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Rice Farmers' Adaptation Strategies to Climate Change and Water Input: Evidence From Micro Level Data

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ABSTRACT

The main purpose of this paper is to identify adaptation strategies and factors governing farmers' choice and determine their effects on each adaptation strategy in the face of perceived climate change in the Kamfiruz region of Iran. In this sense, we consider common socio-economic and institutional factors, and also the amount of water input for paddy fields. After surveying the impacts of climate change and production losses due to climate change on rice production, we use a binary logit and multivariate probit model to examine different factors affecting adaptation to climate change and how they affect each adaptation practice in paddy fields. According to the results, adjusting farming calendars, changing crop varieties, increasing consumption of groundwater for irrigation, using irrigation control mechanisms, and intercropping are the most important adaptation strategies. Besides, the estimation of the multinomial logit model implies that eight variables account for **51.4%** of the possibility of adaptation of rice farmers. Moreover, actual changes in the possibility of adoption of adaptive measures concerning a unit of increase in cultivated water, age, educational, income level, farm size and training are **+3.3, -8, +4, +6, +4**, and **+17%,** respectively. However, of these explanatory variables, water and training are the most prominent variables in influencing more adaptation strategies to climatic events. The paper is concluded with suggestions as to some policy interventions to scale up adaptation to climate change in Kamfirouz paddy fields located in Fars province.

1. Introduction

Since the beginning of this century, climate change has emerged as one of the biggest environmental and agricultural challenges (Anik and Khan, 2012; Kongsager *et al*., 2016). Due to low technological level and financial shortage of farmers, agriculture in developing countries, almost located in lower latitudes, are highly vulnerable to climate change (Abid *et al*., 2018) which adversely affects the profits and losses of agricultural activities (Ayouqi & Vercammen, 2014; Bojovic *et al*., 2015). Among the agricultural activities, paddy fields are one of the largest water consumers (e.g. Wang *et al*., 2017) and its yield (rice) is the most susceptible to climate change over time (Sarker, 2012). In addition, the adverse impacts of climate change has led to rice production losses and food insecurity, particularly in the lower latitudes of the world (Rosenzweig and Tubiello, 2007; Sarker, 2012; Misra, 2012; Alam, 2016).

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To reduce costs and damages, scientific assessments insist on mitigation and adaptation strategies given the socio-economic and institutional factors in a region (Islam & Nursey-Bray, 2017; Shahraki *et al*., 2017). Adaptation to climate change refers to the process of adjustment in natural or human-environment systems in response to actual or expected climate or its effects to mitigate harm or exploit associated beneficial opportunities (Thompson-Hall *et al*., 2016; Alam *et al*., 2017). Furthermore, climate change adaptation actions mitigate climate vulnerability (Sarkodie and Strezov, 2019). Thus, investigating the adaptation strategies to reduce the potential negative impacts of climate change and reinforcing the advantages associated with climate change are now gaining importance around the world.

Based on a brief review of the literature and numerous other studies, adaptive span is influenced by several factors such as perceptions about climate change and access to favorable technology, institutions and policies (Alam *et al*., 2016; Brulle *et al*., 2012; Haden *et al*., 2012;; Mertz *et al*., 2009; Adger *et al*., 2003; Baccari *et al*., 2017). In this context, according to most studies, adaptation can occur at a national, regional or local level (Sarker, 2012; Abid *et al*.,

2018). Although considerable studies have been made on the topic of assessing adaptation strategies in agricultural aggregate level (e.g., Bryant *et al*., 2000; Calzadilla *et al*., 2014; Trinh *et al.*, 2018; Tripathi and Mishra, 2017), little attention has been given at a micro-farm (local) level so far. Furthermore, the studies that have investigated rice producers' adaptation strategies at a micro-farm level (Alam *et al*., 2012; Anik and Khan, 2012; Alauddin and Sarker, 2014; Khanal et al., 2017) have not considered the necessary water input and irrigation system. However, the latter studies have focused more on climatic parameters and less attention has been paid to socio-economic characteristics of households and farms or essential inputs such as water.

In the present study, we investigate the impact of water consumption on the choice of adaptation strategies and their effect on these strategies. Moreover, we consider changes in the irrigation mechanism as one of the adaptation strategies. Besides, we address common socio-economic factors taken into consideration by previous studies (e.g., Deressa *et al*., 2009; Hisali *et al*., 2011; Tripathi and Mishra, 2017; Trinh *et al*., 2018).

Here, we try to answer the following questions: how do farmers adapt to changing climatic conditions, particularly in a drought area? What are the major adaptation strategies in the study area? What are the determinants that influence farmers' adaptive strategies against climate change in the region? And how are the impacts of crucial factors such as water consumption on the selection of adaptation strategies and their effect on these strategies? We try to answer these questions through evaluating the theory of random utility and a micro-econometric model on a case study of rice growers in Kamfiruz in the city of Marvdasht, Fars province, Iran.

