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FARMERS' PERCEPTION OF AND ADAPTATION TO CLIMATE CHANGE: AN INVESTIGATION IN NORTHEAST VIETNAM

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This study investigates farmers' perception of and adaptation to climate change in Thai Nguyen province in the Northeast region of Vietnam. Using a structured survey questionnaire, personal interviews were conducted with 534 farmers in the study province. A multivariate probit model was utilized to examine factors affecting farmers' choices of adaptation to climate change. The results show that climate change has threatened farmers' livelihood and agricultural cultivation. Gender, education, farming experience, land, perceived temperature, perceived precipitation, income source, climate information, agricultural training, membership and credit access significantly affect farmers' choices of different adaptation methods. The results suggest that government should integrate climate change adaptation activities into local development plans. In addition, climate information, agricultural training, and community-based networks should be made available and accessible to all farmers.

Keywords: Climate Change, Perception, Adaptation, Northeast Vietnam
JEL Classification: Q12, Q54, O13

1. INTRODUCTION

Impacts of climate change are inevitable and apparent in all states and oceans (IPCC, 2014). Increasing temperature, decreasing precipitation, extreme weather events, and natural disasters are happening more frequently and estimated to continue in the near future (IPCC, 2014; UN, 2018). Moreover, climate change has exerted serious consequences on the development of every nation (ADB, 2013). The increase in global temperatures has seriously reduced the availability of water source, affected the sustainability of ecosystems, decreased the productivity of food production, increased the coastal land loss and increased human health burden, which costs the world economy substantial losses annually (IPCC, 2014). Demetriades and Esplen (2010) estimate that every year from five percent at least to 20 percent at most of the global Gross Domestic

Product (GDP) has been spent on climate change adaptations. According to UN (2018), in 2017 alone, the world economy lost more than US$ 300 billion mostly due to natural hazards.

Vietnam is categorized as one of the very few countries in the world most heavily affected by climate change (Nguyen and Shaw, 2010; Schmidt-Thomé et al., 2015). According to Thuc et al. (2016), over 57 years (from 1958 to 2014), the annual mean temperature in Vietnam has increased by approximately 0.6ºC and the sea level has risen about 2.45 millimetres per year during the period 1960 to 2014. Moreover, extreme temperatures and weather events had increased in the past two decades. The temperature and rise in sea level are predicted to keep increasing by late 21st century. Specifically, the average annual maximum and minimum temperatures would increase from 1.7ºC to 2.7ºC and 3.0ºC to 4.0ºC, respectively. Meanwhile, rise in sea level would be around 55 centimetres (Thuc et al., 2016). Increasing changes in the temperature and rise in sea level have exerted critical impacts on all sectors and regions of the country (ADB, 2013).

The agricultural sector plays a crucial role in Vietnam's economy. The sector makes up approximately 20 percent of the country's GDP (Rutten et al., 2014). According to Shrestha et al. (2016), the rice yields produced by Vietnam remarkably contribute to global food security as the country is the second-largest rice exporter in the world. However, climate change has badly affected the sector's growth. According to FAO (2011), under climate change, Vietnam's agriculture has experienced severe impacts on agrometeorology, crop growth rate, crop water demand, growth and spread of detrimental pests, growing seasons, crop geographic distribution, rice and maize output, and animal husbandry. This threatens food security in Vietnam and affects global food security (Yu et al., 2013).

To respond to climate change impacts, farmers in Vietnam have used diverse strategies to adapt to climate change to sustain their production and increase productivity. For example, in the Mekong River Delta, rice farmers planted different crops, changed planting time and improved irrigation (Le et al., 2005). Similarly, in the coastal central region, farm households adjusted farming calendar, intercropped and used weather forecasting information to foresight the crops (Trinh et al., 2018). While farmers in Northwest mountainous area of Vietnam modified, varied and protected crops to deal with landslides and flash floods, which have happened more frequently (Pham et al., 2019), and ethnic farmers in Northeast mountainous region have used their knowledge and skills to deal with climate variability and extreme weather events (Son et al., 2019).

Climate change and its impacts are recorded in almost all regions of Vietnam (Thuc et al., 2016). However, there are not many studies in the Northeast compared to other regions of the country despite increased climate change impacts in the Northeast. Particularly, the number of extreme hot days in the region have risen in the past 20 years (Thuc et al., 2016). The annual average temperature in the region was 0.72ºC higher than the period 1962 to 1990 (Thuy et al., 2019). Thus, there is a need to have more information on climate change impacts and adaptation in the Northeast region to assist farmers to adapt to climate change impacts. The paper is organized as follows: Section 2 reviews the relevant literature. Section 3 describes the methodology. The results are presented in Section 4. Section 5 concludes the paper.

2. LITERATURE REVIEW

Many studies have investigated the strategies applied by local farmers and farming communities in different places to adapt to climate change. For example, in a study to explore strategies used as well as the barriers faced by farmers in the Nile Basin of Ethiopia in respond to consequences of climate change, Desersa et al. (2008) find that demographic factors, such as gender, age, education, household wealth together with accessibility to credit, agricultural services, climate information, social capital and climate variability features are influential to farmers' choices of climate change adaptation. However, financial constraints and lack of adaptation information are obstacles to farmers to adapt to climate change.

According to Zhai et al. (2018), lack of funds and timely information critically hinder farmers from adopting measures to respond to negative impacts of climate change on their livelihoods. Likewise, Fosu-Mensah et al. (2012) further find that poverty is also an obstacle preventing farmers from carrying out adaptation actions despite their high awareness of negative impacts of rising temperature and decreasing precipitation over the years. The authors recommend that climate change related information and government policies should be communicated to farmers in rural areas. In addition, accessibility to credit and training services should be more available and flexible to assist farmers to deal with the consequences of climate change (Fosu-Mensah et al., 2012; Zhai et al., 2018).

