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FACTORS AFFECTING THE ADOPTION OF ADAPTATION MEASURES TO CLIMATE CHANGE: A CASE STUDY IN HUONG PHONG COMMUNE, HUONG TRA TOWN, THUA THIEN HUE PROVINCE

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Abstract: In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans. Vietnam generally and the coastal area in Thua Thien Hue province particularly is vulnerable to climate change and some extreme climate events. Adaptation is considered as one of the best long-term strategies to community to better face with local extreme conditions and associated climate change. This study used Logistic regression model to determine factors influencing farmers' decisions to adopt climate change adaptation measures. The results indicated that that age, years of schooling, years of farming experience of the household head, household size, ratio of number of farm labors to number of consumers, farmer's access to extension services and adaptation measures, and the place where farmer lives factors significantly influence adoption decisions. From the results, some recommendations were derived to help farmers in the coastal area of Thua Thien Hue province adapt to climate change.

Keywords: climate change adaptation, extreme climate events, Logistic regression, perception, Thua Thien Hue province

1 Introduction

In recent decades, changes in climate have influenced natural and human systems on all continents and across the oceans [1]. Climate change, in the form of higher temperature, reduced rainfall, and sea level rise, negatively affects crop production in low-income, agriculture-based economies, and long coastline countries like Vietnam [2,3]. Within the country, the central coast is considered as one of the most vulnerable areas, and Thua Thien Hue province, generally, and Huong Phong commune, particularly, is greatly influencedby the effects of extreme climate events [4]. In order to reduce negative impacts of climate change, adaptation needs to be considered as one of the policy options that is an important component of climate change impact and vulnerability assessment [5].

There were severalstudies showing that knowledge of the adaptation methods and factors affecting farmers' choices enhances policies toward tackling the challenges ofclimate change imposing on Thua Thien Hue province's, in general, and Huong Phong commune's

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farmers, in particular. Until present, however, little is known about factors that affect farmers' adoption of climate change adaptation measures in Huong Phong commune. For those reasons, this study is conducted to determine factors influencing this problem.

The objectives of this study are(1) to illustrate farmers' perception of climate change and their decision to adopt adaptation measures, (2) to determine factors influencing farmers' adoption of climate change adaptation measures, and (3) to formulate recommendations for policies and programs helping farmers in Huong Phong commune, in particular, and in the coastal area in Thua Thien Hue province, in general, adapt to climate change.

Several researchers argued that adaptation to climate change is a two-stage process involving perception and adaptation stages [5, 6, 7, 8, 9]. The first stage is assessing farmer's perception that climate change has occurred or not, and the second one is examining whether the farmer responds to this perception in the form of adaptation. Previous studies on adoption of climate change adaptation measures have shown that farmers' adoption decisions depend on household characteristics (such as age, gender, education, farming experience of household head, family size, rate of farm labor and consumer, and income), institutional characteristics (access to extension works and adaptation measures), and infrastructure (distance to output markets, area where people live) [2, 4, 7, 10].

2 Methods and data

2.1 Site selection

Huong Phong is a small coastal commune located in the northwest of Huong Tra town, Thua Thien Hue province. Two-thirds of the commune border is surrounded by the Huong River and Tam Giang lagoon that has numerous advantages in agriculture production, aquaculture, and fisheries. Huong Phong inherits all the characteristics of the climate of Thua Thien Hue. In addition, due to the geographical location, terrain conditions, and the relatively low elevation of 0.5 m to 1 m above the sea level, the impact of natural disasters and climate change on the local human life and agriculture, aquaculture is very serious and tremendous [4]. According to the commune statistical record in 2015, in Huong Phong, the total natural area was 1584.03 hectares, of which agricultural land accounted for 773.81 hectares. The livelihood of most households in Huong Phong commune is agriculture production (including crop production, livestock, and aquaculture).

