The Impact of Climate Change on Agriculture and Suitable Agro-Adaptation in Phufa Sub-District, Nan Province, Thailand

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Abstract

This research aims to examine the perceptions and adaptations of climate change by upland farmers in the Northern Thailand. Primary data was collected from six rural communities in Phufa Sub-district, Nan Province, Thailand, using a questionnaire survey on a sample of 400 farmers and six focus group discussions. The ordered logistic regression was used to analyze probabilities in agro-adaptation strategies of climate change. Research finding shows that majority of the farmers have perceived increasing temperatures and declining rainfall. The majority of farmers have experiences of decrease crop yield and crop quality due to the potential impacts of climate change. Research results show that overall 68% of the farmers adopt their farm practices due to climate change and related risks. Most of the farmers preferred changing farm management as key adaptation practices followed by diversification of income-generating and livelihood activities, as well as changing in crop pattern and crop calendar. The ordered logistic regression estimation shows that marital status, farm land slope, government support and help, source of weather information, confident of weather information, and farmer's experiences on the impact of hot weather and extreme climatic event are among the factors which positively and significantly affect farmers' adaptation level. The participants of six focus group discussion proposed the framework of climate-smart upland farmers as the guideline for climate change adaptation. This research confirmed that ordered logistic models can be used to analyze climate change adaptations level. The framework of climate-smart farmers also provides information for designing policies to face with climate change of upland farmers in Thailand. Scaling up environmental friendly adaptation practice needs strong policy support to promote climate-smart farmers movement.

Keywords: Climate Change, Upland Agriculture, Impact, Adaptation, Phufa Sub-District

Introduction

Climate has been deemed as a important factor disrupting the production of agricultural sector and food security, especially in part of agriculture in Thailand, which majority is identified as rain-fed system. Rain-fed agriculture is the main livelihood of Thai communities in the upland area. Also, in Phufa Sub-district (north of Thailand) upland farmers are at greater risk from climate change. Some special characteristic differentiate the upland and lowland, such as topography, elevation, soil fertility, water source, and local climate. The area between 18-20°N latitude in Northern Thailand with elevation between 700-2,500 meter from mean sea level, mostly possess cooler temperature. However, this area has some agriculture characteristic and practice, which are explicitly different from the lowland. The agricultural production area in Northern Thailand is approximately 23% of the total area, accounting for 12.85 million hectares, with only 0.77 million hectares under irrigation system (Panomtarinichigul, 2008). The livelihoods of the upland farmers based on cultivating marginal hilly land areas, which are very vulnerable to related potential risks of climate change (Pulhin et al., 2007). Similar to most developing countries, Thailand is vulnerable to climate related impacts such as temperature increase, rainfall variability, and drought. The vulnerable groups are the upland farmers who have either limited resources or depending on rain as main source of water for farming and household used. Thus, promotion of adaptation strategies for the upland farmer are in need to reduce vulnerability of upland farmers to climate change.

Adaptation to climate change refers to a shift in natural or human systems in accordance to expected climatic stimuli. Therefore, mitigate negative effects and take advantage of opportunities related with climate change (Intergovernmental Panel on Climate Change (IPCC), 2007). In summary climate change adaption can be said to be a techniques, method or skills used in reducing the vulnerability it causes to human life and their livelihoods as a consequence of climate variability. Farmers can apply different strategies in actualizing and reducing the risk of climate change impacts, through adequate and effective adaptation strategies, which relates their currently faced climatic issues. The potential impacts of the climate change is unequally distributed over different geographic areas, therefore, the adaptation levels vary according to the magnitude of climate change impact (Shiferaw, 2014; Sharma, 2016). We can find a set of adaptation practices that the farmers applied to reduce the impacts of climate change among literatures, which includes: changing of crop variety, shifting planting dates, mix crop and livestock production, soil and water management, tree plantation and agro forestry, and seek off-farm employment. Irrigation system development and water harvesting are among some of the several practices to enhance farmers resilience in the face of climate change (Nhemachena & Hassan, 2008; Lasco et al., 2011; Abid et al., 2016).

The literature about climate change adaptation practices at farm level is relatively limited especially in developing countries due to limit of research focus on environment vulnerability, local risk perceptions and stimuli leading to adaptation (Bryant et al., 2000). There are increasing recognition of an important for field-based studies to help properly in understanding the local level risks and adaptation response to climate change (Moser & Luers, 2008). Therefore, this research will enhance a valuable contribution to an understanding of farm level risk in Northern Thailand. Findings of community-based studies may also assist policy makers to design demand-based policies that will better prevent farmers from climate change. Understanding the perception and adaptation proper practices at a community level are important for achieving environmental friendly adaptation options in a climate-vulnerable area.