Arunrat et al. (2017) reveal that apart from socio-demographic characteristics of farmers that contribute to their decisions in selecting climate change adaptation methods, other factors such as farm experiences, income and training are statistically significant to farm households' decision to adapt to drought and flood in Yom and Nan basins, Phichit province of Thailand. Moreover, communication about climate change significantly affects farmers' intention to apply adaptation strategies. Specifically, the more the farmers are informed of climate change and related issues via diversifying sources and channels, the more likely they would implement adaptation methods.

Similarly, Trinh et al. (2018) study in the coastal central region of Vietnam shows that training attendance and farm size significantly affect farmers' likelihood to adapt to climate change compared to other factors, such as damage level, education, farming experience and credit access. Meanwhile, the availability of labour for farm work and the participation in farmers' association are not significant. Le et al. (2015) confirm that education level, gender, age, household size, ethnicity, organization membership, climate change information and changes in temperature in rainy season are statistically important to farmers' decision to adapt to climate change in the Mekong Delta of Vietnam.

With special focus on the relationship between property rights and the likelihood of farmers in northern Benin of West Africa to apply particular adaptation strategies, Yegbemey et al. (2013) investigate the influence of property rights categorized into institutional arrangements on land (inheritance, gifting, renting, and purchasing) and rights on land (ownership, rights of cutting trees, rights of selling, leasing, gifting, and inheriting) on the probability of farmers to adapt to climate change. The authors' result shows that land ownership is positively significant on the farmers' decision to select adaptation measures to climate change.

Dang et al. (2014) argue that understanding how farmers perceive and adapt to climate change is critical to develop relevant adaptation strategies. Therefore, many scholars have studied the effects of farmers' perception of climate change and its impacts on their adaptation to climate change. For example, Deressa et al. (2008) reveal that in the Nile Basin of Ethiopia, farmers who have observed changes in temperature and rainfall are more likely to adapt to climate change. Similarly, Piya et al. (2013) find that farmers who have noticed a decrease in rainfall are likely to diversify their livelihood or build water collection tanks as methods to adapt to climate change. Pham et al. (2019) examine adaptation to climate hazards of farming households in northern mountainous region of Vietnam reveals that farmers' perception of increasing flash floods and landslides is a key factor affecting their decisions to adapt to climate change.

The literature has documented different significant levels of the factors affecting farmers' choices of adaptation measures to climate change. For example, in the studies of Trinh et al. (2018) and Zhai et al. (2018) gender is not statistically significant to farmers' likelihood to adapt to climate change. However, Arunrat et al. (2017) find that gender is significant in farmers' decision to adapt to climate change. Farm size is negatively significant in Ndamani and Watanabe's (2016) study but positively significant in Trinh et al.'s (2018) study. In addition, according to Pyia et al. (2013), farm households who have access to information on climate change via radio are likely to diversify their livelihood activities and select different type of plants, but do not change sowing time. This indicates that the effect of one variable on specific adaptation strategies of farmers vary based on the nature of the strategy as well as the locations where the study is conducted.

3. METHODOLOGY

3.1. Study Province and Data Collection

Figure 1 shows the study province. Nearly 70% of the province's population live on agriculture (GSO, 2017). Of the total land area (352,664 hectares), agricultural production land accounts for approximately 32% (112,190 hectares). The major annual crops are rice (71.1%), followed by maize (17.8%), vegetable (14.7%), sweet potatoes (4.2%), cassava (2.9%) and peanut (3.8%). In addition, tea production is an important income source of the farmers in the province (Thai Nguyen Statistic Office, 2018).

Climate change has increasingly affected the province and people’s lives, especially agricultural production (SRD, 2010; Nong et al., 2020). Particularly, extreme weather events have happened more often. According to a report by Thai Nguyen Provincial Committee on Natural Disaster Prevention and Recue (2017), there were 24 cold spells and 9 heat waves in 2016. Natural disasters have caused damage to people and property. For example, in 2017 there were 38 natural calamities including storms, cyclones, floods and heavy rains. Eleven deaths and three injuries were caused by these natural disasters. In addition, 38 houses were destroyed, and 1,849 houses were flooded. Approximately 1,794 ha of rice cultivation and 131 ha of crop areas were swept by floods. The total loss from natural disasters in 2017 was estimated at 160 billion Vietnam dongs (Thai Nguyen Statistics Office, 2018).

