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Determinants of farmers' adaptation to climate change in agricultural production in the central region of Vietnam

Thoai Quang Trinh[a,*], Roberto F. Rañola, Jr.[b], Leni D. Camacho[c], Elisabeth Simelton[d]

[a] Department of Economics, Vietnam National University of Forestry, Vietnam
[b] Department of Agricultural and Applied Economics, University of the Philippines Los Baños, Philippines
[c] Department of Social Forestry and Forest Governance, University of the Philippines Los Baños, Philippines
[d] Climate Change Scientist, World Agroforestry Centre (ICRAF), Vietnam

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ABSTRACT

This paper discusses the likely changes in farm cultural practices that farmers would adopt to minimize agricultural production losses as a response to the increasing occurrence of extreme weather conditions due to climate change in the Central Region of Viet Nam. Using binary logit model and multivariate probit model, this paper examined different factors influencing farmers decision on adaptation to climate change in their agricultural production. Training attendance, farm size, damage level, educational level, farming experience, access to credit, and gender were the factors that influenced significantly the probability that farmers would adapt to climate change. Of these factors, attendance in climate change training and farm size were the most important factors affecting the farmers decision on adaptation to climate change, while labor availability and membership in local organizations were not. Three policy recommendations were proposed to enhance small-scale farmers adaptive capacity to climate change in the region. These include: i). broadening of training courses on climate change; ii). institute policies that would promote consolidation of farmlands; and, iii). integrate concepts of climate change and climate change adaptation into the operation of the local organizations.

1. Introduction

Climate change has become a threat to human society (Ramirez-villegas et al., 2012; Kibue et al., 2015), particularly in developing countries where smallholder farmers are greatly affected and are becoming increasingly vulnerable to extreme weather events caused by climate change (Lotze-Campen and Schellnhuber, 2009; Esham and Garforth, 2013; Altieri and Nicholls, 2017; Comoé and Siegrist, 2015). Thus, adaptation to climate change is now gaining wide recognition and is a focal concern around the world (Smit and Skinner, 2002; Wilbanks et al., 2007; Thornton and Comberti, 2013). However, developing countries have lower adaptive capacity and do not have the essential technology for adaptation to climate change (Lotze-Campen and Schellnhuber, 2009).

Agriculture as the major sustainable source of food is highly dependent on and strongly affected by weather and extreme climatic events (Mjelde et al., 1989; Das, 2005; Motha and Murthy, 2007; Sivakumar, 2011; CIE, 2014). In recent decades, climate change has adversely affected crop production and yields in important agricultural regions of the world (Almaraz et al., 2008; Reidsma et al., 2009). In addition, the adverse impacts of climate change on agricultural production has led to high poverty incidence (Mendelsohn et al., 2006) and food insecurity in the world (Das, 2005; Rosenzweig and Tubiello, 2007; Nelson et al., 2009; Misra, 2012; Connoly-Boutin and Smit, 2015). However, few smallholder farmers have enough resources or capacity to adapt to climate variability and change (Verchot et al., 2007; Nyamadzawo et al., 2013). Thus, most countries in the world have increasingly considered improving farmers' adaptive capacity to climate change in agriculture to ensure food security and secure livelihood of smallholder farmers (Smit and Skinner, 2002; Verchot et al., 2007; Nelson et al., 2009; Kibue et al., 2015).

Agriculture is an important sector for Vietnam since it accounts for one-fifth of the GDP, employs nearly half of the country's labor force (GFDRR, 2011), and provides an income source for three-quarters of the population of the country (Cooke and Toda, 2008; Shrestha et al., 2014). Thus, the Vietnamese Government has intensified its efforts to reduce vulnerability and improve its adaptive capacity in addressing the impacts of climate change in agricultural production (Trinh et al., 2013; Schmidt-Thomé et al., 2015). Furthermore, farmers have initiated a number of autonomous and planned adaptive practices, such as changes in sowing dates, switching to drought-tolerant crops, changing crop varieties (e.g.,

* Corresponding author.
E-mail addresses: thoaitq@vfu.edu.vn, thoaivfu@gmail.com (T.Q. Trinh).

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salinity-tolerant varieties of rice), and switching to rice-fish rotations (World Bank, 2010). However, farmers in Vietnam still have limited understanding of the importance of climate change adaptation to their livelihoods (Le et al., 2014a).

The Central Region of Vietnam has been highly vulnerable to extreme weather events such as flood, typhoon and drought (Boateng, 2012). In addition, the frequent occurrence of extreme weather events serves as a challenge to agricultural production in the region (ISPONRE, 2009; Bruun and Casse, 2013). Given the importance of this issue, several studies were undertaken in an attempt to determine the impacts of climate change on agricultural production and describe farmers adaptive practices to climate change in the region. Shrestha et al. (2014) analyzed the impacts of climate change on winter and summer paddy yield, and evaluated several adaptive practices to climate change in the central region. The results of this study indicated that the plausible adaptive strategies for rice cultivation in the region include changing planting dates, supplementary irrigation, proper nutrient management and switching to new rice varieties. Shrestha and Bui (2015) listed some adaptive practices of farmers in the region as a response to climate change such as altering transplanting dates and introducing supplementary irrigation. Tran et al. (2015) compared the adaptation behavior between poor and non-poor farmers of the central region and concluded that non-poor farmers were more likely to adopt more sophisticated responses compared to the poor farmers.