Phufa sub-district located at northeast of Nan Province with total area is approximate 204 km^2. The climate characteristic of research area is mountain climate with relatively dry, a single rainy season that generally begins between May and October. The average annual rainfall amount is about 1,200 mm. An average temperature is 25 °C. It has total population of 2,900 in 2014. Most farming communities are major crops including up-land rice, maize, and agroforestry. Phufa Project was the study area, which is an activity of HRH Princess Maha Chakri Sirindhorn. It connects the people in the urban to those in the rural area. Phufa is now flourishing in business, some portion of the results of the word related impetus venture works under the idea of sustainability. Phufa projects expects to expand villagers' income, mostly farmers in urban regions, who make utilize nearby materials, and also aptitude and neighborhood knowledge, allowing those in the urban to purchase valuable craftsmanship merchandise for their regular daily existence at a reasonable costs. The uniqueness of these items, especially the handiwork, is that they keep up innovation in both structure and shading. Likewise, a few items are accessible from remote regions that are not accessible to tourists (Fernquest, 2012).

This research integrated quantitative and qualitative data collection and analysis. This mixed method allows use quantitative data to augment a qualitative output involve community-based participatory approach to reflect participants' point of views regarding future climate change adaptation. This research suggested that environmental policy makers should actively involved local farmers in the designing and implementing of policies to deal with climate change.

Methods and Materials

The study took place in six villages in Phufa sub-district of Northern Thailand in 2011. The villages were purposively selected based on vulnerability to climate change. This research examines the perceptions and adaptation experiences of climate change by upland farmers living in the Northern Thailand. Addressing the following research questions:

Q1. What are farmers'perception about climate change in the research area?

Q2. What are factors affecting adaptation practices of upland farmers in respond to climate change situation?

Q3. What are the framework of climate change adaptation as proposed by upland farmers?

This research relied on both qualitative and quantitative method to answer these specific questions. The ordered logistic regression model was used to analyze the predictors of climate change in adaptation level. This model had been in used on few climate change studies apart from Thailand. Tesso (2013), for instance, used the ordered logistic model to analyze factors affecting the individual vulnerability to climate change impact among crop production communities of western Ethiopia. Quiroga, Suárez, & Solís (2015) also adopted the ordered probit model to analyze factors that affect the coffee farmers' perceptions of adaptive capacity in Nicaragua. However, there has been a limited used of ordered logistic regression model in studies on adaptions of climate change in Thailand. This research will therefore focus further on how ordered logistic regression model can be utilized in investigating local farmer's adaptations of climate change. The results of statistical analysis were disclose in focus group discussion to construct the framework of climate-smart farmer development.

This research collected data by questionnaire survey and focus group discussions (FGDs). 400 farmers involved in the questionnaire survey were selected from the communities using systematic sampling techniques. A trained research assistant was conducted and visited each purposively selected household, and interviewed household head or a knowledgeable person of the household. Then, statistical results were contributed to FGDs with farmers, who were willing to join research focus group. About 30 participants, including village's leader, attended each meeting. All of participants shared their views and experiences in an informal environment. Participatory tools were use during FGDs, for documenting included perceptions of the climate change, climate change adaptation practices over time, and framework of climate-smart farmer. Thus, captured data and result of econometric model were ascertained through key informant interviews in FGDs. The proposed adaptations were selected based on the experiences of smallholder farmers of South East Asia, presented by Lasco et al. (2011). Some of the proposed options were common for the villages. Among the proposed options, changing crop variety, cropping pattern and crop calendar, changing in current farm management practices, and diversification of income generating and livelihood activities have been adopted in the upland area of Northern Thailand.