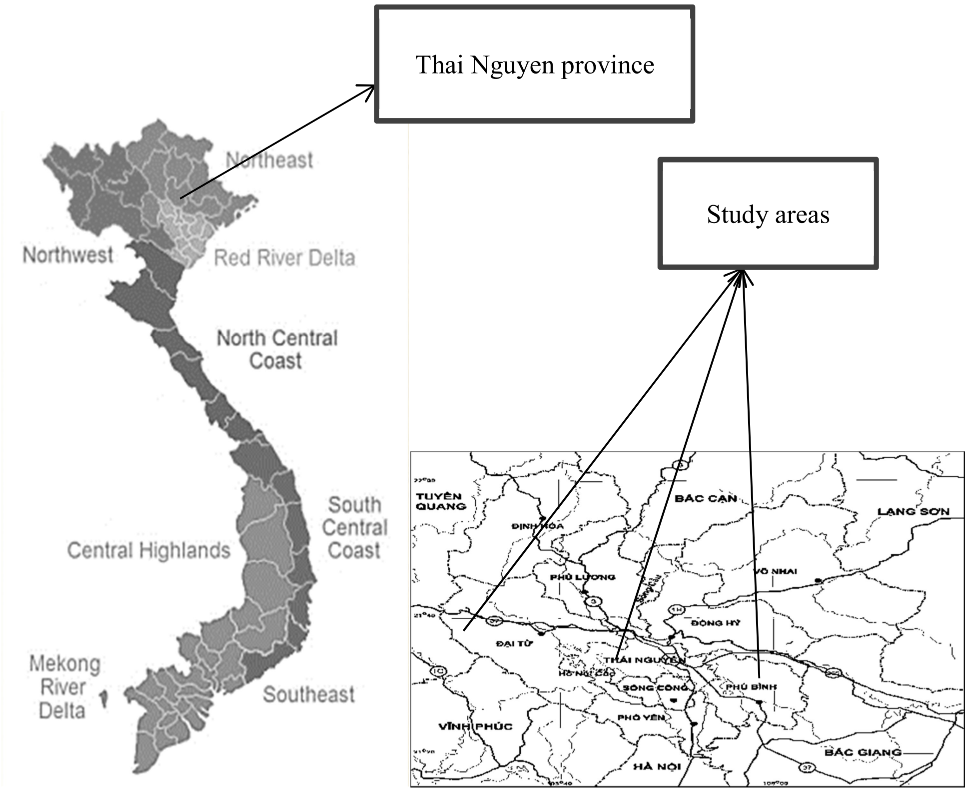


Figure 1. The study province and study areas

Data collection was conducted in two stages: from June to July 2017 and from April to May 2018. The first stage included gathering secondary data on climate variability, extreme weather events, and climate-induced disasters. In addition, information on agricultural production in the province, activities in agricultural extension and enhancement, plans and programmes related to climate change adaptation were also collected during this stage. The second stage interviewed the farmers. A structured questionnaire was used in the interviews and consists of five sections: 1) climate change information and concerns; 2) climate change impacts; 3) livelihood assets and climate change; 4) climate change adaptation; and 5) socio-demographic characteristics of the respondents. Specific questions related to the theme of each section were developed to interview the farmers. The questionnaire was pre-tested before the interview to ensure that the questions were well understood and applicable in the local context.

Two districts and a city were selected using simple random methods (Figure 1). In each study area, two communes were randomly chosen. Farmers in the study areas were conveniently invited to participate in the personal interviews. The A total of 562 farmers were approached to participate in the interviews. However, only 534 farmers agreed while 28 farmers refused to take part in the interviews.

3.2. Empirical Model

Dependent variables

Many studies have investigated how farmers in different countries and regions are adapting to climate change. The adaptation strategies applied by farmers can be similar or vary. These adaptation strategies include soil conservation, crop varieties, growing trees, changing planting date and irrigation in the Nile Basin, Ethiopia (Desersa et al., 2008) and Nigeria (Ofuoku et al., 2012); crop diversification, farm size reduction, changing planting date, off-farm jobs, choosing plant varieties in Ghana (Fosu-Mensah et al., 2012); livelihood diversification, varietal selection, water collection tanks, adjusted sowing time, and traditional coping strategies in Nepal (Piya et al., 2013); water harvesting, irrigation, changing crop varieties, changing planting dates in Anhui and Jiangsu province in China (Kibue et al., 2016); changing rice varieties, crop rotation, changing production site, increasing the use of irrigation, and adjusting the farming calendar in Thailand (Arunrat et al., 2017); agricultural tillage systems and agricultural technology adaptation in Henan province, China (Zhai et al., 2018).

According to Le et al. (2015), farmers in the Mekong Delta in Vietnam have applied crop varieties, changed planting dates, intensified irrigation and diversified crops to respond to climate change impacts. Apart from adopting crop variety, farmers in the coastal central of Vietnam have used adaptation methods such as adjust farming calendar, follow up with weather forecasting and intercropping (Trinh et al., 2018). In a study in Yen Bai, a mountainous province in the Northwest region of Vietnam, Pham et al. (2019) reveal that farmers focused on crop pattern modification, crop variegation, crop varieties, crop management and protection to adapt to landslides and flash floods. In addition, local farmers sold properties, migrated to the city, borrowed money or received support from friends, relatives or the local authorities to deal with the consequences of landslides and flash floods.

Based on the literature, in-depth interviews, meetings and discussions with functional agencies in the study areas, five major adaptation methods applied by farmers are used as the dependent variables in the model. They include: (1) selection of seedlings resistant to climate change, (2) investment in irrigation, (3) adjusting cultivation time, (4) changing farming techniques, and (5) application of traditional experience. Selection of seedlings resistant to climate change is the most common method used by farmers in the study area (88.01% of the farmers). Approximately 66.5% of the farmers have changed their farming practices to adapt to extreme weather events and climate variability. Around 42% of the farmers invested in irrigation while 37% decided to adjust the cultivation time to respond to climate variability. Only 20% of the farmers have applied traditional experience in respond to climate change impacts. This includes observation of weather patterns over time to decide on which seasons to grow which crops, selection of crops that are most suitable to local land condition and using organic fertilizers (see Table 1).

Table 1. Adaptation methods to climate change adopted by farmers in the study area

Adaptation methods	% of farmers adopted
Selection of seedlings resistant to climate change	88.01
Investment in irrigation	42.32
Adjusting cultivation time	37.08
Chaning farming techniques	66.48
Application of traditional experience	20.04

In this study, each adaptation method is a binary dependent variable, which is coded 1 if the respondents adopt a method and 0 otherwise. To estimate the relationship between the independent variables and a multi-choice dependent variable, either the multinomial logit or multivariate probit models have been widely employed. For example, Deressa et al. (2008) used the multinomial logit model to investigate factors affecting farmers' adaptation strategies in the Nile Basin of Ethiopia. The same method was used by Le et al. (2015) in the Mekong Delta of Vietnam, Arunrat et al. (2017) in Thailand, and Zhai et al. (2018) in Henan Province of China. Meanwhile, Piya et al. (2013), Yegbemey et al. (2013), Trinh et al. (2018) and Pham et al. (2019) used multivariate probit model to study the determinants of farmers' choices of different adaptation methods in mid-hills Nepal, northern Benin of West Africa, coastal central region of Vietnam and Northwest of Vietnam, respectively.