An understanding of the factors affecting farmers decision in applying a particular adaptive practice among the available strategies may provide a very basis for formulating policy recommendations that would be responsive to climatic changes (Piya et al., 2013). However, despite the high occurrence of climate-induced agriculture risks, no studies have identified the factors affecting farmers adaptive choices in their agricultural production under changed climate condition in the Central Region of Vietnam. Hence, the purpose of this paper is to examine if, and how the factors that relate to household's livelihood assets influence farmers adaptive strategies for climate change in the region.

2. Methodology

2.1. The study site and method of data collection

This study was conducted as part of a project on climate-smart agriculture and climate services, in Ky Son commune, Ky Anh district, Ha Tinh province in the northcentral Vietnam (Fig. 1). The study site included My Loi village, one of the first CCAFS climate-smart villages in Southeast Asia. The commune was chosen as the study area due to its exposure to multiple extreme weather events such as temperature and water stress, flood, storm and typhoon (Le et al., 2014b).

This paper used both primary and secondary data. The secondary data included information on the socio-economic conditions of the study area. The annual reports of the local government in the study sites, baseline ICRAF's reports and other published documents were major sources of secondary data for this study. Personal interviews with 400 farmers in My Loi and other villages of Ky Son commune were undertaken using prepared questionnaires. The stratified random sampling method with stratum is village was used in determining the respondents. The sample size included respondents in all villages of Ky Son commune. The number of respondents in each village was selected based on its percentage of households in total household of the whole commune. In addition, the study randomly selected respondents in each stratum (village). Respondents were mainly farmers whose livelihood mostly depends on the agriculture and forestry sector.

A pilot survey of 20 respondents in My Loi (project site) and My Lac village (non-project site) of Ky Son commune was also conducted to test the suitability of the questionnaire. The primary data collected in this study included information regarding all livelihood assets of the households. It also included information about damage level due to extreme weather events in household's agricultural production and farmers adaptive strategies to these events.

2.2. Conceptual framework

Conceptually, extreme weather events due to climate change (e.g., droughts, floods, cold spells, etc.) could adversely affect household's livelihood. Therefore, farmers would adopt different adaptive practices

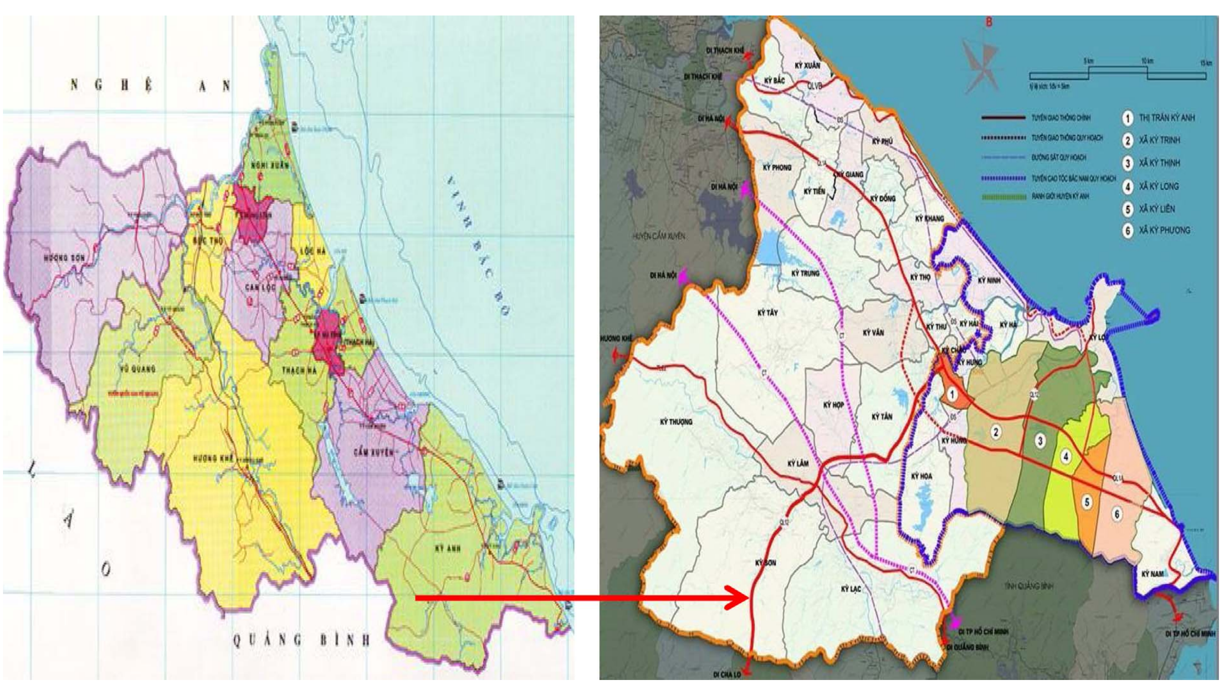

Fig. 1. Map of the study site.