The selection of Huong Phong commune for this study was based on the following criteria:

- The commune faces critical problems of climate change.
- There have been some projects and programs aiming at raising awareness and helping local farmers to adapt and reduce impacts of natural disasters and to ensure livelihoods in the context of climate change (Project on community-based disaster risk reduction and adaptation to climate change in Huong Phong and Hai Duong communes, SRD, 2011–2014; Project of building community models to adapt to climate change through conservation and sustainable use of natural resources in Huong Phong commune, CORENARM, 2009–2012).

- The commune has experienced the application of different climate change adaptation measures in recent years, and different climate change adaptation measures are available.
- This commune is representative for the coastal area of Thua Thien Hue province.
- The output from the research in Huong Phong commune can be applied in other coastal areas in the central region of Vietnam.

Thuan Hoa and Tien Thanh villages in Huong Phong commune were selected as the study site. Thuan Hoa village is located along the coast of the Tam Giang lagoon on one side and the Huong River on either side, and it comprises Ru Cha mangrove forest. Tien Thanh village is in the inner area from the coastline. According to the Agricultural department and Extension division of Huong Tra town, Thuan Hoa and Tien Thanh are the most and least vulnerable village to climate change in Huong Phong commune, respectively.

2.2 Data collection and sampling selection

Data collection

Primary data and qualitative information were collected by using group discussion with diverse stakeholders, household surveys with a structured questionnaire, and participatory observation. Secondary data were collected from various organizations and departments from the province, district, and commune levels such as statistical departments, research centers, NGOs, and mass organizations.

Sampling selection

Seventy households belonging to two villages of Huong Phong commune were randomly selected for interviewing the head of villages and key informants. Of which, two households did not participate in the interview and eight households did not perceive that climate had been changing in the local area. Thus, these ten households were removed from the sample. Hence, the final sample size is sixty households (30 in each village).

2.3 Analytical framework

This study used descriptive and inference analyses for the first stage and applied econometric regression approach, namely logistic regression model, for the second stage. Because the second stage of adaptation is a sub-sample of the first one, it is likely that the second stage subsample is non-random and different from those who did not perceive climate change creating sample selection bias.

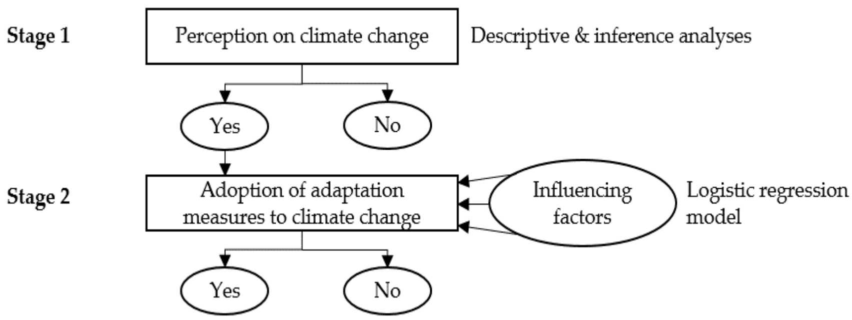

Figure 1. Methods for data analysis in the study

The logistic model is

$$\log\left(\frac{\pi}{1-\pi}\right) = Y = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \cdots + \beta_{12} \cdot X_{12},$$

where $\frac{\pi}{1-\pi}$isthe odds ratio in favor of the adoption of climate change adaptation measures,

$$Y = \begin{cases} 0, & \text{the farmer did not adopt climate change adaptation measures;} \\ 1, & \text{the farmer adopted climate change adaptation measures.} \end{cases}$$

X_i:is different factors hypothesized to affect adaptation (Table 1).