While both multinomial logit and multivariate probit models can explain the effect of the same set of explanatory variables on different choices, the multinomial logit model limits in a way that it assumes the choices are independent (Pyia et al., 2013). In addition, the multinomial logit model fails to investigate the correlation between the choices (Seo and Mendelsohn, 2007). In our study, there might be interactions amongst the dependent variables, such as different adaptation methods adopted by the farmers. Therefore, a multivariate probit model is used to investigate the factors affecting farmers' choices of climate change adaptation methods.

Following Chib and Greenberg (1998), Tabet (2007) and Pyia (2013), the multivariate probit model assumed each subject has J distinct binary responses and has a covariate vector of variables, which can be discrete or continuous. Let $Y_{ij} = (Y_{i1}, \ldots, Y_{iJ})$ denote a binary response on the i^{th} subject ($i = 1, 2, \ldots, n$).

Let $X_i = \text{diag}(x'_{i1,} \ldots, x'_{ij})$ is a $J \times k$ covariate matrix, let $Z_i = (Z_{i1,}, \ldots, Z_{ij})'$ denote a J-variate normal vector of latent variables with distribution $Z_i \sim N(X_{i,}\beta, \sum)$.

$$Z_i = X_i\beta + \varepsilon_i, \ i = 1, \ldots, n,$$

where: $\beta = (\vec{\beta}'_1, \ldots, \vec{\beta}'_J)$ is a $p \times J$ matrix of unknown regression coefficients; ε_i is a $J \times 1$ vector of residual error distributed as $N_J(0, \sum)$, where $\sum$ is the $J \times J$ correlation matrix of Z_i.

The relationship between Z_{ij} and Y_{ij} in the multivariate probit model is defined as follows:

$$Y_{ij} = \begin{cases} 1 \ if \ Z_{ij} > 0 \\ 0 \ otherwise \end{cases}, \ j = 1, \ldots, J.$$

Thus,

$$P(Y_i = 1 | \ \beta, \sum) = \Phi(Z_i),$$

where Φ is the probit link denoting the cumulative distribution function of the normal distribution.

The likelihood of the observed data Y is obtained by integrating over the latent variables Z:

$$P = (Y_i = y_i | X_i, \beta, \sum) = \int_{A_{iJ}} \cdots \int_{A_{i1}} \Phi_J(Z_i | X_i, \beta, \sum) dZ_i,$$

where A_{ij} is the interval (0, ∞) if Y_{ij}= 1 and the interval (−∞, 0] if Y_{ij}= 0.

Independent variables

Based on the literature, the study hypothesizes that 13 variables including gender, education, farming experience, labour, agriculture land, perceived temperature, perceived precipitation, income, income source, climate information, agricultural training, membership and credit access affect farmers' choices of climate change adaptation. Table 2 describes the independent variables of the multivariate probit model. The variation inflation factor (VIF) scores for all the independent variables are below 10 and the mean VIF score is 4.25 indicating that multi-collinearity is not a problem in our study model.

Table 2. Description of Independent Variables

Variable	Description	Coded	Mean	SD	Min	Max
Gender	Gender of the farmers	1 = Male 0 = Female	0.5412	0.4988	0	1
Education	Educational level the farmers completed	1 = Never go to school 2 = Primary school 3 = Secondary school 4 = High school 5 = Vocational training 6 = College 7 = University	3.6161	1.2052	1	7
Farming experience	Number of years the farmers engage in agriculture cultivation	Years	20.9400	10.1047	3	50
Labour	Number of family members at the labour age	Persons	2.4494	0.8920	0	6
Land	Total land area used for agricultural production	Square metres	2204.75	2118.30	315	16000
Perceived temperature	Farmers' perception on the change in temperature the past 5 years	1 = Increased 0 = Decreased/Unchanged	0.9157	0.2780	0	1
Perceived precipitation	Farmers' perception on the change in precipitation in the past 5 years	1 = Decreased 0 = Increased/Unchanged	0.5243	0.4999	0	1
Income[1]	Household's average monthly income	1 = < 3 million VNDs 2 = 3 to 4 million VNDs 3 = 4 to 6 million VNDs 4 = 6 to 8 million VNDs 5 = 8 to 10 million VNDs 6 = > 10 million VNDs	2.9662	1.4595	1	6
Income source	Sources of income	1 = From agriculture 0 = Other sources	0.6479	0.4780	0	1

[1] Income is measured in VND. The approximate exchange rate between USD to VND is \$1 = 23,278VND (2019).