The main methodology is an estimation of ordered logistic models, which were used to analyze the main factors affecting farmers' adaptations level. Ordered logistic model has proven useful as econometrics method to analyze the impacts of socio-economic factors on stakeholder insights, and particularly to understand individual perceptions of climate change and adaptation (Asante et al., 2012; Tesso, 2013; Archie, 2014; Opiyo, Wasonga, & Nyangito, 2014; Quiroga, Suárez, & Solís, 2015). Compared to frequency used methods for qualitative dependent variable analysis (binary and nominal data), ordered logistic model have the advantage that they useful for ranked or leveled data (Javali and Pandit, 2010). This research separates farmers' adaptation into 4 levels. Thus, the ordered logistic model can be performed the probability of the adaptation being in the higher level. In order to analyze the factors that affect the farmers' adaptations level, this research applied an ordered logistic model (Greene, 2002) as shown in Equation (1)

$$Y_i^* = X_i'\beta + u_i \qquad (1)$$

Where Y_i is a latent measure of farmers' adaptation in 4 levels if, Y_i = 1: adaptation level 1, Y_i = 2: adaptation level 2, Y_i = 3: adaptation level 3, and Y_i = 4: adaptation level 4 (reference category). X_i is a vector of explanatory variables that influence the farmers' adaptations; β is a vector of coefficients to be estimated; and u_i is the white noise error term that assumed to have standard normal distribution ($u_i \sim IID(0, \sigma^2)$. Y_i is unobserved variable; as we can only observe the categories of responses as ordinal choice relative to thresholds can be show in Figure 1

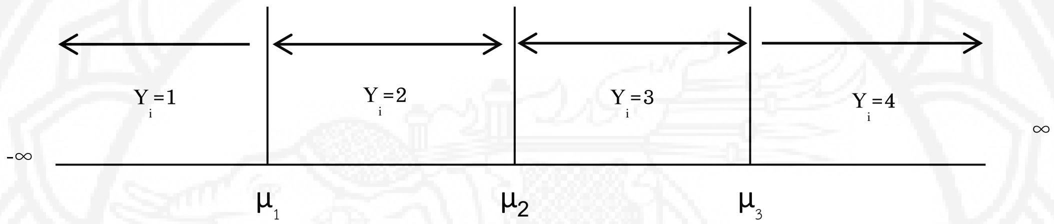

Figure 1 The Ordinal Choice Relative to Thresholds

The choice we observe are based on a comparison of "sentiment" toward higher adaptation level Y_i^* relative to certain thresholds, There are M = 4 alternatives, M-1= 3 thresholds and μ_1, μ_2, μ_3. The sentiment toward higher adaptation level are Adaptation level 4 if $Y_i^* > \mu_3$, Adaptation level 3 if $\mu_2 < Y_i^* \leq \mu_3$, Adaptation level 2 if $\mu_1 < Y_i^* \leq \mu_2$, and Adaptation level 1 if $Y_i^* \leq \mu_1$.

The maximum likelihood estimation (MLE) can be applied to estimate the vector of parameters β and thresholds m with consistent and asymptotic estimators. Thresholds m is an array of normal distribution related to the definite values of the explanatory variables. The positive sign of parameter β implies higher adaptation level that the value of related explanatory variable increases (Greene, 2002).

Results

Perception of Climate Change

Perceptions of climate change usually bases on observations of climate variability that affect farmers' lives (Weber, 2010). Farmers were asked questions about changing in temperature, rainfall as well as drought incident. The result of structure interview from 400 respondents shows that the most of farmers have observed increasing temperatures and drought incident, and deceasing rainfall. The survey data shown in Table 1 indicates that 83% of the farmers have a perception on climate change. About half of farmers believe that climate change caused by natural incorporate with human system. The majority of farmers have experiences of decreasing crop yield and crop quality due to the potential impacts of climate change. Research result shown that overall 32% of the farmers did not adapt to climate change. From the remaining 68%, most of farmers preferred changing farm management as key adaptation practices followed by diversification of income sources and livelihood activities, as well as changing in crop pattern and crop calendar.

Table 1 Perceptions of Climate Change Impacts and Adaptation Practices

Perceptions of Climate Change Effect and Adaptation (%)		
Climate Change	No	68 (17.0)
	Yes	**332 (83.0)**
Cause of Climate Change	Natural system	111 (27.5)
	Human system	90 (22.3)
	Natural and human system	**196 (48.5)**
	Don't know	7 (1.7)
Effect of Climate Change	No	165 (41.2)
	Yes	**235 (58.8)**
Effect in Summer Season (Fab-May)	Decrease yield	**129 (47.4)**
	Decrease quality	103 (37.9)
	Weed problem	13 (4.8)
	Increase insect, pest, and plant diseases	27 (9.9)
Effect in Rainy Season (May-Oct)	Decrease yield	**58 (46.0)**
	Decrease quality	37 (29.4)
	Weed problem	23 (18.3)
	Increase insect, pest, and plant diseases	8 (6.3)
Effect in Winter Season (Oct-Fab)	Decrease yield	**38 (47.5)**
	Decrease quality	28 (35.0)
	Weed problem	11 (13.8)
	Increase insect, pest, and plant diseases	3 (3.8)
Adaptation	No	128 (32.0)
	Yes	**272 (68.0)**
Adaptation Practices	Change crop variety	34 (7.0)
	Change in cropping pattern and crop calendar	57 (11.7)
	Change in current farm management practices	**251 (51.5)**
	Diversification of income-generating and livelihood activities	145 (28.8)