Hypothesis: $H_0: \beta_0 = \beta_1 = \cdots = \beta_{12} = 0$ (Using logistic model is not suitable)

$H_a: At\ least\ one\ \beta \neq 0$ (Using logistic model is suitable)

Table 1. Description of predictor variables for logistic regression model

Variable	Description	Expected Sign
X_1	Area (= 1 if farmer ϵThuanHoa and 0 if farmer ϵTienThanh village)	+
X_2	Age of household head (continuous)	-
X_3	Gender of household head (= 1 if male and 0 otherwise)	+
X_4	Years of schooling of household head (continuous)	+
X_5	Farming experience of household head (continuous)	+
X_6	Household size (continuous)	+
X_7	Ratio of number labor in farm to number of consumers (continuous)	+
X_8	Farm income in '000VND (continuous)	+
X_9	Distance to output market (continuous)	-
X_{10}	Access to credit (= 1 if access and 0 otherwise)	+
X_{11}	Access to extension services (= 1 if access and 0 otherwise)	+
X_{12}	Access to adaptation measure (= 1 if access and 0 otherwise)	+

3 Results and discussion

3.1 Farmers' perceptions of climate change in the study area

- **Temperature changes**

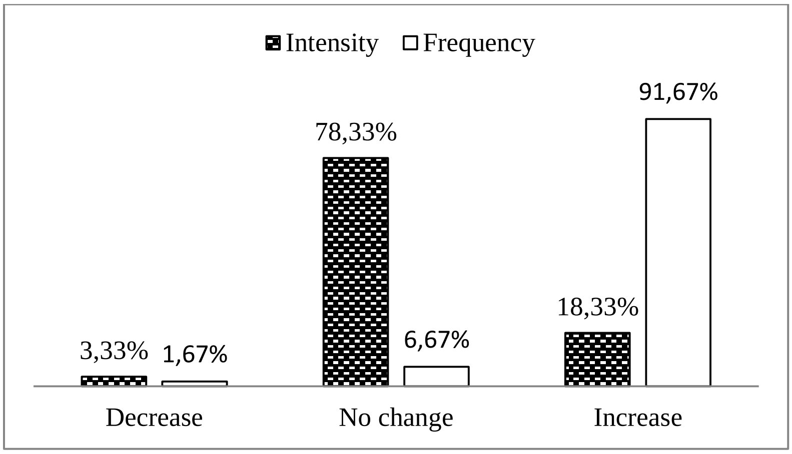

Figure 2. Farmers' perceptions of change in temperature from 2008 to 2015 (*N* = 60)

Source: *Household interview, 2016*

Most of the respondents perceived that there was no temperature change, but the frequency of high-temperature occurrence increased. According to group discussions, the dry season came earlier and lasted longer compared with that in the past. The time with high temperature was from March to September (period 2012–2016), (especially in May, June, and July), compared with April to August (period 2008–2011). The period with low temperature was from December to January of the next year. This is consistent with temperature data recorded by Thua Thien Hue Meteorological Stations.

Table 2. Monthly temperatures of Thua Thien Hue province from 2008 to 2014 (°C)

Year	Month												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Avr. Year**
2008	19.6	15.8	21.8	25.9	26.7	28.6	28.9	28.2	27.0	25.5	22.7	19.8	24.2
2009	18.5	23.1	24.3	25.5	26.7	29.2	28.5	28.3	26.9	25.6	22.6	21.2	25.0
2010	21.0	22.2	23.7	26.1	29.3	29.4	28.8	27.4	27.4	24.8	22.6	21.3	25.3
2011	17.1	19.5	18.9	23.9	27.1	28.8	29.0	28.4	26.7	24.7	23.6	18.7	23.9
2012	19.3	20.1	22.6	26.3	28.4	29.2	28.9	28.9	26.6	25.4	25.0	22.8	25.3
2013	19.8	22.9	24.6	26.2	28.7	28.5	27.9	28.4	26.6	24.6	23.6	18.3	25.0
2014	18.7	20.4	23.0	27.2	29.3	30.4	29.0	28.6	27.8	25.2	24.7	19.7	25.3