Table 2. Description of Independent Variables (con't)

Variable	Description	Coded	Mean	SD	Min	Max
Climate information	Farmers received information on climate change	1 = Yes 0 = No	0.2041	0.4034	0	1
Agricultural training	Farmer received training on agricultural extension	1 = Yes 0 = No	0.4270	0.4951	0	1
Membership	Farmers are member of the Farmers' Union	1 = Yes 0 = No	0.6142	0.4872	0	1
Credit access	Farmers have access to formal financial institutions	1 = Yes 0 = No	0.1385	0.3458	0	1

4. RESULTS AND DISCUSSIONS

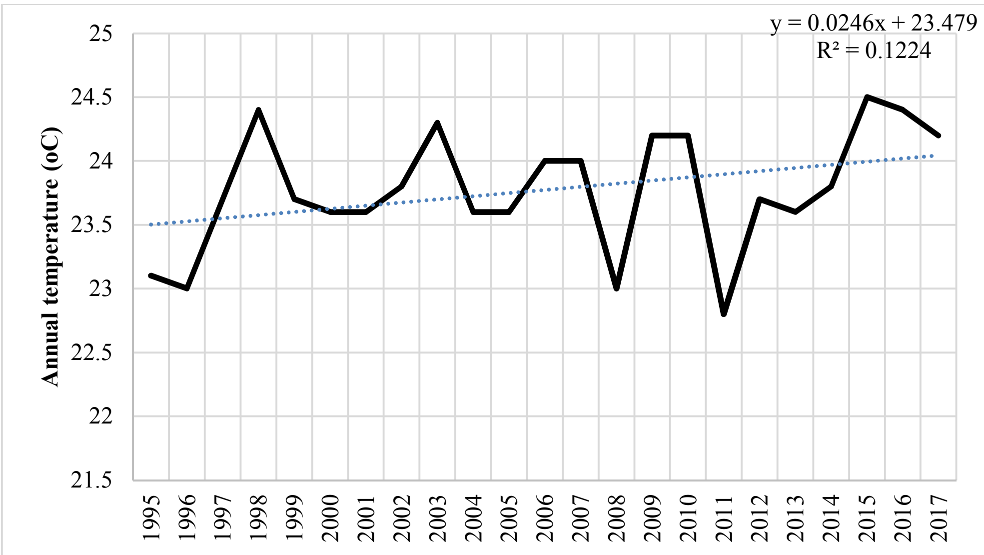
4.1. Farmers' Perception of Climate Change

The result shows 91.57% of the farmers have perceived the increase in temperature while half of the farmers have noticed the decrease in the precipitation over the five years from 2012 - 2017. There is statistically different between farmers' perception of change in temperature and precipitation. In addition, approximately 84.27% of the farmers see heatwave increasingly happening, followed by the cold spell (76.22%), storm (61.24%), drought (57.68%) and flood (49.06%) (see Table 3). The results are similar to Huong et al. (2017) and Pham et al. (2019) studies in the Northwest of Vietnam. According to Huong et al. (2017), farmers in three northwest provinces including Hoa Binh, Son La and Lai Chau noticed increased climate hazards such as droughts, landslides, heavy rain, flash floods and frequent extreme heat. In addition, farmers in Yen Bai province have suffered from the increasing occurrence of landslides and flash floods, which seriously endangered their lives and damaged their crops (Pham et al., 2019). According to MONRE (2010), these extreme climatic events cumulatively affect the Northern region of Vietnam. Furthermore, these events are forecasted to happen more in the Northeast provinces in the future (Thuc et al., 2016).

In order to verify the farmers' perception of climate variability in the province, we analyzed the data on annual temperature and rainfall for the period 1995 to 2017. The result shows the mean annual temperature increased by 0.02ºC, which clearly indicates the trend of increasing temperature in the past two decades (see Figure 2). The average annual precipitation has decreased over the last 22 years by approximately 3.6mm exhibiting a moderate declining trend (see Figure 3). These results are comparable to our survey result that most farmers (91.57%) noticed the increased in temperature. However, only around half of the farmers noticed the decreased in rainfall while 12.36 % of the farmers noticed the volume of rainfall unchanged. A similar result is found in the study of Huong et al. (2017) where farmers in the Northwest of Vietnam observed the increased change in annual temperature but a minor decreased change in annual rainfall.

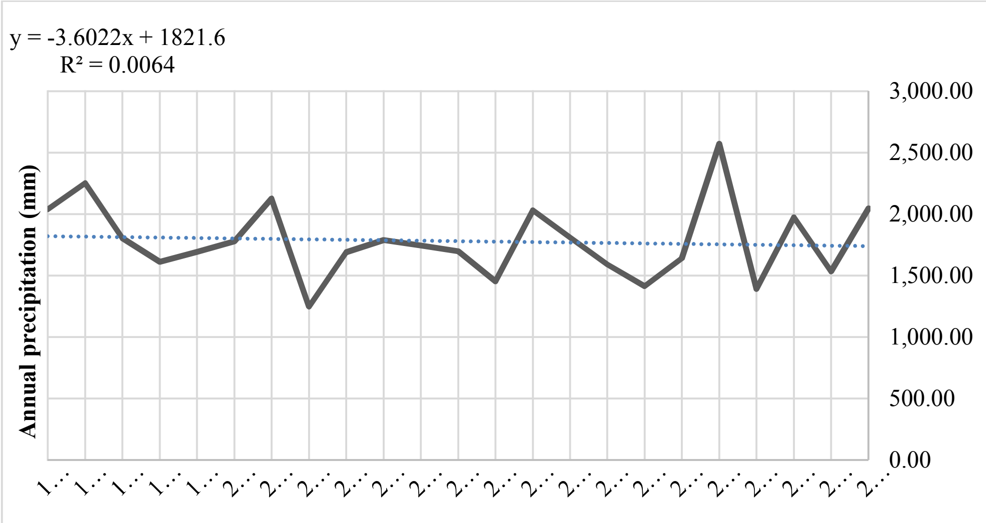
Table 3. Farmers' Perception of The Changes such as Climate Variability, Natural Disasters, and Extreme Weather Events over Five Years (2012-2017 in Percentage)

	Increased	Decreased	Unchanged
Temperature	91.57	3.18	5.24
Precipitation	35.21	52.43	12.36
Drought	57.68	16.67	25.66
Flood	49.06	21.16	29.78
Storm	61.24	16.48	22.28
Cold spell	76.22	15.17	8.61
Heatwave	84.27	7.12	8.61



Source: Thai Nguyen Hydro-meteorological Station.