Econometric Analysis of Agro-Adaptation Levels

This research identified the significant determinants of adaptation practices using an ordered logistic model to provide policy recommendation detailing, which factors to target, and how to target them. Table 2 shows the variables included in this research and descriptive statistics. We reported data about adaptation level, human capital, social and physical capital, and natural capital as some variables analyzing climate risk for the 272 farmers who did adapt to climate change. Descriptive statistics consist of the mean and standard deviation for the continuous variables, and the frequency of the discrete variables.

Table 2 Description of the Variables in the Ordered Logistic Regression Model

Variable	Description	Frequency (%)	Mean	SD
	Dependent Variable			
(Y_i)	Adaptation level (order) Y_i =1 if household adapted their practice at least one practice, Y_i =2 if household adapted their practice at least two practices, Y_i =3 if household adapted their practice at least three practices, Y_i =4 if household adapted their practice at least four practices	 98 (36.0) 122 (44.9) 34 (12.5) 18 (6.6)	1.897	0.861
	Explanatory Variable Human Capital			
X_{11}	Age of the respondent in years	-	45.880	13.230
X_{12}	Gender of the respondent (dummy) = 1 if the respondent is male, 0 otherwise	135 (49.6) 137 (50.4)	0.508	0.501
X_{13}	Marital status of the respondent = 1 if the respondent is married , 0 otherwise	240 (88.2) 32 (11.8)	1.998	0.478
X_{14}	Education level = 1 if below fundamental school = 2 if fundamental school = 3 if high school = 4 if bachelor degree = 5 if above bachelor degree	96 (35.3) 96 (35.3) 62 (22.8) 14 (5.1) 4 (1.5)	2.133	2.776
	Social and Physical Capital			
X_{21}	Farm land area of the respondent in rai	-	14.021	11.583
X_{22}	Farm land slope (dummy) = 1 if farm land is steep slope, 0 otherwise	138 (50.7) 134 (49.3)	0.505	0.501
X_{23}	Main water source (dummy) = 1 if rainfall water, 0 otherwise	181 (66.5) 91 (33.5)	0.715	0.453
X_{24}	Government support1 (dummy) = 1 if the respondent is supported in form of integrated development, 0 otherwise	174(64.0) 98 (36.0)	0.628	0.484
X_{25}	Government support2 (dummy) = 1 if the respondent is supported in form of off-farm activity, 0 otherwise	15 (5.5) 257 (94.5)	0.060	0.238
X_{26}	Government support3 (dummy) = 1 if the respondent is supported in form of agro-tourism, 0 otherwise	5 (1.8) 267 (98.2)	0.018	0.131
X_{27}	Government help (dummy) = 1 if the respondent is helped in form of training and site visit, 0 otherwise	152 (55.9) 120 (44.1)	0.510	0.501
	Natural Capital			
X_{31}	Source of weather information 1 = 1 if the respondent is received information from neighbor, 0 otherwise	50 (18.4) 222 (81.6)	0.222	0.416
X_{32}	Source of weather information 2 = 1 if the respondent is received information from community leader, 0 otherwise	74 (27.2) 198 (72.8)	0.288	0.453
X_{33}	Source of weather information 3 = 1 if the respondent is received information from government officer, 0 otherwise	23 (8.5) 249 (91.5)	0.078	0.268
X_{34}	Source of weather information = 1 if the respondent is received information from the internet, 0 otherwise	5 (1.8) 267 (98.2)	0.015	0.122

Table 2 (Cont.)