Therefore, the objectives of the current research were to determine the variables that influence households' decision procedure in selecting adaptation strategies and the level of using each adaptation strategy against climate variability for rice farms using a binary logit and multivariate probit models, and to specify the actual value of variations in the probability of adoption of a specific adaptive practice with regard to a unit of change in the explanatory variables through marginal effect (ME) calculations.

The rest of the paper is structured as follows. First, we present a review of the literature. Next, we describe the study sites and data collection procedure and analytical methods. Then, the results of the research and discussion are presented. The last part provides conclusions and policy recommendations.

2. The Literature and research background

The interrelationship between climate change and agriculture is undeniable. Depending on regional location or latitudes and socioeconomic characteristics, the direct and indirect effects of weather variability on agricultural production could be either desirable or undesirable (Tripathi and Mishra, 2017). Early studies on the effect of climate change focused on the agriculture of developed countries (e.g. Reinsborough, 2003) and thereafter attentions were drawn to the agriculture of developing countries (e.g. Deressa and Hassan, 2009; Abid *et al*., 2016). These studies demonstrate that, due to the exposure of agriculture to climatic events, the undesirable impacts and damage levels are high. Research by Kumar Jha *et al*. (2017) shows that climate susceptibility related to agriculture, water and socio-economic dimensions of people in developing countries is possible to be alleviated to a great extent.

Adaptation is a key solution to alleviate the severity of these impacts and damages. Adaptation to climate change, as explained by IPCC (2014) and Alam *et al*. (2017), is some modifications in the human-environment system at the micro level in response to climatic conditions to alleviate damages or apply pertinent beneficial opportunities.

There have been broad researches on adaptation with the variability in climate using different methods and approaches. These methods include two principal groups: general equilibrium models and partial economic models (Sarker, 2012). Though several approaches of these models (e.g. crop-based models and Ricardian approach) encompass some adaptation issues, they are unable to investigate the determinants of farmers' adaptation process (Deressa and Hassan, 2009). In many studies, logit and probit models have been applied to evaluate the determinants of farmers' adaptation choices to deal with climate change (see, for example, Hisali *et al*., 2011; Piya *et al*., 2013; Ashraf *et al*., 2014; Mehar *et al*., 2016; Trinh *et al*., 2018). The logit and probit models are analytical tools that are used when the number of farmers' choices on adaptation strategies is limited to two options (Greene, 2012). In most previous studies, the number of adaptation choices has usually been more than two. In this situation, an extension of logit and probit models, called multinomial logit (MNL) and multinomial probit (MNP), are applied. MNL and MNP models assess the effects of independent variables on a dependent variable (the choice of adaptation) with multiple choices (Sarker, 2012). The MNL model has analytical superiorities for available binary findings (Cramer, 2003) and presents an almost precise and simple estimation process versus MNP models (Kropko, 2007). Even though an MNL model can be employed to identify the determinants of adaptation measures and can be used to calculate the effect of explanatory variables on the adaptation, it is unable to estimate the actual change in adaptation choices in terms of probabilities for changes in independent variables. This problem can be found in many previous studies such as Alauddin and Sarker (2014), Alam *et al*. (2017), Asfaw *et al*. (2018), and Trinh *et al*. (2018). To obviate this problem, we adopted the marginal effect (ME).

Therefore, we determine different factors that affect adaptation to climate change and investigate their effects on each adaptation practice in paddy fields using a binary logit and multivariate probit models, respectively. Besides, we

specify the actual value of variations in the probability of adoption of a specific adaptive practice concerning a unit of change in the explanatory variables through ME calculations.

2.1. MATERIALS AND METHODS

We analyze farmers' perceptions of weather events using binary choice models. The binary logit model has widely been applied since the 1960s because it has analytical superiorities in dealing with discrete binary outcomes (Cramer, 2003; Trinh *et al*., 2018). The general form of a binary logit model is as follows (Schüppert, 2009):

$$P_i(Y_i) = \frac{e^{b_0+b_1x_1+\cdots+b_nx_n}}{1+e^{b_0+b_1x_1+\cdots+b_nx_n}} \quad (1)$$

where P_i shows the probability of Y occurrence (Yi = 1: event occurs; Yi = 0: event does not occur), b indicates the vector of parameters, and x is the vector of the effective factors. ME coefficient is an indispensable estimation to evaluate the binary logit model and these coefficients are defined by the following formula (Greene, 2012; Trinh *et al*., 2018):

$$ME = \frac{\partial \lambda (X'B)}{\partial X} = \lambda (X'B)[1 - \lambda (X'B)]B \quad (2)$$

Where the X index demonstrates the effective factors or independent variables matrix in the logit model and B indicates a matrix of parameters in the logit model.

