation as follows:

1. Based on the cross-sectional primary data, the value of the white pepper price did not varied. Thus, the price of white pepper cannot be chosen as an independent variable in all logit model equations in this study.
2. The farming experience and the farmer's age showed a high correlation to the correlation coefficient of 0.6. Similarly, farm size and total revenue of farming have highly correlated to each other, where the coefficient correlation value is 0.99. Thus, the farming experience and farmer'age should not be in the same logit model equation because, as Gujarati (2004) said, if two variables with high correlation are placed as the independent variable in the same equation, then they can cause multicollinearity problems leading to biased estimation. The same applies to farm size and total revenue of farming.

Results and discussion

The estimation results from the logit model regression equations can be seen in table 2. The influence of factors affecting farmers' adaptation strategies to climate change can be explained as follows:

Diversification

TABLE 2.

Parameter estimation of the logit model of adaptation strategy (n = 70)

Independent variables	Adaptation strategy as dependent variable (dummy where 1 = implemented and 0= not implemented)									
	Diversification		Mixed cropping		Crop residues as compost		Building wells for water harvesting		Using organic fertilizer	
	coefficient	Prob.	coefficient	Prob.	coefficient	Prob.	coefficient	Prob.	coefficient	Prob.
Farming total revenues	4.5E-08****	0.0060	2.93E-09	0.5294	2.70E-08****	0.0091	-4.20E-09	0.3217		
Age							0.0084	0.7891		
Gender			-1.749*	0.1292			-1.937****	0.0095	-2.7039***	0.0186
Experience	0.0394	0.4872	-0.0273	0.4752	-0.2719**	0.0799			0.0373	0.3077
Education (dummy)[a]	1.00415	0.4436	0.1274	0.890	-0.17627	0.901	0.01962	0.9794	1.1675	0.2094
Membership in farmer cooperative[b]	-0.2742	0.8553	-0.2839	0.7777			-0.6150	0.5543	-2.2513***	0.0378
Membership in agricultural extension group (dummy)[c]	2.2728**	0.0785	0.2595	0.7703	0.5230	0.7343	0.2592	0.7334	-1.0805	0.2074
Membership in other rural organization (dummy)[d]	-1.1368	0.3414	-0.4537	0.52	1.6719	0.2252			1.1245**	0.0934
Constant	-3.0002*	0.1289	2.8735***	0.0424	-4.5496***	0.0101	1.2970	0.3695	3.0505***	0.0326
LR Statistic	29.742****		6.312		18.7954****		14.997***		16.674***	
Prob (LR Statistic)	0.000106		0.5037		0.0020		0.0202		0.0105	

Source: own source

****, ***, **, * are significant at 1, 5, 10, and 15 % probability level, respectively.

[a] Dummy, 1 = senior high school and above and 0 = otherwise.

[b] Dummy, 1 = member of farmer cooperative and 0 = otherwise.

[c] Dummy, 1 = member of agricultural extension group and 0 = otherwise.

[d] Dummy, 1 = member of other rural organization 0 = otherwise.

Diversification of farming is adopted to minimize losses due to the farming failure of certain types of cropping in anticipation to extreme climates. Factors affect the diversification of farming can be explained as follows: firstly, the farming total revenues have a statistically significant effect at α = 1 percent on the farming diversification, where the higher revenue from farming they have, the higher the probability to implement on-farm diversification. This evidence is the same as the finding by Asfaw et al. (2017) in Ethiopia that the better livelihood of farmer household, the higher the propensity to diversify their farming.

Secondly, membership in agricultural extension groups has a statistically significant effect on farming diversification at the α = 10 percent. Positive coefficient value shows that farmers who participate in extension groups have a higher probability to apply farming diversification than those farmers who do not participate. Ehiakpor et al. (2016) said that involvement in extension groups enabled farmers to share the technical experience of adaptation strategies to one another, so that their involvement in farmer groups would improve the probability to implement farming diversification. The same findings are indicated by several studies (Asfaw et al., 2017). Meanwhile, the membership in cooperative and other village organizations did not have a statistically significant effect on farming diversification. This phenomenon shows that membership in cooperatives and other village organizations does not increase farmers' probability to diversify their farming as one of their adaptation strategies to climate change.

Mixed cropping

Mixed cropping is meant in this study as planting two or more cropping in the same area at the same time with white pepper as the main crop and the others as subsidiaries. This study found that as many as 78.57 percents of white pepper farmers cultivate mixed cropping in research location.