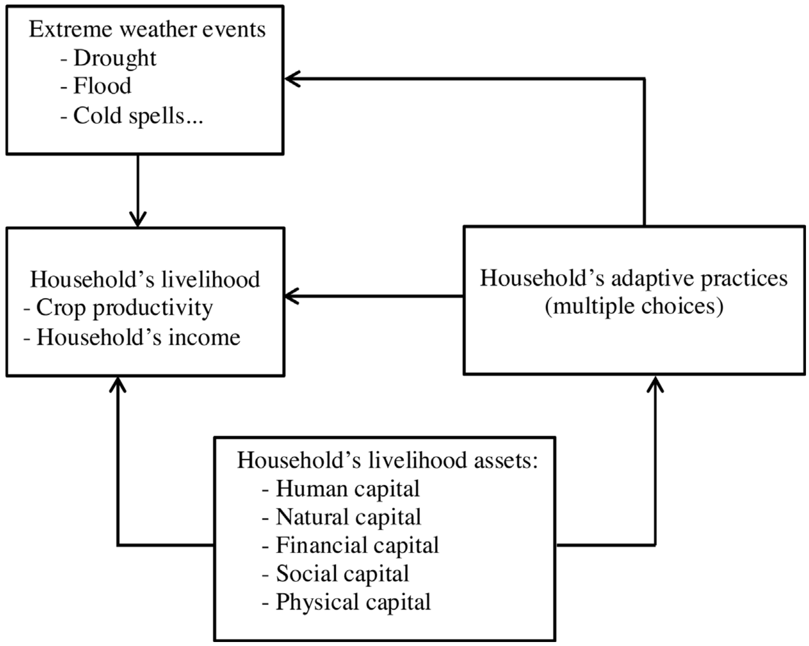

Fig. 2. Factors affecting household's adaptation practices to climate change (modified based on DFID, 1999).

to reduce the negative effects of climatic changes on their livelihood. These adaptive practices however may be influenced by the household's livelihood assets.

This paper discusses the effects of livelihood assets on household's adaptive practices to climate change in agricultural production (Fig. 2). The major hypothesis of this paper is that "households with higher damage level due to climate change and better livelihood assets will be more likely to apply adaptive strategies compared to other households".

DFID (1999) defined five household's livelihood assets namely, human capital, natural capital, financial capital, physical capital, and social capital. At the household level, human capital consists of the amount and quality of labor available. Social capital refers to the social resources that enable people to pursue their livelihood objectives, such as network and connectedness that can expand people's access to wider institutions, membership of more formalized groups and relationships of trust, reciprocity and exchange. Natural capital is natural stocks that are useful for people's livelihood and includes intangible public goods such as atmosphere and biodiversity or divisible assets used directly for production (trees, land, etc.). Physical capital encompasses basic infrastructure such as enabling affordable transport, secure shelter and buildings, adequate water supply and sanitation. It also includes clean and affordable energy, and access to information and producer goods, including tools and equipment. Finally, financial capital comprises financial resources for achieving livelihood objectives, such as available stock and regular cash inflow.

2.3. Analytical tools

2.3.1. Binary logit model

The binary logit model has been widely adopted since 1960s because it has analytical advantages in dealing with discrete binary outcomes (Cramer, 2003). The general form of a binary logit model is as follows (Cramer, 2003; Greene, 2003):

$$P_i(Y_i = 1) = \frac{e^{X\beta}}{1 + e^{X\beta}}$$

Where:

P_i is the probability of the occurrence of one event ($Y_i = 1$: event occur; $Y_i = 0$: event does not occur),

β is vector of parameters, and X is vector of the factors affecting.

Marginal effect (ME) coefficient is a major tool for analyzing the binary logit model. Marginal effect coefficients are determined through the following formula (Greene, 2003):

$$ME = \frac{\partial \Lambda(X'\beta)}{\partial X} = \Lambda(X'\beta)[1 - \Lambda(X'\beta)]\beta$$

Where: X is independent variables matrix in logit model (factors affecting)

β is a matrix of parameters in logit model

This study used a binary logit model to analyze the various factors affecting farmers' decision in applying adaptation strategies to extreme weather events in agricultural production. Farmers' decision in applying adaptation strategies is of a discrete choice form (i.e. yes, no). Specifically, one (1) denotes farmers who adapted to climate change in their agricultural production. By contrast, zero (0) denotes farmers who did not adapt to climate change. The study hypothesized that there are different factors affecting farmers' decision in applying adaptive strategies to climate change in agricultural production (Table 1).