Figure 2. Mean Annual Temperature in Thai Nguyen Province in the Period 1995-2017



Source: Thai Nguyen Hydro-meteorological Station.

Figure 3. Mean Annual Precipitation in Thai Nguyen province in the Period 1995-2017

The result shows 79.96% of the farmers reported changes in climate variability, extreme weather events and natural disasters as worse in the last five years and 68.16% thought it would get worse in the future. In addition, the farmers disclosed that climate change has threatened their localities in different ways. For example, 79.40% of the farmers reported that climate change reduced their agriculture productivity. Approximately 83% of the farmers revealed negative impacts of climate change on agriculture, including crop lost, increased insects and diseases in plants due to flood, drought and unpredictable weather. The result shows 57.85% of the farmers claimed that diseases in human beings have increased because of changes in climate conditions. Furthermore, climate change leads to decreased income, shortage of fresh water and damaged infrastructure as reported by 49.44%, 40.26% and 40.64% of the farmers, respectively. The survey results are similar to the findings of the sustainable livelihood response to climate change of the northern Thai Nguyen by SRD (2010) report. According to the SRD report, changing temperature and unpredictable weather prevented plant growth while pests and diseases flourished, leading to reduced productivity. Climate changes have caused other problems, such as water scarcity, extreme weather events (heavy rain, hail, heatwave and cold spell) that have gradually worsened people's livelihood.

4.2. Factors Affecting Farmers' Adaptation to Climate Change

Table 4 presents the estimated results of the multivariate probit model. The Log

Pseudo likelihood is highly significant at 1% level (Wald $X^2(65) = 198.81$ and $\text{Prob} > (X^2) = 0.0000$) indicating that there is a relationship between the explanatory variables and farmers' choices of different adaptation methods to climate change. The Likelihood ratio test is significant at 1% level ($X^2(10) = 29.6376$ and $\text{Prob} > (X^2) = 0.0010$) showing that the adaptation methods are correlated and the multivariate probit model is appropriate for the study.

Regarding the interrelation amongst adaptation methods adopted by the farmers in the study area, selection of seedlings resistant to climate change is positively related to investment in irrigation, adjustment of cultivation time and changing farming techniques but is negatively correlated with the application of traditional experience. Farmers' choices of adjusting cultivation time and changing farming techniques are significantly associated with their choice of investment in irrigation. Similarly, the choice of changing farming techniques by farmers is complemented by the choice of adjusting cultivation time. Lastly, farmers' choice to apply traditional experience to adapt to climate change has a positive relationship with their choice of investment in irrigation and significantly increased their choice to adjust cultivation time. Farmers' choice of adopting traditional experience negatively affects their choice of changing farming techniques but not significant (see Table 4). These results indicate that one adaptation method adopted by farmers is either supplemented or prevented by another. Similar results are found in studies of Piya et al. (2013) in mid-hill of Nepal, Trinh et al. (2018) in the coastal central area of Vietnam and Pham et al. (2019) in the mountainous province of Northwest of Vietnam. Specifically, Piya et al. (2013) find that farmers who choose to adjust sowing time are more likely to select improved varieties of maize but not likely to reserve water in tanks. Likewise, Trinh et al. (2018) show that the method of changing crop varieties to adapt to climate change can be enhanced by using new plants, changing planting time, getting weather forecast information and practice intercropping. Pham et al. (2019) also reveal that farmers' choice of soil management and plant protection is accompanied by their choice of changing crop varieties but restricted by their choice to change crop pattern.

Table 4 shows gender is negatively significant to farmers' choice of changing farming practices.

Female farmers tend to choose changes in farming techniques than male farmers. For three adaptation methods including investment in the irrigation system, adjusting cultivation time, and application of traditional experience, gender exhibits a negative relationship but is not statistically significant. Gender is positively related to farmers' choice of selection of seedlings resistant to climate change but not significant.

Education positively affects farmers' choices of two adaptation strategies including investment in irrigation and adjusting cultivation time. Farmers with higher education choose to invest in irrigation and adjust cultivation time to confront climate change and extreme weather events. This is because farmers with higher education have capacities and more accessibility to information leading to greater opportunities to adapt to climate change.

Farming experience is positively significant to farmers' choices of seedlings resistant to climate change and changing farming practices but negatively significant to farmers' choice to adjust cultivation time (see Table 4). This means that the more years the farmers spent on agricultural work, the more likely they choose to select seedling varieties and apply new farming skills to adapt to climate change. The results indicate that experienced farmers in agriculture are knowledgeable on local agriculture and the environment; proactively seek appropriate ways including planting varieties, crop rotation, and crop diversification to adapt to climate change, which agree with studies of Maddison (2007), Hilary et al. (2013), and Arunrat et al. (2017). However, experienced farmers do not adjust cultivation time to adapt to changes in climate conditions because of the concerns over the requirement of more human resources and hesitance from older farmers who have more experiences but lack of interest and motivation to adapt to climate change. The finding is similar to Ndamani and Watanabe's (2016) study.

Table 4 also shows land variable is negatively significant to farmers' choice of selection of seedlings resistant to climate change, indicating that farmers who own larger agriculture land might not select seedlings resistant to climate change. However, land is positively significant to farmers' choice to change farming practices, that is, farmers who own more land area used for agricultural production would choose farming techniques that are suitable for their land features to increase productivity and sustain crops production. This is because they are concerned about the large amount of human and financial resources (such as the cost to purchase enough seedlings, watering and fertilizers and aftercare) needed if they apply the method.