The logit model equation of mixed cropping (table 2) shows only one independent variable with a significant effect on the mixed cropping strategy, i.e., the farmer's gender. The coefficient value of this binary qualitative dummy variable is negative and statistically significant at $\alpha = 15$ percent. This means the probability of female farmers to adopt a mixed cropping strategy is higher than in male ones. This can happen according to Singh et al. (2016) because these female farmers are assessed by all their family members who have the character and experience to be trusted and to make the best decisions for their farming business.

Crop residues as compost

Kassam and Friedrich (2012) and Bhaktikul (2012) said that farmers' strategy to use crop residues as compost can be seen as an adaptation behavior to climate change because this action is categorized as conservation farming, which is one of the ways to adapt one's farming to climate change. The logit regression equation (table 2) relates to factors that affect the use of crop residues as compost and found these facts: firstly, farming's total revenues have statistically a significant effect at $\alpha = 1$ percent on the use of crop residues as compost. This evidence supported the previous study that found that the better the farming revenue they had, the higher the propensity to implement an adapted strategy to climate change (Asfaw et al., 2017), i.e., the use of crop residues as compost.

Secondly, the experience has statistically a negative significant effect on the use of crop residues as compost at the level of # = 10 percent. The fact that all samples in this research cannot explain what climate change means and how to anticipate it, shows their limited information about climate change. Singh et al. (2016) said that farmers who had many experiences, but minimal access to information about climate change tend to be reluctant to implement an adaptation strategy. This is the explanation why farming experience negatively affects the use of crop as compost.

Building wells for water harvesting

Building wells for water harvesting is a behavior or action that reflects the farmers' adaptation to climate change (Rejekiningrum et al., 2011) because this action is an implementation of agricultural conservation as a kind of land management technology to improve plant resistance to drought. The results show that 47.14 percent of farmers take this action.

The logit model equation of building wells for water harvesting (table 2) shows only one independent variable that has a significant effect on this strategy, namely, the farmer's gender. The coefficient number of this binary qualitative dummy variable is negative and is statistically significant at $\alpha = 1$ percent. This means that the probability of female farmers to build a well for water harvesting is higher than the male ones. This can happen according to Singh et al. (2016) because these female farmers are assessed by all their family members who have the character and experience to be trusted and make the best decision for their farming business, in this case, building wells for water harvesting.

Using organic fertilizer

The logit regression equation (table 2) relates to factors affecting the use of organic fertilizer and provides the following facts: firstly, gender has a significant effect on this strategy. The coefficient of this binary qualitative dummy variable is negative and is statistically significant at $\alpha = 1$ percent. This means the probability of female farmers to adopt the use of organic fertilizer strategy is higher than the male ones. Singh et al. (2016) explained that this phenomenon can happen because female farmers agreed with all their family member to make the decision for choosing adapted strategy regarding the climate change and, especially in this case, using organic fertilizer.

Secondly, membership in the cooperative has a significant effect on using the organic fertilizer at the level of # = 5 percent. The regression coefficient value of this binary qualitative dummy variable is negative, indicating that farmers who are not cooperative members have a higher probability in using organic fertilizer than those farmers who are members.

Thirdly, membership in the farmer group for extension has a significant effect on the use the organic fertilizer at the level of $\alpha = 10$ percent. The coefficient value of this binary qualitative dummy variable is a positive indication that farmers who are members of the group for an extension have a higher probability to use organic fertilizer than those farmers who are not members.

Fourthly, education is not a determinant of the use of organic fertilizers. The effect of this variable is not significant on the use of organic fertilizer. This means there is no difference in the probability of using organic fertilizer between farmers whose education is high school or above and farmers whose education is below the high school. So does experience, this independent variable is not a determinant that affects the use of organic fertilizer by farmers.

Conclusion

Female farmers are adopting climate change adaptation strategies much more than male ones. Thus, government programmes related to accelerating the understanding and implementation of climate change adaptation in white pepper farming should be prioritized to the female farmers as the main target.

Farmer group for extension affected only the farming diversification as an adapted strategy to climate change and has no effect on other adaptation strategies. Farmers' membership in cooperative and other village organization has not contributed to adopt any adaptation strategy to climate change. This phenomenon showed the limited contribution of agricultural extension groups and other farmers' organizations in providing insights and improving skills and knowledge as related to climate change adaptation in white pepper farming. Therefore, knowledge and technical skills of extension agent at a local level, related to implementing adapted strategies of climate change, must be increased and materials regarding the implementation of climate change adaptation should be part of the agricultural extension syllabus for white pepper farmers.

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Notes

* Research article