2.3.2. Multivariate probit model

Based on the collected data, the farmer's adaptive strategies to extreme weather events in this study area offer multiple choices. Theoretically, these options are highly interrelated and interdependent. In other words, multiple adaptive strategies of farmers to extreme events in agricultural production are correlative. The correlation between the different multiple options is the main source of the correlation between error terms (Belderbos et al., 2004). However, the multivariate probit model could eliminate these correlations (Nhemachena and Hassan, 2007; Huguenin et al., 2009; Gebregziabher et al., 2015).

The multivariate probit (MVP) model includes simultaneous models. These models reflect the influences of the set of explanatory variables on each of the different options and allow error terms to be freely correlated (Golob and Regan, 2002; Greene, 2003; Lin et al., 2005). In addition, the MVP model allows a flexible correlation structure for the unobservable variables (Huguenin et al., 2009). The MVP model assumes that given explanatory variables, the multivariate response is an unobserved latent variable arising from a multivariate normal distribution (Piya et al., 2013).

The formula of the multivariate probit model for observation i and equation m is as follows (Cappellari and Jenkins, 2003; Huguenin et al., 2009; Tocco et al., 2013):

Table 1
Explanatory variables for the empirical binary logit and multivariate probit models on farmer's adaptive strategies to extreme weather events

Variable definition	Mean (n = 400)	Std. Deviation
Age of respondent (years)	44	11
Educational level of respondent (years of schooling)	7.9	3.8
Household's farm income (VND million/year)	15.1	10.9
Damage level due to extreme events (VND million/year)	1.9	2.3
Family agricultural labor (laborers involved in farm)	2	1
Farm size (sao/500 m^2)	6.6	4.5
Farming experience (years)	23.7	11.0
Number of cultivated plots (plots)	6.6	4.3
Gender of respondent (1 = male)	0.24	0.43
Access to credit (1 = yes)	0.63	0.48
Attendance in climate change training (1 = yes)	0.21	0.41
Membership in local organizations (1 = yes)	0.96	0.20

$Y_{im} = 1$ if $Y_{im}^* > 0$ and 0 otherwise ($i = 1, 2, \ldots, N$; $m = 1, 2, \ldots, M$)

$$Y_{im}^* = X_{im}*\beta_m + \varepsilon_{im}$$

Where:

N is number of observations,

M is number of options,

X_{im} is matrix of explanatory variable,

β_m is matrix of parameters, and

ε_{im} is matrix of error terms.

This study applied the MVP model to analyze the factors affecting the probability that farmers used different adaptive strategies to cope with extreme weather events. The study also hypothesized that there are different factors influencing the farmers adaptive practices to climate change. These factors were related directly to all livelihood assets including human, physical, social, economic, and natural capitals (Table 1).

3. Results and findings

3.1. Impacts of climate change on agricultural production

Climate change has caused the higher frequency and intensity of extreme weather events in the Ha Tinh province (Ha Tinh Provincial People's Committee, 2014). Moreover, the frequency and the strength of these climate stresses are likely to be more serious in the context of climate change in the province (ISPONRE, 2009). Droughts, floods, cold spells and typhoon occur annually in the province, with drought occurring most frequently. Annually, the drought period in the region starts in April and most seriously in July (ISPONRE, 2009). Moreover, drought occurs more often and longer in the region (Coulier, 2016).

Farmers in the region mentioned five major adverse effects of climate change on their agricultural production (Table 2). Among these effects mentioned by the farmers, decreasing crop yield and increasing production cost were popular since they were reported by a large number of farmers in the region (67% and 38%). There are two main seasons for crop production in the study area. The first season starts annually from January while the second season begins on June. January has been characterized by many cold spells which have become more frequent that is inhibiting the growth of cultivars. The production cost of many farmers during this season is higher since they have to use more labor for replanting of seedlings and application of more fertilizers.

Awareness of trained farmers regarding the adverse impacts of climate change on agricultural production is significantly different from those who are non-trained. The proportion of trained farmers who

Table 2
Farmers' perception on the adverse impacts of climate change on agricultural production in Ky Son, Ky Anh, Ha Tinh, Vietnam 2016 (% of respondent)

Indicator	Trained group (n = 84)	Non-trained group (n = 316)	DIFF[a]	Whole sample (n = 400)
Decrease crop yield	99	59	40[b]	67
Increase production cost	61	32	29[b]	38
Intensify adaptation cost	12	2	10[b]	4
Reduce cultivated land	8	9	−1[ns]	9
Soil erosion	4	4	0[ns]	4

[a] DIFF is a different value between two groups.
[b] is significant at 1% and ns is non-significant based on Z-test for the difference between proportions.

Table 3
Farmers' losses in agricultural production due to climate change in Ky Son, Ky Anh, Ha Tinh, Vietnam, 2016.