This study used a binary logit model to evaluate the factors influencing farmers' decision to employ adaptation activities against climate change in rice production. Specifically, one (1) denotes households who adapted to weather events in their rice production and zero (0) represents households who did not. The research assumes that there are various determinants influencing paddy households' choice in employing adaptive practices to extreme climatic events in rice production (Table 1).

As described in detail by Greene (2012), the MNL model only shows the net effect of explanatory variables on adaptation choices. Adaptation choice is the dependent variable. However, the MNL model is unable to provide the actual change and probabilities in the target variables. Therefore, following Bryan *et al*. (2013), Asfaw *et al*. (2018) and Trinh *et al*. (2018), ME was employed in this study too. ME coefficient is an indispensable estimation to evaluate the multinomial logit model and these coefficients are defined as below (Greene, 2012):

$$ME = \frac{\partial \lambda (XB)}{\partial \lambda} = \lambda (XB)\left[1 - \lambda (XB)\right]B \quad (3)$$

where X demonstrates the matrix of explanatory variables and B represents the matrix of parameters in the logit model.

As a result, ME estimated the anticipated shift in the likelihood adoption of a major adaptation strategy as to a unit change in the socio-economic and farm factors and production variables.

2.2. Multivariate probit model

Based on the collected information, adaptive strategies for climate change usually suggest multiple options. Theoretically, these multiple adaptive strategies are highly correlative. The correlation between different multiple choices is a major source of correlation between error terms (Belderbos *et al*., 2004). However, by using the multivariate probit (MVP) model, one can eliminate these correlations and interrelationships (Gebregziabher *et al*., 2015; Trinh *et al*., 2018).

This study employed the MVP model to appraise the factors influencing the probability that rice farmers applied different adaptive practices to climate change. The study also hypothesized that various factors were influencing adaptive actions of rice farmers in the face of perceived weather events. These factors were directly related to all human, social, and economic variables (Table 1).

Table 1. Explanatory variables for the study models on paddy farmers' adaptive strategies

Factors	Mean (n=360)	Std. Deviation
Age of the household head (years)	48	15
Educational level of household head (years of schooling)	5.9	4.3
Household size (number of people)	5	4
Farming experience of household head (years)	27.6	15.7
Household's farm income (VND millions/year)	51.5	31,4
Damage level due to extreme events (VND millions/year)	18	11.7
Number of cultivated plots (plots)	2.9	1.3
Farm size (hectares)	2.3	1.5
Water (m^3 / ha)	18998.9	12336.1

Household land tenure (yes=1, no=0)	0.48	0.5
Attendance in climate change training (yes=1, no=0)	0.13	0.34
Access to agricultural credit (yes=1, no=0)	0.42	0.5

The formula of the MVP model for observation i and equation m is as follows (Chib and Greenberg, 1998; Tocco *et al*., 2013):

$$Y_{im^*} = X_{im^*}\beta_m + \varepsilon_{im} \quad (4)$$

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

where, N is number of observations, M is number of options,X_{im} is matrix of explanatory variable, β_m is matrix of parameters, and ε_{im} is matrix of error terms.

2.3. The study area and method of data collection

We chose Kamfiruz district as a case study, coordinated on 29°52′ 27″N 52°48′09″E, located in the city of Marvdasht, Iran's Fars province (Figure 1). In this area, sowing of paddy fields starts in early June. The harvest time usually begins in early October and continues until mid-November. Due to low rainfall in recent years in Fars Province, as well as output reduction of the Doroodzan Dam, optimal irrigation facilities are not provided in this area (Sabuhi *et al.*, 2012). Therefore, in addition to common socio-economic factors, it is worthy to consider water use as one of the important determinants to measure rice farmers' adaptation strategies, so it can be used in planning.

Micro data at the farm level, which were collected through a survey conducted by the researcher, was the main source of data for this analysis. In doing so, the statistical population is rice farmers of Kamfiruz in the city of Marvdasht where more than 70 percent of rice is produced. This research used both primary and secondary data. The primary data culled in this article contained information about detriment level and adverse impacts due to extreme climatic events in rice production and farmers' adaptive strategies to these weather events. The secondary data regarded the socio-economic features of the study area. These data were collected from rice farmers by a questionnaire and interviews. The questionnaire was used to aggregate data from a total population of 2016 farmers. Given that different rice cultivars are grown in all villages of Kamfiruz district, the sample was taken by a two-stage cluster method in which the main clusters were villages of this section and the sub-clusters were rice producers. In the first stage, based on the relations and sampling formulas, 43 villages from 48 villages of Kamfiruz district were selected. Then, in the second stage, a sample of 5100 rice users was selected and 360 samples were selected (in each stage, Cochran's general formula was used to estimate sample size).