Source: Thua Thien Hue Meteorological Stations, 2015

- **Precipitation change**

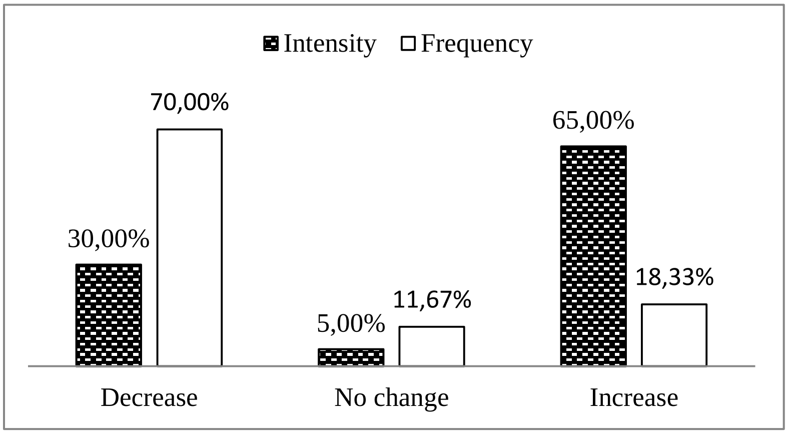

Figure 3. Farmers' perceptions of change in precipitation from 2008 to 2015 ($N = 60$)

Source: the household interview, 2016

Respondents perceived that there was a decrease in frequency and an increase in intensity in terms of precipitation. According to group discussion, the rainy season came later and ended earlier compared with that in the past. Namely, it came in late September and ended in January next year instead of in August and February. This also matches with precipitation data recorded by Thua Thien Hue Meteorological Station.

Since data recorded from Thua Thien Hue Meteorological Stations did not only represent for Huong Phong commune but also covered the whole province, the comparison between farmers' perceptions on temperature and precipitation and Thua Thien Hue Meteorological Station's statistical record appeared to be approximately homogeneous in period 2008–2014.

Table 3. Monthly precipitation of Thua Thien Hue provincefrom 2008 to 2014 (mm)

Year	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avr Year
2008	118.2	84.6	80.2	74.1	195.3	24.1	25.8	63.3	478.7	1523.9	670.7	510.1	3849.0
2009	256.0	24.1	86.8	149.0	220.3	106.0	78.5	98.0	1298.6	833.8	331.5	334.5	3817.1
2010	111.5	12.7	89.3	52.3	68.1	139.3	231.3	648.8	177.4	1129.9	829.7	107.5	3597.8
2011	361.2	14.3	167.4	72.9	148.9	87.9	16.0	59.3	741.5	1259.5	842.4	709.5	4480.8
2012	155.9	76.1	17.3	51.1	216.1	20.4	25.4	168.9	436.1	408.8	489.1	304.2	2369.4
2013	47.3	27.0	64.0	25.4	43.4	96.0	118.3	39.3	569.0	520.6	1091.8	89.9	2732.0
2014	75.9	30.3	16.7	5.3	79.5	2.7	224.7	135.6	44.9	698.6	274.7	775.4	2364.3

Source: Thua Thien Hue Meteorological Stations, 2015

- **Climate extreme events**

Droughts, floods, cold spell and storms, whirlwind, and tropical low pressure were the main climate extreme events in Huong Phong commune.

Table 4. The trend of climate extremes in Huong Phong commune

Climate events	Frequency		Intensity		Irregularity	
	Past	2008–2015	Past	2008–2015	Past	2008–2015
Flood	+++++	++	++++	++	Frequent	Frequent
Storms	++++	+++	+++	++++	Forecastable	Unforecastable
Cold	++++	+++	++++	+++	Frequent	Infrequent
Drought	+++	++++	++++	++	Frequent	Frequent

Note: The number of plus (+) indicates an increasing trend gradually

Source: Group discussion, 2016

3.2 Farmers' adaptation measures in the study area

There were 65.18 % of respondents having adopted one or more climate change adaptation measures. Those measures were (1) using tolerant varieties and breeds, (2) adjusting seasonal calendar, (3) production techniques and livestock management, (4) irrigation, and (5) soil conservation. While 34.82 % of the surveyed farmers reported not to have taken any adaptation method for five major reasons: lack of information, lack of money, shortage of labor, shortage of land, and poor potential for irrigation.