Variable	Description	Frequency (%)	Mean	SD
X_{35}	Speed of weather information reception 1= during incident 2 = 1 day early 3 = 1 week early 4 = 1 month early	 189 (69.5) 71(26.1) 6 (2.2) 6 (2.2)	1.313	0.694
X_{36}	Confident of weather information Strongly unconfident 1-2-3-4-5 strongly confident	2 (0.7) 6 (2.2) 92 (33.8) 114 (41.9) 58 (21.4)	3.758	0.852
X_{37}	The effect of hot weather = 1 if farmer perceive that hot weather affect their farm, 0 otherwise	70 (25.7) 202 (74.3)	0.258	0.438
X_{38}	The effect of extreme climatic event = 1 if farmer perceive that extreme climatic event affect their farm, 0 otherwise	120 (41.1) 152 (55.9)	0.408	0.492
X_{39}	Source of adaptation information = 1 if the respondent is received information from private sector, 0 otherwise	31 (11.4) 241 (88.6)	0.125	0.331

The results of ordered logistic model estimation presented in Table 3. For the model specification, the Likelihood Ratio (LR) χ^2 test states that at least one of the explanatory variables' regression coefficients is not equal to zero in the model. The LR χ^2 statistic can be calculated by 2L(null model)-(2L(fitted model))=634.876-522.963=111.913, where *L(null model)* is from the log likelihood with just the explained variable in the model (Iteration 0) and *L(fitted model)* is the log likelihood from the final iteration with all the estimated parameters. The Nagelkerke R^2 indicates that 37.3% of the variance in adaptation level can be predicted from the three groups of explanatory variables in this study. Thus, the result of Pearson's χ^2 goodness of fit test shows that we can accept the null hypothesis that the observed data in this study are consistent with the fitted model.

Table 3 shows the estimated parameters on the estimation of farmers' adaptation level. The direction and magnitude of the estimated coefficients identify that an increasing of a positive direction coefficient increases the probability of the adaptation being in the higher level, yet decreases the probability of it being in the lower adaptation level. For the human capital variable, the relationship between farmers' adaptations level and marital status is clearly stated. The ordered log-odds for married respondent being in the higher adaptation level is 0.777 more than single, devoted, and separated respondent while the other explanatory variables are being constant. The parameter estimates for social and physical capital is clearly significant, reflecting that the ordered log-odds for steep land slope being in a higher adaptation level is 0.683 more than the other type of land slope. The ordered log-odds for rain water being in a higher adaptation level is -1.175 less than the other type of agricultural water sources. The ordered log-odds for the government support in term of integrated development and off-farm activity promotion being in a higher adaptation level is -0.613 and -1.389 less than the other type of the government support, respectively. However, the ordered log-odds for the government support in term of agro-tourism and agricultural training and site visit being in a higher adaptation level is 2.904 and 0.807 more than the other type of government support, respectively. The most of natural capital variable induce an increase the likelihood of adaptation level. The ordered log-odds for the source of weather information from community leader and the internet being in a higher adaptation level is 0.1.758 and 3.270 more than the other source of information, respectively. However, The ordered log-odds for the source of weather information from government being in a higher adaptation level is -1.503 less than the other source of information. The confident in weather and warning information induce and increase in adaptation level, a one level increase in confident level would induce in a 0.851 unit increase in the ordered log-odds of reaching a higher adaptation level. Farmers have experiences about the effect of hot weather and extreme climatic event, including natural disaster induce and increase in adaptation level. The ordered log-odds for the effect of hot weather and extreme event being in a higher adaptation level is 0.767 and 0.485 more than the other group, respectively. The ordered log-odds for the source of adaptation information from private sector being in a higher adaptation level is -0.896 less than the other source of information.