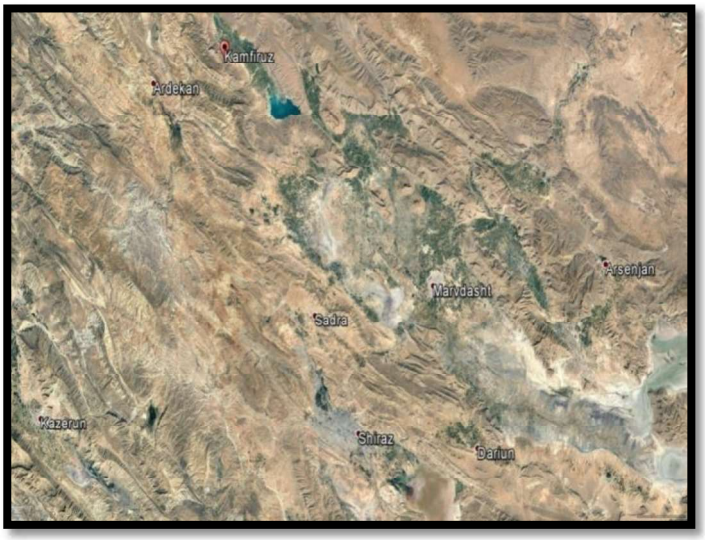


Fig. 1. Kamfiruz district, Iran (https://maps.google.com).

3. Results and Discussion

In this section, after surveying the effects of climate change and its resulting production losses on rice crop, we investigate farmers' adaptation strategies in paddy fields. At last, we analyze the estimated results of the determinants of adaptation in the binary logit model and the MVP model.

3.1. Impacts of climate change on rice production

Climate change has increased both the frequency and strength of severe weather events in Fars province. In recent years, the occurrence of multiple droughts in Fars province has posed many challenges in various sectors, especially paddy water resources. Moreover, drought occurs more often and longer in the region. Rice farmers in the study area reported four dominant adverse effects of extreme climatic events on their rice production (Table 2).Among these impacts expressed by the households, reducing crop yield was common so that it was mentioned by a large number of households in the Kamfiruz region (72%). Perception and recognition of climate change and its effects on rice production by trained farmers is significantly higher than that of untrained farmers. The trained households who recognized the decline in crop yield and the increasing cost of irrigation in paddy fields (92% and 37%) are significantly more than the untrained farmers (61% and 15%). This indicates the importance of training courses in improving farmers' awareness of weather events and their impacts on rice production. The study by Trinh *et al*. (2018) also shows that training courses affect farmers' knowledge of climate change impacts.

In addition, most farmers (65%) reported that they could not cultivate during the sowing season (from early-June to mid-July) due to drought. The percentage of trained rice farmers who lessened cultivated land due to consecutive droughts (71%) is significant. This demonstrates the negative effects of drought on rice production in the region.

The result of higher cost due to the lack of tracking climate change information' shows that there is no significant difference between the trained and untrained households. This reveals that more attention should be paid to climate change and related information.

Table 2. Farmers' perception on the negative effects of climate change on paddy farms in Kamfiruz region 2016 (% of rice farmer)

Indicator	Trained group n= 48	Untrained group n=312	DIFF*	Whole sample N=360
The decline of crop yield	92	61	31[a]	72
Higher irrigation cost	37	15	22[a]	18
Reduction of rice acreage due to drought	71	52	19[a]	65
Higher cost due to the lack of tracking climate change information	16	17	-1[ns]	7

*DIFF is a different value between trained and untrained groups.
a shows significance at the $p < 0.01$ level, and *ns* represents non-significance based on Z-test

3.2. Production losses due to climate change

The sample farmers were asked about their perception of crop damage and actual production losses experienced in the last production year, whose results are illustrated in Figure 2.