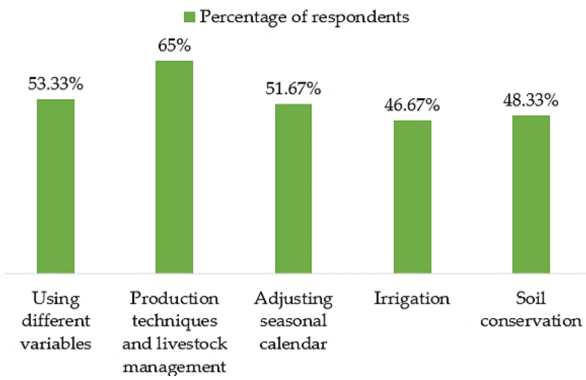

Figure 4. Adaptation measures to climate change in the study area

Source: Household interview, 2016

4.3 Determinants of farmers' adoption of climate change adaptation measures

Firstly, look at the goodness of fit test (Table 6). The p-value is low (< 0.001) and the observed chi-square value (32.606) is greater than the critical table chi-square values ($\chi^2_{0.1,12} = 18.5493$ and $\chi^2_{0.05,12}$= 21.026), so the decision is to reject the null hypothesis ($H_o: \beta_1 = \beta_2 = \cdots = \beta_{12} = 0$ or using the logistic model is not suitable for this study).

In addition, the Nagelkerde R^2 of 62.1 % revealed that 62.1 percent of the probability of adopting adaptation measures is explained by the logistic model.

The classification table showed the logistic model predicted correctly 9 farmers out of 15 interviewed farmers not adopting adaptation measures, that is, the percentage of non-occurrences correctly predicted is $\frac{9}{15} = 60\ \%$.With the total of 45 interviewed farmers adopting adaptation measures, the model predicted wrong 3 farmers, that is, the percentage of occurrences correctly predicted is$\frac{42}{45} = 93.3\ \%$. The overall success rate of the logistic model is high, namely, $\frac{51}{60} = 85.0\ \%$.

Therefore, the statistical testing results proved that using logistic regression model in this study is completely suitable.

Table 5. Classification table

	Observed		Predicted		
			Adaptation		Percentage Correct
			0.00	1.00	
Step 1	Adaptation	0.00	9	6	60.0
		1.00	3	42	93.3
	Overall Percentage				85.0

Source: Results of logistic regression model (SPSS), 2016

Secondly, the results from the Logistic model (Table 6) indicated that the adaptation process is driven by some factors. Variables that positively and significantly influence the adoption of climate change adaptation measures in the study are education, farming experience of the household head, household size, ratio of number of farming laborers to number of consumers, access to extension work and adaptation measures, and area. On the other hand, age of household head negatively related.

The fitted logistic model is

$$\log\left(\frac{\pi}{1-\pi}\right) = Y = -8.154 + 2.189 \cdot X_1 - 0.256 \cdot X_2 + 0.961 \cdot X_3 + 0.328 \cdot X_4 + 0.266 \cdot X_5$$
$$+1.289 \cdot X_6 + 7.826 \cdot X_7 + (4.818E - 5) \cdot X_8 - 0.247 \cdot X_9 - 0.230 \cdot X_{10} + 2.693 \cdot X_{11} + 2.979 \cdot X_{12},$$

whereπ is the estimated probability of adaptation.

Age of the household head: The age variable of the household head is negatively statistically significant in logistic models (sig. < 0.1). For each one-year increase in farmers' age, the odd of adaptation increase by 0.774 times (other variables are fixed). This is possible because younger farmers have a tendency to be more active and innovative due to their longer planning horizons and lower risk aversion, thus younger farmers had a greater likelihood of adopting climate change adaptation measures.