Table 3 Estimated Parameters for Ordered Logistic Regression of Adaptation Model

Variables	Estimate	S.E.	Wald	Sig.	95% Confidence Interval	
					L-bound	U-bound
Human Capital						
Gender (x_{12})	0.069	0.263	0.068	0.794	-0.447	0.585
Age (x_{12})	0.009	0.011	0.792	0.374	-0.011	0.030
Status-married (x_{13})	0.777**	0.387	4.021	0.045	0.018	1.536
Education (x_{14})	0.111	0.145	0.587	0.444	-0.173	0.396
Social and Physical Capital						
Land size (x_{21})	-0.013	0.011	1.410	0.235	-0.034	0.008
Land slope-steep (x_{22})	0.683**	0.275	6.183	0.013	0.145	1.221
Rain water (x_{23})	-1.175***	0.286	16.859	0.000	-1.735	-0.614
Government support-integrated development (x_{24})	-0.613**	0.300	4.175	0.041	-1.201	-0.025
Government support-off-farm activity (x_{25})	-1.389**	0.576	5.810	0.016	-2.518	-0.260
Government support-agro-tourism (x_{26})	2.904**	1.176	6.102	0.014	0.600	5.208
Government help-training and site visit (x_{27})	0.807***	0.276	8.550	0.003	0.266	1.348
Natural Capital						
Source of weather information-neighbor (x_{31})	0.349	0.396	0.776	0.378	-0.427	1.125
Source of weather information-leader (x_{32})	1.758***	0.349	25.316	0.000	1.073	2.443
Source of weather information- government (x_{33})	-1.503***	0.532	7.976	0.005	-2.546	-0.460
Source of weather information-internet (x_{34})	3.270**	1.292	6.408	0.011	0.738	5.801
Speed of weather information (x_{35})	0.211	0.208	1.033	0.309	-0.196	0.619
Confident of weather information (x_{36})	0.851***	0.186	20.896	0.000	0.486	1.216
Effect of hot weather (x_{37})	0.767**	0.312	6.043	0.014	0.156	1.379
Effect of extreme event (x_{38})	0.485*	0.258	3.535	0.060	-0.021	0.991
Source of adaptation information-private (x_{39})	-0.896**	0.442	4.119	0.042	-1.762	-0.031
Model Specification	-2 Log likelihood = 522.962 Pearson's χ^2 -Goodness of fit test=0.784				LR χ^2 test = 111.913*** Nagelkerke R^2=0.373	

Note: ***, **, and * indicate that the null hypothesis is rejected at the 0.01, 0.05, and 0.10 significance level.

The Framework of Climate-Smart Upland Farmers

The participants of six focus group discuss (FGDs) confirmed that they have been facing adverse impacts of climate change overtime and adapting with strategies as per their own traditional knowledge, adaptive capacity, skill, and information. Researchers presented some conceptual frameworks of climate-smart agriculture to the FGDs for their opinion in the light of their knowledge and experiences. Selected proposed frameworks based on the results of econometrics procedures on factors affecting upland farmer in adaptation level. Climate-smart agriculture (CSA) presented by Food and Agriculture Organization of the United Nations (FAO) (2013), it contributed to the achievement of 2030 sustainable development goals. It joins the three pillars of sustainable development, such as; (economic, social and environment) by tending to food security and atmosphere challenges. It made out of three main pillars: economically expanding agricultural productivity, rural efficiency and livelihoods; adjusting and constructing strength to environmental change; and diminishing as well as evacuating ozone harming substances outflows, where conceivable. This methodology intends to strengthen employments and food security, especially for smallholders, by further improving the quality of administration and utilization of regular assets and enfolding fitting techniques and advances for the generation, through the means of preparing and advertising agricultural products. The proposed framework in Figure 2 shown that climate information is essential to enhance farmer's perception and impact assessment, the arrangement of local coping and adaptation strategies, the implementation of adaptation practices, policy support and expanding scale (Selvaraju, Gommes, & Bernardi, 2011). Impact assessment encloses evaluation of variability and change in expected climate on agricultural systems; decrease yield; decrease quality; weed problem; increase insect, pest, and plant diseases. Consequently, environmental friendly adaptation practices can be applied to mitigate an adverse impact of climate stimuli. Therefore, we can find the common adaptation practices that the upland farmers can used to mitigate the impact of climate change in this study. Including changing current farm management, diversification of income generating and livelihood activities, changing cropping pattern and crop calendar, including changing crop variety are among some of practices to enhance local farmers' resilience in the face of climate change. According to statistical results, farmers use different farm management practices relating to self-sufficiency agriculture, agroforestry, crop rotation, soil management and conservation, effective microorganisms and bio-way, reduce chemical fertilizer and pesticide, fire management, farm irrigation system, and organic fertilizer.

However, upland agricultural systems have own characteristics and dynamics. Designing of improve adaptation practices is important to mitigate the location-specific impacts and risks of climate change. This research emphasized the role of driver and supporter of climate-smart scheme in promoting climate change adaptation, and, thus, it could be recognize as a baseline design of localized adaptation practices. The main drivers of climate-smart movement included farmers, community leader, government sector, and private sector. The potential supporters consist of the organization involve with integrated development, agricultural extension (crop, livestock, forestry, fishery, land development, community development), local administrative organization, and weather and early warning station. This multi-stakeholder can support agro-adaptation through participatory basis and capacity building of weather observation, weather forecast, weather impact observation, adaptation, weather-related disaster early warning system, and weather insurance system. Adaptation strategies in local level, farmers took center stage in developing 'climate-smart' practices on the basis that willing participation of vulnerable farmers is important for enhancing design, adoption and ownership of adaptation (Wright et al., 2014).