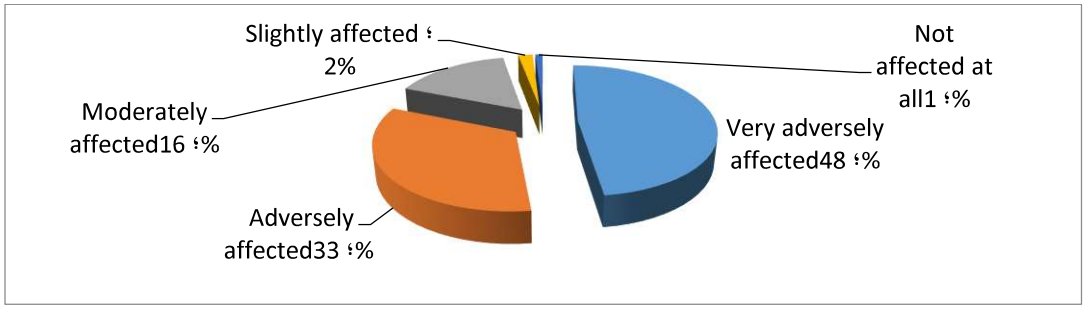


Fig. 2. Rice farmers' perception about crop damage

Almost 80% of paddy farmers reported that their crop was damaged either very severely or severely by climatic factors. The remaining 20% belonged to the groups of either moderately or slightly affected. A very tiny percentage of farmers mentioned that the crop was only slightly affected. Farmers were also asked to provide their opinions on the amount of production losses for rice varieties. These views are presented in Figure 3 while descriptive statistics of production loss are reported in Table 3. It can be seen that the mean production loss was 37%, whilst the maximum was 90%.

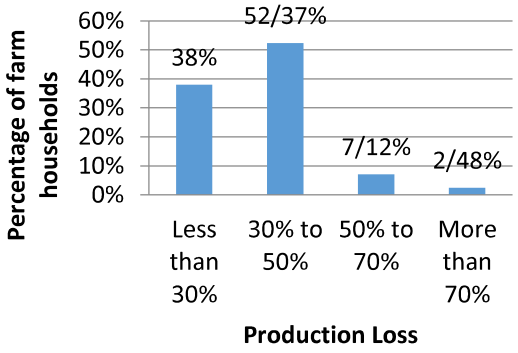


Fig. 3. Production loss incurred by rice farmers

More than 50% of farmers reported that they incurred a 30% to 50% production loss due to high temperatures and rainfall scarcity. Just 38% of farmers had less than 30% production loss. On average, nearly two-thirds of the farmers faced production losses of 30% to 90%.

3.3. Paddy farmers' adaptive strategies to climate change

According to interviews with the rice farmers about their crop production losses due to reiterated occurrences of climatic events, particularly constant droughts in the region, climate change has affected rice crop production adversely. Therefore, to mitigate the situation, farmers have given more attention to the application of different adaptive actions to alleviate the damage caused by climate change (Figure 4). According to Tang (2019), adaptation strategies which bridge the current gaps of adaptation are crucial.

Few rice farmers (10%) had only one strategy. Most households have adopted more than one strategy. Paddy farmers usually adopted two to three adaptive strategies. Only 3% of the farmers applied all of the existing strategies to adapt to climate change in their rice production. These findings are very similar to the findings of Alam *et al*. (2017), Tripathi and Mishra (2017), Kibue *et al*. (2016), and Sarker (2012) on how farmers in some countries adapted to climate change.

Table 3. Descriptive statistics of production loss incurred by rice farmers

Variable	No	Min	Max	Mean	Std Deviation	variance
Production loss	360	2	90	35.24	13.78	212.23

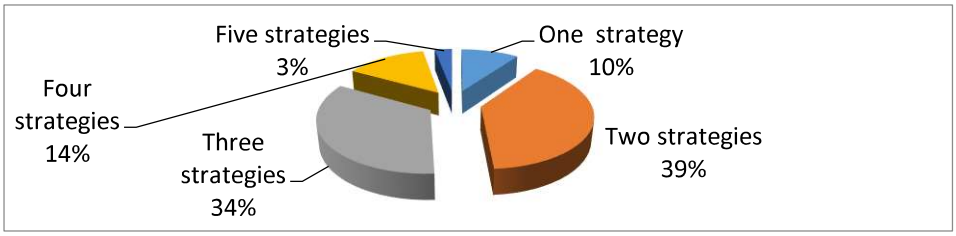


Fig. 4. Number of adaptive strategies of rice farmers to climate change

Table 3 presents all the adaptive actions employed by paddy farmers. They include adjusting farming calendars, changing crop varieties, increasing the use of groundwater for irrigation, using irrigation control mechanisms, and intercropping. Among them, most farmers apply the strategy of using more groundwater for irrigation (84%). This strategy is insignificant and, therefore, not desirable. Moreover, this practice has obviously reduced their dependency on rainfall and helped them to minimize the adverse impact of drought. But, the method they use to irrigate their paddy fields is not appropriate. Rice farmers generally overuse water-flooding in their farms, which depletes water tables more. In most cases, they are unaware of advanced and efficient irrigation systems (75%), such as Centripet irrigation which is one of the methods for distributing water from above by the sprinkler method and

needs significantly less labor and water. These findings are closer to the findings of Tripathi and Mishra (2017) in India. The percentage of farmers who collated with climate change by using different crop varieties (e.g. short duration, drought-resistant) and irrigation control mechanisms (including new irrigation systems and water allocation rights) were 53 and 30%, respectively. A little percentage of the household heads (25%) in the study area expressed that they modified planting, harvesting, and fertilizing timing in the rice production.