Year of schooling of household head: The education of household head variable was significant at the 10 % level. As can be observed in Table 6, the positive and significant sign of education indicated that the years of education significantly increases the probability of adaptation (sig. <0.1). If the education level increases by 1 year, the odds of adaptation of household head increase by 1.388 times, regardless of other factors. This implicates that the respondent's level of education (measured in years) drives up the probability of climate change adaptation.

Years of farming experience of household head: The years of farming experience is positively related to the adoption of adaptation measures (sig. <0.05). That reveals that experienced farmers are in the vanguard of adaptation. It is apparent that more experienced farmers are more likely to record adaptation measures. For 1 more year of farming experience, the odds of adaptation increase by 1.305 times (other variables do not change).

Being the head of the household also increases the probability that the farmer can adapt, perhaps because he or she is in control of the household resources.

Household size: The results indicated that the household size increases the likelihood of adopted climate change adaptation measures (sig. < 0.1). It appears that larger farms are more likely to adapt to climate change. This is consistent with the idea that adaptation has a fixed cost element, implying that information gathering is less worthwhile for small farmers [10]. Thus, households with a larger pool of labors are more likely to adopt adaptation measures to climate change and use it more intensively and efficiently. The increase in odds of adaptation by increasing household size by 1 person is 3.628 times, holding other factors fixed.

Ratio of number of labors in farm to number of consumers: Table 6 showed that the rate of the number of farm labors and consumers is positively linked to the adoption of adaptation measures (sig.< 0.1). The higher ratio of the number of farming labors to the number of consumers is, the higher labor endowment household has, which presents the productivity of family.

Access to extension services: There was a positive relationship between access to the extension of farmers and their adoption of climate change adaptation measures (sig. < 0.1). The odds of adaptation to climate change from farmers accessing to extension work $(X_{11} = 1)$(X is 14.775 times greater than the odds of adaptation from those not accessing $(X_{11} = 0)$(X(holding other variables constant). Being in receipt of free extension advice provided by extension agents, public sources, or any other organization, farmers' awareness on climate change and adaptation measures isdefinitely upgraded. Thus, farmers' contact with extension agents or any other sources which might provide information on climate change, livestock or crop production, raises the probability to take up relevant adaptation measures.

Access to adaptation measure: The access to adaptation measure is positive, andstatistically significant in the logistic model (sig. < 0.05). The odd of adaptation for farmers having accessed to adaptation measures $(X_{12} = 1)$(X is 0.051 times greater than the corresponding odds for those having not accessed to adaptation methods yet, regardless of other variables. The access to adaptation measures improves knowledge on climate change and natural resources and enhances the experience of collecting and applying a sustainable way for local climate change adaptation strategies. Therefore, in the context of Huong Phong commune, the opportunity of accessing to adaptation measure increases the probability of adaptation.

Area: The area indicator is positively linked to adaptation (sig. < 0.1). According to the regression results, the odd of adopting adaptation methods for people in Thuan Hoa village is 8.929 times greater than those in Tien Thanh, regardless other indicators. This relationship reveals that awareness of climate change impacts and necessity of adaptation, as well as adaptation capacity of Thuan Hoa village's people is higher than those of Tien Thanh’s.In general, farmers who live in coastal areas and are highly vulnerable to climate change, are more likely to have perceived and adapt to climate change than those livingin the midlands and highlands.