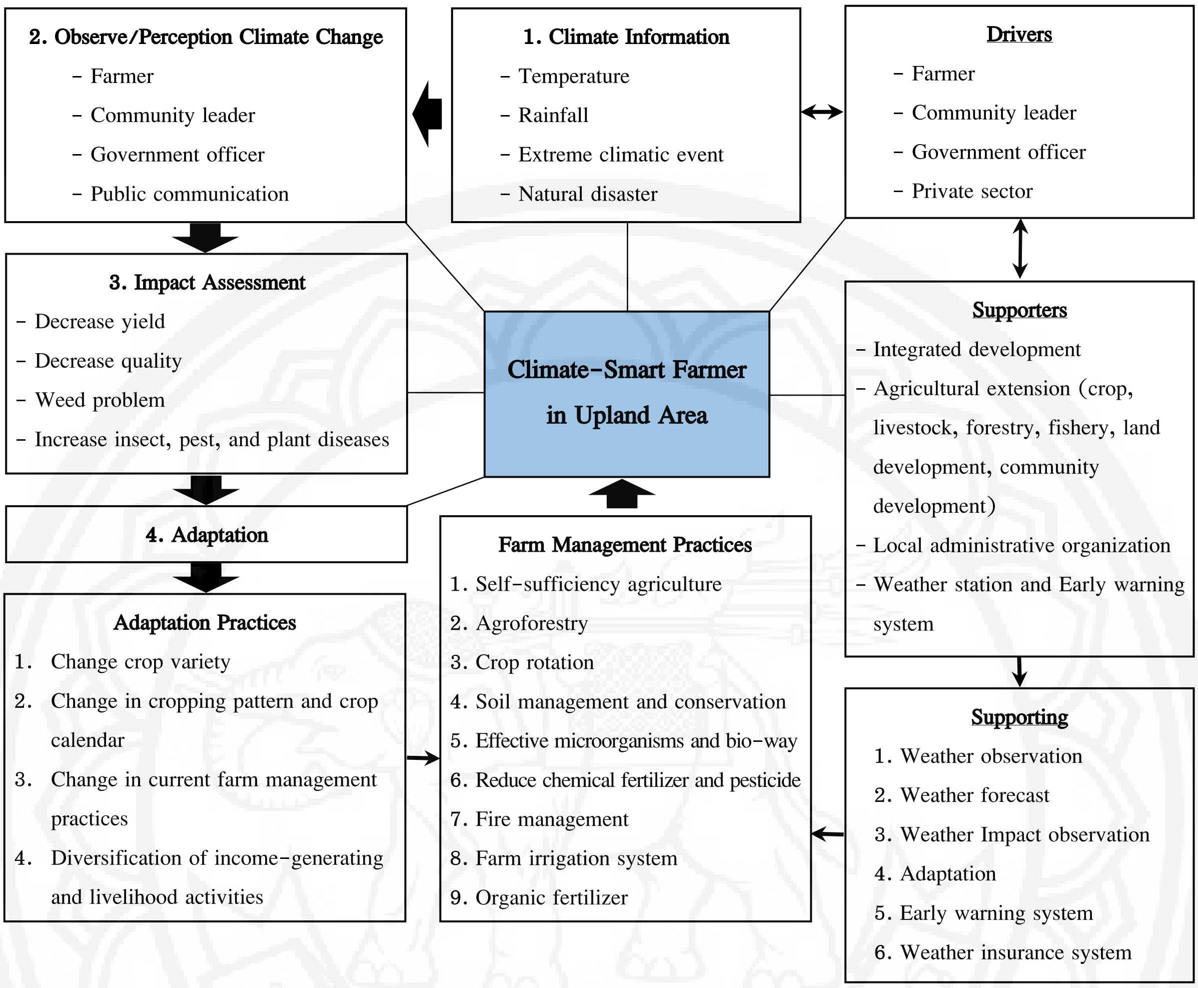

Figure 2 The Framework of Climate-Smart Farmers in Upland Area

Discussion

The research finding shows that majority of farmers in the study area perceived that temperatures are rising and rainfall is declining. Respondents identified various impacts of climate change. The negative impacts include, declining output and quality of agricultural products, weed problem, and increasing insect, pest, and plant diseases. These specific problems also caused by other factors (e.g. declining soil fertility), therefore it is discussed that climate change interacts with the other socio-economic and ecological problems, which must be addressed collectively (Fox, 2002). Consistent with results of some previous studies (Lasco et al., 2011; Abid et al., 2016), this research identified a set of farm level adaptation strategies applied by farm households that include changing farm management practices, diversification of income-generating and livelihood activities, changing cropping pattern and crop calendar, and changing crop variety, relying upon the nature of the climate risks. A result from econometric analysis is consistent with prior research (Debalke, 2011; Archie, 2014; Shiferaw, 2014). The ordered logistic regression results show that marital status, farmland slope, government support and help, source of weather information, confident of weather information, and farmer's experiences on the impact of hot weather and extreme climatic event are among the factors, which are positively and statistical significantly affected to farmers' adaptation level.

Developing and implementing climate change adaptation are advised to policymakers. Upland farmers should also focus on livelihoods and food security, and the following can become a significant part of adaptation process such as: increasing perception and awareness of climate change at the community level, provision of special support-such as information, technology, alternative sources of income, post-harvest facilities, credit facilities, weather insurance schemes; and early warning system at local site. Moreover, adaptation can be categorizes at individual, household, farm, community, and larger institutional scales (Adger, Arnell, & Tompkins, 2005). In the framework of climate-smart farmer development, we suggest the potential of community in adaptation levels. Community level adaptation may proceed via collective action, the ability of a group to follow a common interest, and the provision of public goods and facilities (Poteete & Ostrom, 2004; Tompkins and Eakin, 2012). Collective action provides the pooling of resources, wisdom, knowledge, and efforts for community members. The level of cooperation in local areas is thus potential in examining final outcomes (Paul et al., 2016). This approach was recognized as community-based adaptation (CBA) which requires collective effort and social capital, incorporate with information of long-term climate variability and the potential impacts into planning process, local knowledge and perceptions of climate change and risk management procedures, concerns local decision making process, and along with community demands (Bryan & Behrman, 2013). Through CBA, local farmers are encouraged to employ their local wisdom, knowledge and skill, which build their self-reliance, drive and commitment to the challenges brought by future climate change. This CBA is a community-led mechanism, based on communities' priorities, demands, knowledge and coping capacities, which should empower farmer to plan for and cope with the impacts of future climate change (Reid, 2016).