Among significant strategies applied in the study area, the use of different crop varieties is the most prevalent strategy that paddy farmers used to adapt to extreme weather conditions. This adaption choice was also observed in the results of Sarker (2012) in Bangladesh, Comoé and Siegrist (2015) in Côte d'Ivoire, Jin *et al*. (2016) in China, Alam *et al*. (2017) in Bangladesh, and Trinh *et al*. (2018) in Vietnam. Of course, training courses for climate change and its conditions play a crucial role in influencing adaptive actions and how to apply them to cope with climate change in rice production (Table 3).

Table 3. Farmers' main choices for adaptation with climate change in Kamfiruz region, 2016 (% of rice farmers)

Adaptive strategy	Trained group n= 48	Non-trained group n=312	DIFF*	Whole sample N=360
Adjusting farming calendars	42	20	22[a]	25
Changing crop varieties	71	48	23[a]	53
Increasing the use of groundwater for irrigation	31	75	-44[ns]	84
The use of irrigation control mechanisms	64	23	41[a]	30
Intercropping	16	4	12[a]	7

* DIFF is a different value between two sample groups.

a shows significance at the $p < 0.01$ level and *ns* represents non-significance according to Z-test for the difference between trained and non-trained proportions.

Most farmers who were aware of climate change applied adaption choices compared to unaware farmers who did not participate in the training courses. The percentage of trained farmers who modified farming calendars, changed crop variety, used irrigation control mechanism, and applied intercropping were 42, 71, 64, and 16%, respectively. These figures are significantly higher than their counterparts for the untrained group (48, 23, 20 and 4%, respectively). This supports the importance of training on climate change in reinforcing the adaptive potentials of households in the face of perceived climate change in rice production. These results are almost in accordance with the findings of Sarker (2012) and Trinh *et al*. (2017). In contrast, the findings of Piya *et al*. (2013) in Nepal and Mu *et al*. (2015) in Myanmar indicated that training courses had adverse or no significant impacts on applying adaptive strategies by farmers.

3.4. Factors affecting farmers' decision to apply adaptive strategies to climate change

The binary logit model was employed to determine the factors influencing the decision of farmers to apply adaptation actions in rice production. Choosing or not choosing an adaptation strategy by the head of a household is a binary value (1, 0). One (1) separates the paddy farmers who chose one or more strategies while zero (0) separates paddy farmers who did not even use adaptation to climate change. Initially, 12 explanatory variables were applied in the empirical model (Table 1). However, after examining the multicollinearity problem by using the correlation matrix, only eight variables were finally found to be effective in this model. In addition, according to Woodridge (2013) and Trinh *et al*. (2018), robust standard error procedure could effectively solve the issue of heteroskedasticity of the binary logit model to ensure the significance of the model. Table 4 reports the estimated variables of this model. The Wald $\chi^2(8)$ is highly significant at the $p < 0.01$ level (Prob> $\chi 2=0.0000$), indicating that the distinct relationship between the eight effective variables and rice farmers' use of adaptation strategy is significant. The value of Pseudo R^2 (0.523) predicates that these eight explanatory factors explained 52.3 percent of the probability of adaptation of paddy farmers. There were six significant determinants positively affecting the application of adaptive practices by farmers. These variables included education, experience in agricultural, income level, farm size, water use, and training courses (Table 4).

About the age of household head, the chance of using adaptation strategies by young farmers is greater as the negative and significance sign implies. Years of education and farming experience of the household head is a significant determinant of adopting an adaptation strategy to climatic events in rice production in Kamfiruz region. Income factor raises the possibility of selection of one or more adaptive actions to climate change in rice production. In addition, according to the figures in Table 4, it is more likely that paddy farmers with larger farms use adaptation to climate change as compared with farmers who cultivated

smaller farms. This result is consistent with the findings of Ashraf *et al*. (2014), Asfaw *et al*. (2018), Jin *et al*. (2016), and Trinh *et al*. (2018). The positive water variable indicates that increasing water use leads to more use of adaptation strategies for irrigation control. Participation in training courses had the most significant impact on applying adaptation to climate change by paddy farmers. The assistance of adaptive practices by the trained households on climate change was 17 percent higher compared to the untrained households. Similarly, the assistance of adaptive strategies to rice farmers with a higher educational level was 4% higher than rice farmers with lower educational level. Besides, high-income farmers were 6% more likely than rice farmers with lower income level to adapt their farming practices. The percentage of adaptive activities to climate change of farmers with larger farms was 4% higher than farmers with smaller farms. Moreover, the probability of adaptation to climate change was approximately 3% higher for farmers with higher water consumption than those with lower water use. But, considering the negative marginal effect of the age variable, the percentage of adaptation to climate change was 8% higher among younger farmers than among older farmers. About the access to credit factor did not show any significant effect on farmers' decision to adapt to climatic events.