Item	Amount (n = 400)
Have been damaged by extreme events (% of respondent)	78
Cannot plant for the 2nd season due to drought (% of respondent)	56
Loss proportion of annual crop in the total crop income (%)	19
Estimated loss of annual crop per ha (VND million/USD)	9.0 (395[a])
Estimated loss of annual crop per year (VND million/USD)	2.4 (105[a])

[a]Value in US dollar (in 2016, US$1 = 22,800 VND).

recognized the decline in crop yield and increase in production and adaptation cost as adverse effects of climate change on agricultural production (99%, 61% and 12%) is significantly higher than the percentage of non-trained people (59%, 32% and 2%). This demonstrates the importance of training courses in improving the farmers knowledge about climate change and its adverse impacts on agricultural production.

Table 3 shows the losses due to extreme weather events in farmers agricultural production. Many farmers (78%) reported that their agricultural production was damaged by extreme weather events. In addition, a number of the farmers (56%) reported that they could not cultivate during the second season (summer-autumn season) due to drought. This again shows the seriousness and/or adverse effects of drought on agricultural production in the region.

The second cropping season (summer-autumn season) in the region starts annually in June. However, June and July are the periods when extreme drought is experienced in the area and this is likely to become worse in the coming years (ISPONRE, 2009). With drought and poor irrigation systems, most farmers in the region cannot cultivate their rice fields. While farmers may attempt to grow green beans during this season, the yield is also very low due to the scarcity of water. As a result, farmers allow their lands to lie fallow during this summer-autumn period and work instead as hired agricultural laborers. The earnings from their work as hired agricultural labor is contributing significantly to household's income in Ky Son commune (Coulier, 2016).

Farmers also reported losses in their agricultural produce due to extreme weather events. On the average, annual crop production loss of each household in the study site was estimated at 2.4 million VND (US $105) per year or 9.0 million VND (US$395) per hectare due to extreme weather events. The loss was due mainly to a decrease in crop yields and increase in production cost (cost of seedling, fertilizer, etc. for replanting). Although the annual crop production loss may seem low in absolute terms, for the farmers it composes nearly 20% of household's income from annual crops. This is a heavy burden for farmers in the

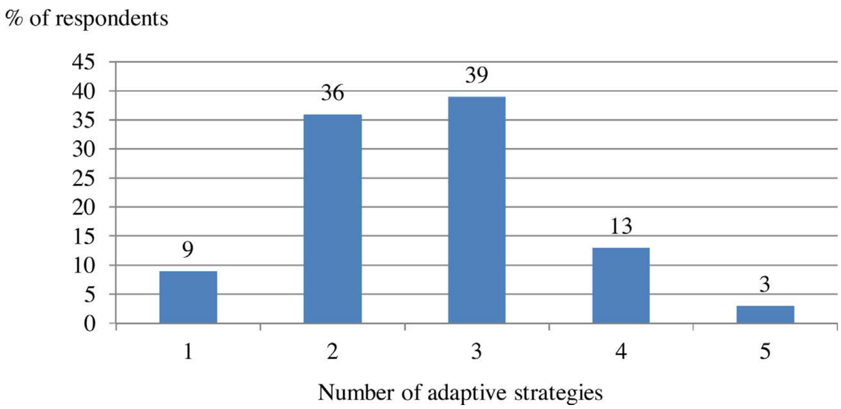

Fig. 3. Number of adaptive strategies of farmers to climate change.

commune, especially poor farmers whose livelihood depends largely on agricultural production.

3.2. Farmers adaptation to climate change in agricultural production

Climate change has affected adversely agricultural production, especially the annual crops in the study site. This is evident based on the farmers reports of their agricultural production losses due to frequent occurrences of extreme weather events in the region. Therefore, to mitigate the situation, farmers have given more attention to the application of different adaptive practices to eliminate or minimize the damage caused by climate change (Fig. 3).

A large number of the farmers (74%) in the region reported that they applied at least one adaptive strategy to extreme weather events in their agricultural production (Table 4). However, few farmers (9%) had only one adaptive strategy to climate change. Normally, farmers applied from two to three adaptive practices. Only 3% of the farmers used all of the adaptive strategies to cope with climate change in their agricultural production.

Table 4 shows the specific adaptive strategies used by farmers to cope with climate change in their agricultural production. These include changing crop varieties, switching to new cultivar types, adjusting farming calendar, monitoring weather forecasts, and intercropping. Among them, monitoring weather forecasts and changing crop varieties are the most popular practices. The percentage of people who confronted with extreme events in agricultural production by changing crop varieties and monitoring weather forecast news were 66 and 67%, respectively. Many farmers in the region reported that they used drought-tolerant crop varieties, especially in rice production during the second season. They also used short-season crop varieties to avoid floods that always occur during harvesting time of the second season. Annually, floods in the study area start in August but occur most frequently in September until November (ISPONRE, 2009).

Training courses on climate change played a crucial role in influencing farmers to adopt adaptive practices to cope with extreme weather events in agricultural production (Table 4). Many more farmers who participated in training courses on climate change employed adaptive strategies compared to farmers who did not attend the training courses. The percentage of trained farmers who monitored weather forecasts, changed crop variety, adjusted farming calendar, and applied intercropping were 85, 80, 46 and 19%, respectively. The figures are significantly higher than the percentage of farmers who did not undergo (62, 62, 23 and 2%). This confirms the importance of the training courses on climate change in improving the adaptive capacities of farmers to extreme weather events in agricultural production.