Conclusion and Suggestions

The research provided insights into the usage of mixed method research that applied questionnaire survey incorporate with focus group discussion in selected upland sub-district. Primary data was collected from six rural communities in the Northern Thailand, using a questionnaire survey of 400 farmers and six focus group discussions. The study uses ordered logistic model to analyze the level of agro-adaptation of climate change. The results showed that majority of the farmers have perceived the rising temperatures and declining rainfall. The impacts of climate change include declining crop output and crop quality. Respondents have been implementing among set of adjustments in current farm management practices in response to climate stimuli. The ordered logistic model analysis reveals that human capital, social and physical capital, and natural capital all influence upland farmer adaptation level. Thus, climate-smart farmer will be played an important role for dealing with future climate change of smallholder farmer in upland area. Public policy should be created and supported farmers for adaptation movements including the provision of confidential weather and climate change information to farmer for their decision-making, promotion the source of fund for their additional cost, implementation of on-farm resource management systems, sharing experience among farmers, and adaptation monitoring and evaluation inclusive with area specific-context. This research recommends that government should formulate policies that supports and incentives for farmers to motivate an adoption of eco-friendly adaptation practices. The potential supporters consist of the organization involve with integrated development, agricultural extension, local administrative organization, and weather and early warning station. This multi-stakeholder can support agro-adaptation through participatory approaches and capacity building of weather observation, weather forecast, weather impact observation, adaptation, weather-related disaster early warning system, and weather insurance system. However, the finding of this research raises the issues for the recommendation to the further study. The main quantitative method is the ordered logistic model, the future studies can be apply the others methods e.g. multinomial model to separate factor affecting each adaptation measure rather than adaptation level. The output of this research may be considered for generalize to the others upland area. Due to the differences in community context, the future studies should attempt to conduct by using suitable method with their community socio-economic and environment context.

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