Table 4. Estimated results of the binary logit model

Indicator	Coefficients	p-value	Marginal effects	p- value
Age of the household head (years)	-0.005*	0.07	-0.08*	0.09
Educational level of household head (years of schooling)	0.21**	0.03	0.04**	0.02
Farming experience of household of head (years)	0.01*	0.09	0.003*	0.07
Household's farm income (VND millions/year)	0.32**	0.02	0.06**	0.01
Farm size (hectares)	0.43**	0.04	0.04**	0.01
Water use (m^3 / ha)	**0.18*****	0.001	0.033***	0.00
Attendance in climate change training (yes=1, no=0)	**1.12*****	0.001	0.17***	0.00
Access to agricultural credit (yes=1, no=0)	0.28ns	0.22	0.05ns	0.23
Constant	-1.52**	0.05	–	–
Log pseudo-likelihood	-184.61	–	–	–
Wald $\chi^2(8)$	38.26	–	–	–
Probe>χ^2	0.00	–	–	–
Pseudo R^2	0.523	–	–	–
Number of observation	360	–	–	–

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

3.5. Investigate factors effects on each adaptive strategy against climate change

The multivariate probit (MVP) model was employed to examine the effects of factors on each adaptation activity. The dependent variables of the MVP model include five choices (specific adaptation actions to climate change) that denote a value of 1 if the households use dominant adaptive practices in the region, otherwise 0. In this model too, after testing for multicollinearity problem employing the correlation matrix among explanatory variables, only eight variables were finally included in the empirical model. Moreover, the model was addressed for heteroskedasticity using the robust standard error procedure. The estimated figures of the MVP model are reported in Table 5.

The Wald $\chi^2(45)$ (Prob > χ^2=0.0000), demonstrating the distinct relationship between the probability of using adaptation choices and eight effective variables, is highly significant. In addition, according to the value $\chi^2(10)$ is significant at the 1% level (Prob > χ^2=0.0000), and this issue is evidence of the correlation between the five adaptive choices to climate change. Besides, the correlation coefficients are relatively high and significant and this means that the various adaptive choices are interdependent. This confirms the functionality and feasibility of the MVP model in this study.

The figures related to explanatory variables in Table 5 show that farmer age significantly affected the selection of only one adaptive strategy in rice production. This strategy is to use groundwater for irrigation. Based on the positive and significant effect of this strategy, the older farmers apply this traditional and inappropriate strategy to a greater extent.

Educational level significantly and positively influences farmers' probabilities of adopting two of five adaptive actions. However, household heads that have higher educational attainment are more likely to match to climate change by switching crop varieties and irrigation control mechanisms. Similarly, farming experience and farm income level significantly influence the farmers' probabilities of adopting these two strategies to adapt to weather events. More experienced farmers have higher probabilities of changing crop varieties and irrigation control mechanisms to adapt to climate change compared to less experienced farmers. Also, households with higher income level change crop varieties and control irrigation mechanisms against climate change versus other households. About farm size factor, there is a significant and positive relationship between the households with larger farmlands and their decisions to adopt three of five adaptive strategies including the adjustment of farming calendars, the use of a different crop cultivar, and more use of groundwater. These results corroborate the studies of Deressa *et al*. (2009, 2011) and Apata *et al*. (2009).