Table 4
Farmers' specific adaptive practices to climate change in agricultural production in the study site, 2016 (% of respondent).

Item	Trained group (n = 84)	Non-trained group (n = 316)	DIFF[a]	Whole sample (n = 400)
Apply at least one adaptation strategy	87	70	17[b]	74
Specific adaptive practices:				
– Follow up weather forecasts	85	62	25[b]	67
– Change crop varieties	80	62	18[b]	66
– Adjust farming calendar	46	23	23[b]	28
– Switch to new cultivar types	13	22	−9[ns]	20
– Intercropping	19	5	14[b]	8

[a] DIFF is a different value between two samples.
[b] is significant at 1% and ns is non-significant based on Z-test for the difference between proportions.

3.3. Factors influencing farmers decision on adaptation to climate change in agricultural production

The binary logit model was used to analyze the factors affecting farmers decision to adapt to extreme weather events in agricultural production. The decision of farmers is a discrete value (1, 0). One (1) denotes the farmers who adapted to climate change while zero (0) denotes farmers who did not adapt to climate change. Initially, 12 explanatory variables were included in the model (Table 1). However, after testing for multicollinearity problem using the correlation matrix among explanatory variables, only 9 variables were finally included in the empirical model. In addition, the issue of heteroskedasticity of the model was addressed using the robust standard error procedure. According to Woodridge (2013), robust standard error could effectively solve heteroskedasticity since it gives relatively accurate P-value to ensure the significance of the model.

Table 5 shows the estimated parameters of the empirical binary logit model. The Wald $\chi^2(9)$ is highly significant at 1% (Prob > χ^2 = 0.0000), meaning that the overall relationship between the nine influential factors and the probability of adaptation of farmers is significant at 1% level. The value of Pseudo R^2 (0.1425) means that these nine explanatory factors explained 14.25 percent of the probability that farmers would adapt to climate change.

There were three significant factors positively affecting the probability of adaptation of farmers. These included farm size, damage level, and attendance in training courses on climate change (Table 5). Attendance in training courses on climate change had the highest significant effect on the probability that farmers would adapt to climate change. The probability of adaptation by farmers who attended the training course on climate change was 15.7 percent higher than those who did not attend, ceteris paribus. The results also showed that households with large farmland areas were more likely to adapt to

Table 5
Estimated result of the binary logit model on farmers' decision on adaptation to climate change in agricultural production in Ky Son, Ky Anh, Ha Tinh, Vietnam, 2016.

Indicator	Coefficients	P-value	Marginal effects	P-value
Attendance in climate change training	1.136***	0.000	0.157***	0.000
Damage level	0.281**	0.025	0.047**	0.014
Farm size	0.140***	0.000	0.023***	0.000
Gender	−0.402ns	0.158	−0.072ns	0.174
Educational level	0.019ns	0.743	0.003ns	0.743
Availability of agricultural labor	0.106ns	0.621	0.018ns	0.620
Farming experience	0.011ns	0.356	0.002ns	0.358
Access to credit	0.285ns	0.271	0.049ns	0.280
Membership in local organizations	0.763ns	0.162	0.153ns	0.224
Constant	−1.844**	0.047	–	–
Log pseudolikelihood	−198.32	–	–	–
Wald $\chi^2(9)$	41.61	–	–	–
Prob > χ^2	0.0000	–	–	–
Pseudo R^2	0.1425	–	–	–
Number of observation	400	–	–	–

***, **, * are significant at 1%, 5%, and 10%, respectively; ns is non-significant.

Table 6
Estimated result of the multivariate probit model of determinants of farmers' adaptive practice to climate change in agricultural production in Ky Son, Ky Anh, Ha Tinh, Vietnam, 2016

Explanatory variables	Adaptation practices				
	Y_1	Y_2	Y_3	Y_4	Y_5
Attendance in climate change training	0.558a	−0.267ns	0.669a	0.667b	0.819a
Farm size	0.051a	0.065a	0.042a	0.057a	0.009ns
Farming experience	0.015b	0.005ns	0.011ns	0.015b	−0.004ns
Educational level	0.043ns	0.028c	0.029ns	0.081b	0.009ns
Damage level	0.069c	0.042ns	0.036ns	0.082b	−0.005ns
Access to credit	0.065ns	0.195ns	0.322b	0.258c	0.031ns
Gender	−0.435a	0.063ns	0.160ns	−0.112ns	0.070ns
Family agricultural labor	0.073ns	−0.079ns	0.118ns	0.083ns	0.063ns
Membership in local organizations	0.622ns	0.558ns	0.627ns	0.469ns	0.140ns
Constant	−1.516b	−2.214a	−2.705a	−1.915a	−1.767a