Farmers who notice the increase in temperature would select seedlings resistant to climate change but would not choose to apply the traditional farming experience. Farmers' perception of the decrease in precipitation adversely influences their decision to invest in irrigation, which can be explained by the fact that, in the study area, decreased rainfall volume is not a major problem and is hardly noticeable. As a result, it is likely that farmers are not concerned with the effect of changes in rainfall on their agricultural cultivation. The use of traditional farming knowledge to adapt to climate change is also not influenced by farmers' perceived change in precipitation (see Table 4).

While a majority of studies claim that farmers' perception of climate variability is significant and positively affect farmers' decision to adopt or not adopt adaptation methods, our study shows a contrast finding on the influence of farmers' perception and their choice of adaptation by using their traditional farming knowledge. Our result is similar to Piya et al.'s (2013) study which revealed that reduced rainfall and increased temperature negatively influenced traditional coping strategies applied by farmers, but the relationship was statistically insignificant.

We further analysed the data from the interviews and found the following possible explanations for our finding. First, using traditional farming experience, though being considered useful and practical to adapt to climate change, is not a common method that farmers in the study areas use to deal with climate change impacts. They simply think that their farm experiences are useful for their cultivation. In addition, traditional and indigenous knowledge to respond to climate change is mostly used by the elderly; younger farmers are more likely to apply modern farming technologies (Son et al., 2019). In this study, only 20% of the farmers adopted the traditional knowledge with 60% of the farmers aged 40 years old and above. Second, farmers who used their farm experience did not observe clearly the changes in the climate variables. Only 16.85% of farmers who applied traditional experience noticed an increase in temperatures and 8.61% of farmers noticed a decrease in rainfall. Third, previous studies have examined the relationship of farmers' perception of climate change and their decisions to adapt or not to adapt to climate change with limited focus on traditional farming knowledge as a method of adaptation to climate change.

Income source is positively significant to farmers' choice of changing farming practices. Households with income mainly from agricultural production would change their farming practices to respond to climate change (see Table 4). This finding is in line with studies of Deressa et al. (2008), Arunrat et al. (2017), and Pham et al. (2019). According to Deressa et al. (2008), farm income of households in the Nile Basin of Ethiopia positively and significantly affects their decision to adopt or not adopt an adaptation method to respond to climate change impacts. Specifically, households with higher income are more likely to change planting date and select crop varieties. Similarly, findings of Arunrat et al. (2017) in Yom and Nan basins, Phichit province of Thailand revealed that increasing income is a decisive factor to famers' likelihood to adjust farming calendar and select different rice varieties. The same result is found in study of Pham et al. (2019) in Yen Bai, a mountainous province in the Northwest region of Vietnam. The authors' result showed a positive relationship between households' farm income and the probability of changing crop pattern, crop variegation and crop varieties.

Accessibility to climate change information, training, credit and farmers' union membership to some extent affect farmers' choices of adaptation to climate change. Climate information is positively significant to farmers' choice of investment in irrigation, changing farming techniques and application of traditional experience. Agricultural training is positively significant to farmers' investment in irrigation and changing farming techniques (see Table 4). Apparently, receipt of climate change information and participation in training courses provides farmers opportunities to get news and updates about the climate, agricultural development, new farming knowledge and skills, and assistance from agricultural experts (Gebrehiwot and van der Veen, 2013; Arunrat et al., 2017; Trinh et al., 2018). We also found that farmers who are members of farmers' union would select seedlings resistant to climate change and change their farming techniques. Similar results are found in the studies of Piya et al. (2013) in Nepal and Arunrat et al. (2017) in Thailand, which reveal that being a member of a local organization, non-government organization or social network increases the probability of the farmers selecting different adaptation strategies to climate change.

Credit access is positively significant to farmers' choice of adjusting cultivation time because more financial capital will ease their decision to adapt to climate change (see Table 4). The result is consistent with Arunrat et al.'s (2017) study which revealed that if the farmers can access to credit, they are more likely to adjust the cropping calendar. However, we found that credit access is negatively significant to farmers' choice of selection of seedlings resistant to climate change and changing farming practices. This is similar to the results in Hilary et al. (2013), Pyia et al. (2013) and Pham et al. (2019). The probable explanation for our result is that most farmers (86.14%) in our study site did not obtain credit from formal financial institutions. They often use their own finance (54.49%) or funds borrowed from mass organizations (36.14%). Nearly half of the farmers (46.44%) had savings, which makes them more active in purchasing new crop varieties and changing their farming techniques.