Table 6. Results of the logistic regression model

		β	S.E.	Wald	D.f.	Sig.	Exp(β)	95 % C.I. for EXP(β)	
								Lower	Upper
Step 1[a]	**Area***	2.189	1.291	2.875	1	0.090	8.929	0.711	112.168
	Age*	-0.256	0.146	3.079	1	0.079	0.774	0.582	1.030
	Gender	0.961	1.379	0.486	1	0.486	2.615	0.175	39.021
	Education*	0.328	0.169	3.757	1	0.053	1.388	0.996	1.934
	Experience**	0.266	0.128	4.314	1	0.038	1.305	1.015	1.677
	Household_size*	1.289	0.751	2.946	1	0.086	3.628	0.833	15.807
	Ratio_labor_consumer*	7.826	4.430	3.121	1	0.077	2505.184	0.424	14784922.812
	Farm_income	4.818E-5	1.306E-4	0.136	1	0.712	1.000	1.000	1.000
	Distance_to_market	-.247	.374	.436	1	0.509	0.781	0.376	1.625
	Access_credit	-0.230	1.036	0.049	1	0.824	0.794	0.104	6.054
	Access_extension_work*	2.693	1.381	3.801	1	0.051	14.775	0.986	221.474
	**Access_adaptation_measures ** **	2.979	1.507	3.908	1	0.048	0.051	0.003	0.975
	Constant	-8.154	7.956	1.050	1	0.305	0.000		
	2-log likelihood	34.875							
	Cox & Snell R Square	0.419							
	Nagelkerde R Square	0.621							
	Chi-square	32.606	Sig	0.001					

Source: Results of logistic regression model (SPSS), 2016

a. Variable(s) entered on step 1: Area, Age, Gender, Education, Experience, Household_size, Ratio_labor_consumer, Farm_income, Distance_to_market, Access_credit, Access_extension_work, Access_adaptation_measures.

***Significance at 5 % level*

**Significance at 10 % level*

4 Conclusions and Recommendations

4.1 Conclusions

The analysis of farmers’ perceptions of climate change indicates that in Huong Phong commune, in recent years (2008–2015), the climate has changed toward higher temperature, reduced rainfall, and climate extremes events such as droughts, floods, cold spell and storms, whirlwind, and tropical low pressure. The perception of climate change and some extreme weather events of local farmers is relatively appropriateand in line with climate data recorded by Thua Thien Hue Meteorological Stations.

In Huong Phong commune, there were several measures which farmers applied for climate change adaptation, including using tolerant varieties and breeds, adjusting seasonal calendar, production techniques and livestock management, irrigation, and soil conservation. However, there were many barriers for scaling up adaptation measures in the study area. Thereisa lack of information, lack of money, shortage of labor, shortage of land, and poor potential for irrigation.

Using the Logistic regression model for investigating the factors influencing Huong Phong commune's farmers to adopt climate change adaptation measures is suitable. Thereby, the significantly positive variables are education, farming experience of the household head, household size, ratio of number of labors in farm to number of consumers, access to extension work and adaptation measures, and area while significantly negative one is age of household head.

4.2 Recommendations

From the literature review about the necessary of adaptation, topographic and climate characteristics of Huong Phong commune, constraints in adopting adaptation measures and the results obtained from the Logistic model, the research indicated severalsolutions to solvethe problems relating to the adaptation measures and helping farmers in Huong Phong commune, in particular, and in the coastal areas, in general, adapt to climate change and cope with extreme weather events. Certainly, the use of the following recommendations and suggestions for other similar areas should be handled with care.

Firstly, enhancing education for people to improve awareness ofclimate change potential benefits of adaptation is one of the sound solutions.

Secondly, adequate access to and introduction of new adaptation measures togetherwith farmer's experience and available knowledge should be provided for farmers by the government to enable them to overcome the major barriers and impacts of climate change.

Thirdly, non-formal educational programs should be encouraged through extension services manned by competent and qualified extension agents to enlighten and sensitize farmers about the impact of climate change on agriculture and aquaculture, and also to train local farmers on how to efficiently utilize farm inputs like farm chemicals, the excessive use of which may aggravate effect of climate change on agricultural and aquaculture production, and mitigate as well as adapt to negative impacts of climate change and extreme weather events.

Fourthly, the local authority, as well as government, should facilitate farmers to access to credit in a form of loans to enable them to overcome the major barrier of adaptation to climate change. This solution could improve the level of adaptation measures.

Finally, the local authority has the duty to carefully consider and adjust common strategies/plans for theirsuitability with the specific area to reduce production risks and to take full advantages of the adaptation measures before launching them forall farmers.

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