Correlation	Coefficients	P-value
ρ_{21}	0.529a	0.000
ρ_{31}	0.358a	0.000
ρ_{41}	0.842a	0.000
ρ_{51}	0.214c	0.053
ρ_{32}	0.156c	0.053
ρ_{42}	0.564a	0.000
ρ_{52}	0.338a	0.002
ρ_{43}	0.568a	0.000
ρ_{53}	−0.089ns	0.327
ρ_{54}	0.293a	0.001
Log pseudolikelihood	−817.44	–
Wald $\chi^2(45)$	137.85	–
Prob > χ^2	0.0000	–
No. of observation	400	–

Likelihood ratio test of H_0: $\rho_{21} = \rho_{31} = \rho_{41} = \rho_{51} = \rho_{32} = \rho_{42} = \rho_{52} = \rho_{43} = \rho_{53} = \rho_{54} = 0$ $\chi^2(10) = 260.12$ Prob $> \chi^2 = 0.0000$.
a, b, c are significant at 1%, 5%, and 10%, respectively; ns is non-significant.
Y_1 = Change crop variety.
Y_2 = Switch to new cultivar types.
Y_3 = Adjust farming calendar.
Y_4 = Follow up weather forecasts.
Y_5 = Intercropping.

climate change as compared with households who cultivated smaller farm areas. Similarly, the probability of adaptation to climate change of households with high damage level was 4.7% higher compared to households with low damage level. The rest of the factors did not show any significant effects on farmers decision on adaptation to climate change.

The multivariate probit (MVP) model was used to analyze the factors affecting the decisions of farmers to adopt each of the adaptive practices to cope with extreme weather events in their agricultural production (Table 4). The dependent variable of the MVP model include five specific choices (specific adaptive practices of farmers) that assumes a value of 1 if farmers apply specific adaptive practices and 0 otherwise. After testing for multicollinearity using the correlation matrix among explanatory variables, only nine explanatory variables were selected. In addition, the model was tested for heteroskedasticity using the robust standard error procedure. The estimates of the MVP model are shown in Table 6. The overall relationship between the farmers probability of applying specific adaptive practices and explanatory variables is also significant at the 1% level based on the values of Wald $\chi^2(45)$ (Prob $> \chi^2 = 0.0000$). In addition, $\chi^2(10)$ is also highly significant (Prob $> \chi^2 = 0.0000$), showing that there is correlation between the five adaptive practices. There is also interdependence between the different adaptive practices used by the farmers as shown by the highly significant correlation coefficients. This validates the feasibility of the MVP model in this paper.

The results as shown in Table 6 show that attendance in climate change training and farm size significantly affected the farmers probability of adoption of four of five adaptive practices in farmers agricultural production. The households with a member attending the training courses are more likely to adapt to climate change by changing crop varieties, adjusting farming calendar, following up weather forecasts, and intercropping. Similarly, the households with large farmlands are more likely to change crop varieties, adjust farming calendar, switch to new cultivar types, and follow up weather forecasts in coping with climate change.

Farming experience and damage level significantly influences the farmers probabilities of changing crop varieties and monitoring weather forecasts to cope with climate change. More experienced farmers have higher probabilities of changing crop varieties and monitoring weather forecasts to cope with climate change compared to those with less experience. Similarly, households with high damage level due to climate change are more likely to change crop varieties and monitor weather forecasts to cope with climate change compared to other households. Contrary to this, farming experience and damage level do not significantly affect farmers decisions in switching to new cultivar types, adjusting farming calendar, and intercropping. Educational level significantly and positively influences the farmers probabilities of switching to new cultivar types and following up weather forecasts. Farmers who have higher educational attainment are more likely to adapt to climate change by switching to news cultivar types and following up weather forecasts.

There is significant relationship between access to credit and farmers decisions in adjusting their farming calendar and monitoring weather forecasts at 5% and 10% significance level, respectively. Households that have access to available credit sources are more likely to adapt to climate change in their agricultural production by adjusting farming calendar and monitoring weather forecasts. Gender significantly influences only the farmers probability of changing crop varieties in coping with climate change. While, there is no significant relationship between availability of agricultural labor, membership in local organizations and the farmers probabilities of adaptation to climate change.

In terms of specific adaptive strategies, households with a member who attended the training courses on climate change are more likely to change crop varieties to cope with climate change. Households that have larger farm areas and high damage level caused by climate change are more likely also change crop varieties to cope with climate change.

The more experienced farmers are more likely to change crop varieties to cope with climate change, but this adaptive practice is significantly less likely to be adopted by male farmers. Households with larger farm size and household's heads who have higher educational attainment are more likely to switch to new cultivar types to cope with climate change in their agricultural production. The adaptive practice of monitoring weather forecasts is significantly influenced by attendance in climate change training, farm size, farming experience, educational level, damage level, and access to credit. Finally, intercropping is mostly practiced by households with a member of the household who has attended training courses on climate change.

