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Adaptive Perception and Adaptation Responses to Weather Shocks: An Adaptation Deficit

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Abstract

This study examines the influence of adaptive perception on farmers' adaptive responses to climate change induced natural shocks in the Mekong River Delta (Viet Nam) from a data set of 329 farmers in 2017. Seemingly Unrelated Regression model is used and results show that, controlling for household and household head's characteristics, farm characteristics, institutional factor, infrastructure, climate conditions, and past climate experiences, adaptive perceptions are the most important factor of adaptive responses. With respect to policy implication, sources and quality of information can be of important consideration due to the potential influences on farmers' adaptive perception and their adaptation assessments. In addition, awareness on climate change and adaptation methods should be highlighted. Other policy options could also be suggested, such as: strengthening education level of farmers, and facilitating cheap technologies for farmers.

Keywords

Climate change, weather shocks, private adaptive responses, adaptive perception, adaptation deficit, Mekong River Delta, Viet Nam.

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Introduction

There is devastating consensus that climate change is leading to an increase in the level of environmental disasters (IPCC, 2012; IPCC, 2014; Field, 2014 among others). Adaptation and mitigation to climate change and extreme events have been implemented and advocated by many governments, scientific communities and international institutions (for example, World Bank, 2013). Along with this, the so-called 'adaptation deficit' (Barr et al., 2010; Brooks and Adger, 2005; Tol and Yohe, 2007) has emerged, playing an increasingly important role in responding to climate change. Adaptation deficit can be seen from both macro and micro levels. From macro level such as country, adaptation deficit is a situation in which a country experiences a lack of institutional, economic, and technological means to facilitate the adaptation process (Fankhauser and McDermott, 2014). From micro level such as individual, literature identifies a set of individual factors that can raise the vulnerability level such as gender, age, health, social status, ethnicity, and class (Adger et al., 2009; Smit and Pilifosova, 2003).

The Mekong River Delta, the major agricultural region of Viet Nam, is identified as significantly vulnerable to climate change (Yusuf and Francisco, 2010). Agricultural production remains the main source of livelihoods for most farmers in this area (Nguyen and Le, 2012; Le et al., 2014). Several Mekong River Delta related studies and reports by McSweeney et al. (2008), EU/MWH (2006), Nguyen (2007) and ADPC/GTZ (2003) clarify the trends of climate change in terms of higher temperature, salt water intrusion, eroded shorelines, exacerbated coastal flooding, rainfall increasingly concentrated over fewer months in the rainy season, while the dry season will be more prolonged. This will lead to more frequent and intense floods and droughts simultaneously. In addition, tropical cyclone and typhoon occurrence are expected to alter and become more intense under a warmer climate as a result of higher sea-surface temperatures.

Since climate change have greater negative impacts on farm households (Yu, Zhu, Breisinger, and Hai, 2010), adaptation measures are therefore important to help farmers to better face extreme weather conditions and associated climatic variations (Adger et al., 2003; Kandlinkar and Risbey, 2000). A better understanding of current adaptation measures and their determinants is important to inform policy for future successful adaptation. Some related studies conducted in the last few years focus on farmers' past climate experiences (see for example, Niles et al., 2015; Le Dang et al., 2014; Geoff, 2014; Nicholas and Gina, 2012). Niles et al. (2015), using farmer survey data from New Zealand, show that limiting factors mediated the effect of past climate experiences on the adoption of adaptation strategies differently in two regions with water acting as a limiting factor in Hawke's Bay and water and temperature as a limiting factor in Marlborough. Le Dang et al. (2014) address the limited understanding of how rice farmers appraise their private adaptive measures and influential factors in the Mekong River Delta of Viet Nam. Authors find that belief in climate change, information and objective resources influence farmers' adaptation assessments. Geoff (2014) also stresses that farmers' climate change beliefs affect adaptation to climate change. Nicholas and Gina (2012) explore commercial farmers' perceptions of and responses to shifting climates in the Little Brak River area along South Africa's south coast and find that farmers' experience with shifting climates plays a large part in driving their adaptive decision-making.