Table 4. Estimated Results of the Multivariate Probit Model

Explanatory variables	(1) Selection of seedlings resistant to climate change			(2) Investment in irrigation			(3) Adjusting cultivation time			(4) Changing farming techniques			(5) Applying traditional experience		
	Coeff.	*Std Err*	*P value*	*Coeff.*	*Std Err*	*P value*	*Coeff.*	*Std Err*	*P value*	*Coeff.*	*Std Err*	*P value*	*Coeff.*	*Std Err*	*P value*
Gender	0.241	0.154	0.119	-0.064	0.117	0.586	-0.11	0.118	0.352	-0.247**	0.123	0.044	-0.131	0.129	0.31
Education	0.117	0.072	0.105	0.156***	0.051	0.002	0.092*	0.051	0.07	0.002	0.054	0.976	-0.025	0.058	0.667
Farming experience	0.017*	0.008	0.059	-0.005	0.006	0.403	-0.012**	0.006	0.047	0.011*	0.006	0.083	0.002	0.006	0.746
Labour	0.041	0.09	0.65	0.079	0.066	0.23	0.05	0.066	0.454	0.077	0.073	0.294	0.024	0.075	0.743
Land	-0.000***	0	0.002	0	0	0.229	0	0	0.585	0.000**	0	0.031	0	0	0.616
Perceived temperature	0.689***	0.227	0.002	0.321	0.219	0.143	0.460**	0.219	0.036	0.059	0.223	0.791	-0.651***	0.209	0.002
Perceived precipitation	0.113	0.162	0.484	-0.438***	0.118	0	-0.025	0.118	0.833	-0.162	0.123	0.187	-0.220*	0.13	0.092
Income	0.006	0.054	0.905	-0.024	0.044	0.587	-0.061	0.045	0.175	0.069	0.048	0.148	0.018	0.049	0.716
Income source	0.268	0.171	0.116	0.182	0.132	0.167	0.207	0.131	0.113	0.296**	0.135	0.029	0.235	0.151	0.12
Climate information	-0.052	0.21	0.803	0.303**	0.148	0.04	0.153	0.149	0.303	0.283*	0.162	0.08	0.327**	0.156	0.036
Agricultural training	0.19	0.165	0.247	0.325***	0.118	0.006	0.101	0.12	0.398	0.417***	0.126	0.001	0.13	0.132	0.324
Membership	0.375**	0.151	0.013	0.088	0.122	0.469	0.12	0.124	0.336	0.444***	0.127	0	0.117	0.137	0.395
Credit access	-0.513***	0.193	0.008	0.105	0.165	0.525	0.373**	0.162	0.022	-0.532***	0.17	0.002	-0.172	0.199	0.388
Constant	-0.613	0.485	0.206	-1.279***	0.394	0.001	-1.019***	0.373	0.006	-0.47	0.407	0.248	-0.525	0.412	0.203

Correlation	Coeff.	Std.Err	P value	Correlation	Coeff.	Std.Err	P value	
ρ_{21}	0.115	0.079	0.149	ρ_{42}	0.176**	0.069	0.010	Log pseudo likelihood: -1388.3279 Wald $X^2(65)$: 198.81 Prob >(X^2): 0.0000***
ρ_{31}	0.125	0.082	0.125	ρ_{52}	0.119	0.075	0.115	No of observations: 534 Likelihood ratio test of Ho:
ρ_{41}	0.135	0.084	0.107	ρ_{43}	0.127*	0.068	0.061	$\rho_{21} = \rho_{31} = \rho_{41} = \rho_{51} = \rho_{32} = \rho_{42} = \rho_{52} = \rho_{43} = \rho_{53} = \rho_{54} =$
ρ_{51}	-0.065	0.092	0.478	ρ_{53}	0.192**	0.080	0.016	$X^2(10) = 29.6376$
ρ_{32}	0.151**	0.068	0.026	ρ_{54}	-0.018	0.081	0.828	Prob > (X^2) = 0.0010***

Note: *, **, *** are significant at 10%, 5% and 1% respectively. Robust standard errors are presented

5. CONCLUSION AND IMPLICATIONS

This study investigates farmers' perception of and adaptation to climate change in Thai Nguyen province in the Northeast of Vietnam. The study results show most of the farmers noticed an increase in temperature, extreme weather events, and natural disasters. However, the farmers noticed a marginal decrease in precipitation. Climate change has threatened farmers' lives and agricultural cultivation in different ways including reduced agriculture productivity, crop loss, increased insects in plants, increased diseases in human, decreased income, shortage of water and damaged infrastructure. Therefore, to respond to climate change impacts, farmers have adopted different adaptation methods. Selection of seedlings resistant to climate change is the most common method used by the local farmers, followed by changing farming practices, investment in irrigation, adjusting cultivation time and application of traditional farm experience. The multivariate probit model result shows that labour and income do not affect farmers' adaptation to climate change while gender, education, farming experience, land, perceived temperature, perceived precipitation, income source, climate information, agricultural training, membership and credit access are significant to farmers' choices of different adaptation methods to climate change. Particularly, education, climate information, agricultural training and membership positively and significantly affect farmers' adaptation to climate change.

Findings from the study suggest some policy implications. Since climate change has increasingly affected farmers' production in the Northeast region of Vietnam, the government should provide more information and communication about climate change impacts and adaptation to climate change to local farmers. In addition, knowledge and skills for agricultural production in responding to climate change impacts should be shared and disseminated among the farmers. This would assist farmers to prepare and actively adapt to climate change. Furthermore, the government should integrate adaptation plans into socio-economic development strategies from national to local level, which would help improve the implementation of action plans feasible and achievable at the local level. Agricultural services significantly affect farmers' adaptation to climate change. These services should be available and accessible to all farmers. For example, training courses in agricultural extension, farming techniques, crop sustainability, land use and pest management and adaptation strategies should be regularly provided and updated to all farmers. Moreover, practical and in-place assistance from agricultural experts should be easily accessible so that farmers can reach for relevant and timely support.

The study results show that farmers' organizations are important to farmers to adapt to climate change. Therefore, it is important that the government expand these organizations' activities to support the farmers. The coordination between functional agencies (agriculture, environment, agri-business, forestry, management of natural resources), local authorities (people's committee, councils), non-government organizations and mass organizations would enhance the delivery of agricultural services to farmers and adaptation plans. Community-based organizations or local groups should be mobilized to implement climate change adaptations. Services, which include the provision of climate change information, skills and knowledge, supportive networks and in-place assistance provided by these organizations and groups, would help farmers proactively adopt diverse methods to respond to climate change and sustain their agriculture practices.

The study was conducted in a province of the Northeast Vietnam. Future research could consider extending the investigation of climate change perception and adaptation to a broader scope to provide more fruitful insights for the development of relevant adaptation strategies. In addition, the study investigates the adaptation methods applied by farmers without examining what method is more practical or efficient, which future research might consider.

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