Table 5. Estimated result of the multivariate probit model

Explanatory variables	Adaptation practices				
	Y_1	Y_2	Y_3	Y_4	Y_5
Age of the household head	-0.02^{ns}	-0.03^{ns}	0.02^{b}	-0.2^{ns}	0.004^{ns}
Educational level of household head	0.03^{ns}	0.05^{b}	-0.025^{ns}	0.08^{c}	0.08^{ns}
Farming experience of household head	0.01^{ns}	0.02^{a}	0.01^{ns}	0.1^{b}	-0.003^{ns}
Household's farm income	0.03^{ns}	0.05^{c}	0.04^{ns}	0.08^{b}	-0.006^{ns}
Farm size	0.04^{a}	0.06^{a}	0.05^{a}	0.05^{ns}	0.008^{ns}
Water use	0.003^{a}	0.05^{b}	0.004^{ns}	0.006^{a}	0.007^{a}
Attendance in climate change training	0.69^{a}	0.58^{a}	-0.27^{ns}	0.65^{b}	0.78^{a}
Access to agricultural credit	0.35^{ns}	0.06^{ns}	0.25^{ns}	0.17^{ns}	0.04^{ns}
Constant	-1.52^{b}	-2.05^{a}	-2.70^{a}	-1.95^{a}	-1.65^{c}
Correlation	Coefficients		P-value		
ρ21	0.53^{b}		0.04		
ρ31	0.31^{a}		0.00		
ρ41	0.78^{b}		0.05		
ρ51	0.28^{a}		0.001		
ρ32	0.13^{a}		0.00		
ρ42	0.48^{a}		0.00		
ρ52	0.33^{a}		0.00		
ρ43	0.51^{a}		0.003		
ρ53	-0.09^{ns}		0.28		
ρ54	0.29^{c}		0.08		
Log pseudo-likelihood	-714.88		_		
Wald $\chi2(45)$	112.15		_		
Prob > $\chi2$	0.00		_		
No. of observation	360		_		

Likelihood ratio test of H0: ρ21=ρ31=ρ41=ρ51=ρ32=ρ42=ρ52=ρ43=ρ53=ρ54=0
$\chi2(10)$=260.12 Prob > $\chi2$=0.0000.
a, b, c are significant at 1%, 5%, and 10%, respectively; ns is non-significant.
Y1= Adjusting farming calendar
Y2= Changing crop varieties

Y3= Increasing use of ground water for irrigation
Y4= Irrigation control mechanism
Y5=Intercropping.

Water consumption and training in climate change significantly affected the adoption of four of five specific choices of adaptation in paddy fields. The amount of water input and attendance in climate change training courses significantly influence the probability of adjusting farming calendars, changing crop varieties, using irrigation control mechanisms, and intercropping in attempt to match with climate change. It is projected that rice farmers with a higher amount of water will be more likely to control water use in their attempt to adapt to climate change if they attend training courses. Therefore, training and water consumption are crucial variables in influencing the adoption of more adaptive activities to extreme weather events.

These findings are very similar to the findings of Alam (2011), Tripathi and Mishra (2016). Finally, there is not a significant relationship between credit factor and households decisions to adopt adaptation strategies.

4. CONCLUSION AND RECOMMENDATIONS

This paper presented adaptive actions at a local level and determined factors influencing farmers' adaptation to weather and severe climatic events such as droughts in Fars region of Iran. In addition, the final part was how explanatory variables affect each adaptation strategy. Paddy fields in Kamfiruz district were selected as a case study because rice is among the crops with a very high water requirement. The results revealed that farmers reduced 65% of their cultivated land due to the extreme weather events, particularly successive droughts and high temperatures. In this regard, to mitigate these losses, households in Kamfiruz adopted different adaptive strategies such as adjusting farming calendars, changing crop varieties, increasing the use of groundwater for irrigation, using irrigation control mechanisms, and intercropping. The most important adaptive strategies adopted by households in the rice fields of the Kamfiruz region were, however, increasing the use of groundwater for irrigation and changing crop varieties. Of course, the use of groundwater is not appropriate at all as shown statistically. Therefore, changing sowing and harvesting timing, cultivation of crops of short duration, inter-cropping, and investment in irrigation help in adapting agriculture to climate change. Besides, developing high-value crop varieties and technologies tailored to local conditions is essential for accelerating the adaptive processes.

The findings of the binary logit model and multivariate probit models in this study indicate that attendance in climate change training courses and water use amount are the most important factors in influencing the adoption of more adaptation strategies to climate change. Other variables that significantly affected farmers' probability of using adaptive practices included age of household, farming experience, educational level, farm income, and farm size. In contrast, access to agricultural credit did not significantly impact farmers' probability of adapting to severe climatic events.

Therefore, to deal with socio-economic changes and some of other changes, expanding the training courses on climate change could be a beneficial way to consolidate adaptive capacities of paddy farmers in the region. These training courses would develop the skills of most farmers, especially those who are less educated and less experienced. Of course, the training courses on climate change should also be understandable for these farmers.

Additionally, one of the agricultural features of Fars province is its reliance on underground water resources. Despite of the consequences of rising temperatures, low raining, frequent droughts, and unequal distribution of rainfall, development projects are less likely to succeed for most water resources in Fars province. Economic, governance and social interventions are necessary to alleviate weather stress. Therefore, provincial government should institute policies that would improve the consolidation of water in the region. To realize this, the first priority is to maintain underground water resources and keep the underground water table in the region to encourage local people to participate in the program. Secondly, local authorities should disseminate information on the benefits of efficient irrigation systems to cope with extreme weather events. Thirdly, it is necessary to promote the training and awareness procedures for the optimal use of water resources.

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