Wolf and Moser (2011), on individuals 'role in climate change, distinguish between understanding (acquiring and employing factually correct knowledge of climate change), perception (views and interpretations based on beliefs and understanding), and engagement (a state of personal connection that encompasses cognitive, affective, and/or behavioural dimensions). In practice, it is possible that adaptation choices may not be in effect due to lacking of clear understanding of adaptation measures, or adaptation deficit exits between adaptive perception and adaptation choices. While several studies so far explore the influence of climate change understanding, perception, or engagement on adaptation behaviour, there is still a missing link between adaptive perception and adaptation behaviour in terms of empirical evidences. By adaptive perception, the current paper means the views and interpretations of adaptive measures based on beliefs and understanding.

The current study employs survey data at household level of 329 farmers in the Mekong River Delta of Viet Nam and the cluster specific fixed effect at household level with clustering standard error at commune level is employed for investigating the influence of farmers' adaptive perception on adaptation responses to climate change induced natural shocks. Results show that, controlling for household and household head's characteristics, farm characteristics, institutional factor, infrastructure, climate conditions, and past climate experiences, adaptive perception is the most important factor of adaptive responses

This paper contributes to the interdisciplinary development literature on climate change adaptation. A plenty of empirical studies have analysed the effects of many factors on climate change adaptation and some most recent developments can be named, such as climate change beliefs (Kuehne, 2014), farmers' perceptions of shifting climates (Wiid and Ziervogel, 2012), limiting factors within a farm system (water or temperature) (Niles et al., 2015), migration (Bazzi et al., 2016; McLeman and Smit, 2006), micro-credit (Fenton et al., 2017), diversification (Howden et al., 2007; Asfaw et al., 2018), gender (Bhattarai et al., 2015), forestry activities in supporting adaptation (Fisher et al., 2010), the role of local seed banks and seed markets (Maharjan and Maharjan, 2018; Nordhagen and Pascual, 2013), and microfinance, agricultural extension, and education (James, 2010).

Our paper makes contributions to the adaptation literature in a number of ways. We provide the first estimation of adaptive perception to adaptive responses to climate change induced natural shocks. As mentioned, earlier work on responses to climate change and/or weather shocks did not concern this issue, to our best knowledge. Therefore, findings from the influence of adaptive perception associated with adaptation choices can be useful inputs for policies to response to climate change and weather shocks. In addition, the current study examines the issue in the context of a large delta in a developing country. Thus, our findings may also provide important implications for other emerging and transition economies similar to Viet Nam and/or regions from developing countries with conditions of natural resources familiar to the Mekong River Delta of Viet Nam.

The structure of the paper is as follows. The next section presents Materials and Methods. Section 3 is about empirical results and discussion. Conclusion and implications for policy are in Section 4.

Materials and methods

1. Data sources and questionnaire

Long An, Ben Tre, Can Tho, Soc Trang, Kien Giang, and Ca Mau are the six provinces randomly selected from 13 provinces in the Mekong River Delta which are defined at different agro-ecological systems that is enable representation for the Mekong River Delta region. One district from each province and two communes from each district were randomly chosen. In total, there are 12 communes and commune centres in the survey. From the official household lists of the twelve communes, farm households were selected by simple random sampling.

The face-to-face structured interviews have been conducted in July of 2017. Four teams of 10 interviewers each had been involved in two intensive training sections, one before and one after the pre-test. The interviewers visited 335, but interviewed 330 farm qualified households, 50 in each commune. Each interview was around two hours in duration. In this study, the farm household was the unit of analysis and the household heads or their spouses were the interviewees. Total number of observations in the final sample for analysis is 329, after removing an observation with missing value.