4. Discussion

The study findings indicated that monitoring weather forecasts, changing crop varieties, adjusting farming calendar, switching to new cultivar types, and intercropping are major adaptive strategies applied by farmers in the study site. These findings are very similar to the findings of Nhemachena and Hassan (2007) and Kibue et al. (2016) on how farmers in some African countries and China adapted to climate change. Among adaptive practices used by farmers in the study site, changing crop varieties is the most popular strategy that farmers used to cope with climate change. This popular adaptive practice was also found in the studies by Comoé and Siegrist (2015) in Côte d'Ivoir, Mu et al. (2015) in Myanmar, Asfaw et al. (2016) in Malawi and Jin et al. (2016) in China. The study also found that using information provided by weather forecasts to adjust agricultural production under climate change condition is the most preferable adaptive strategy adopted by farmers in the study site. This is much different from the findings of other studies such as Piya et al. (2013), Comoé and Siegrist (2015) and Mu et al. (2015) that concluded weather information is only factors affecting farmers adaptive strategies to climate change rather than an adaptive strategy of farmers. The results of these previous studies stated that weather information does not significantly affect farmers decision on adaptation to climate change.

The results of the binary logit model and multivariate probit models employed by this study show that attendance in climate change training and farmland are the most important factors affecting the farmers decisions on adaptation to climate change. Farmers who attended the training courses on climate change were found to be more likely to adopt adaptive practices compared to those who did not attend any training. It was found by the study that although most of farmers in the study site have limited awareness and knowledge about climate change (Ha Tinh Provincial People's Committee, 2014), farmers attending training courses on climate change had better understanding about climate change and its impacts as well as the importance of adaptation in reducing losses. This leads to their better inclination to adapt to climate change to reduce their agricultural production losses. In the study site, there was only 21% of farmers (Table 1) reported that they attended in the training courses on climate change. However, awareness of trained farmers on climate change was much better compared to non-trained farmers (Table 2). In addition, percentage of trained farmers who applied adaptive strategies to climate change is much significant higher than that of non-trained farmers (Table 4). This shows the importance of increasing the training courses on climate change for farmers in Vietnam. Increasing the number of training course on climate change for farmers is one of the most crucial objectives indicated in the National Target Program on Adaptation to Climate Change of Vietnamese Government since 2008 (MONRE, 2008). In contrast, the findings of Mu et al. (2015) in Myanmar and Piya et al. (2013) in Nepal showed that training had negative effects on or did not significantly affect the decision of farmers to adapt to climate change. Another important finding of the study is that larger scale farm households were more likely to adapt to climate change than those with small scale ones. This is consistent with the findings of Nhemachena and Hassan (2007), Piya et al. (2013), Ashraf et al. (2014), Mu et al. (2015), Asfaw et al. (2016), and Jin et al. (2016). This can be explained by the fact that large scale farms tend to suffer from higher economic loss caused by climate change than small scale farms.

In terms of agricultural family labor and membership in local organizations, these factors seemed to have limited influence on the adaptation to climate change of farmers. These findings are similar to the findings of Piya et al. (2013) in Nepal and Mu et al. (2015) in Myanmar. In the study area, there was no significant difference in the amount of agricultural labor availability among studied households. This may help to explain why the probability of adaptation to climate change of farmers was not significantly influenced by this factor. In addition, most organizations in the area except for the Farmer's Union were people's organizations which focused on promoting social activities rather than enhancing agricultural productivity. Thus, a membership of these organizations was not helpful in improving the adaptive capacity of farmers to cope with climate change.

5. Conclusion and policy recommendations

This paper described farmers adaptive practices and determined factors influencing farmers adaptation to climate change in the Central Region of Vietnam. The results showed that farmers were losing 20% of their annual income from agricultural production due to the extreme weather events caused by climate change. In an effort to mitigate these losses, farmers in the region adopted different adaptive strategies such as changing crop varieties, switching to new crop types, adjusting farming calendar, monitoring weather forecasts, and intercropping. The most common adaptive strategies adopted by farmers in the region however were monitoring weather forecast and changing crop varieties.

The results of the binary logit and multivariate probit models indicated that attendance in climate change training and farm size played an important role in explaining the farmers probability of adaptation to climate change. Other factors that significantly influenced the farmers probability of adopting adaptive practice included farming experience, educational level, damage level caused by climate change, access to credit, and gender. In contrast, availability of family agricultural labor and membership in local organizations did not significantly affect the farmers probability of adaptation to climate change. Therefore, broadening the training courses on climate change could be an effective way to improve adaptive capacities of farmers to cope with climate change in the region. These training courses would cater to the less educated and less experienced farmers. The training courses on climate change adaptation should also be simple and understandable for most of farmers, especially those who are less educated. Additionally, provincial government should institute policies that would promote the consolidation of farmlands in the region. To realize this, the first priority is the demonstration coupled with practical results of this policy in other regions to encourage local people to participate in the program. Secondly, local authorities should disseminate information on the benefits of consolidating farmland to cope with extreme weather events. Thirdly, there is a need to simplify the administrative procedures in order to encourage enterprises and farmers to participate in the program. Lastly, other development projects/planning of the region need to integrate the necessary guidelines to promote land agglomeration. Government policies should also encourage the integration of concepts of climate change and adaptation to climate change in the operation of local organizations.

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