The structured questionnaire mainly covers perception of past climate change, climate change adaptation assessment, and a number of influential factors. The questionnaire is refined and finalised based on the information from three focus group discussions in Long An, Ben Tre, Can Tho and six agricultural officers from six provinces. The clarity and relevance of the questions were also tested through the pre-tests with 30 randomly chosen farm households in Ben Tre Province. The data used in this paper are specified from questions about climate change, adaptation assessment, farm characteristics, income, assets, infrastructure and institutional factors.

2. Theoretical framework

We framed our analysis using the standard theory of technology adaptation, wherein the problem facing a representative risk-averse farm household is to choose a mix of climate change adaptation strategies that will maximize the expected utility from final wealth at the end of the production period, given the production function and land, labour, and other resource constraints, as well as climate. Assuming that the utility function is state independent, solving this problem would give an optimal mix of adaptation measures undertaken by the representative farm household, as given by

$$A_h = A(x_h^H, x_h^F, x_h^I, x_h^{IN}, x_h^C, x_h^P; \beta) + \varepsilon_h$$

Where A is the adaptation strategy of household h; x^H_h is a vector of household characteristics (such as gender, age, marital status of the "head" of the household, household size, and wealth), x^F_h is a vector to represent farm characteristics (such as farm size, farm and nonfarm income), x^I_h is a vector to represent institutional factor (access to credit, tenure), x^{IN}_h is a vector to represent infrastructure (distance to input and output markets), $x^C h$ is a vector to represent climate conditions (sunshine and rainfall), and x^P_h is a vector to represent past climate experiences (wind storm, drought, flood, untimely rain, pestilent insect, water shortage). β is the vector of parameters; and ε_h is the household-specific random error term. Households will choose adaptation strategy 1 over adaptation strategy 2 if and only if the expected utility from adaptation strategy 1 is greater than that from adaptation strategy 2, that is:

$E [U(A)] > E [U(A_2)]$

The choice of adaptation strategy is conditioned on a host of household characteristics and climatic, agro-ecological and socio-economic factors. This study focuses on the adaptation definition per se and we therefore employ a dummy variable to measure whether farm households had adapted any measure in response to perceived climate changes. These adaptation measures are elicited at household level.

3. Model specification

3.1. General form of model specification

Common approach uses a univariate technique such as probit/logit analysis for discrete choice dependent variables to model each of the adaptation measures individually as functions of the common set of explanatory variables (for example: Nhemachena and Hassan, 2007; Maddison, 2007). The shortfall of this approach is that it is prone to biases caused by ignoring common factors that might be unobserved and unmeasured and affect the different adaptation measures. In addition, independent estimation of individual discrete choice models fails to take into account the relationships between adoptions of different adaptation measures. Farmers might consider some combinations of adaptation measures as complementary and others as competing. By neglecting these common factors, the univariate technique ignores potential correlations among the unobserved disturbances in adaptation measures, and this may lead to statistical bias and inefficiency in the estimates (Lin et al., 2005; Belderbos et al., 2004; Golob and Regan, 2002).

A multinomial (MNL) discrete choice model is another alternative to the multivariate model with more than two endogenous discrete choice variables (See, for example, Kurukulasuriya and Mendelsohn, 2007; Mendelsohn and Seo, 2007). In the multinomial discrete choice model, the choice set is made up of all combinations of adaptation measures. The shortfall of this technique is that interpretation of the influence of the explanatory variables on choices of each of the original separate adaptation measures is very difficult. The shortfall of this technique is that all multinomial replications of a multivariate choice system have problems in interpreting the influence of explanatory variables on the original separate adaptation measures (Golob and Regan, 2002).

This study follows Zellner's Iterative Seemingly Unrelated Regressions (ISUR) to overcome the shortfalls of using the univariate and multinomial discrete choice techniques. The ISUR technique provides parameter estimates that converge to unique maximum likelihood parameter estimates. The resulting model has stimulated countless theoretical and empirical results in econometrics and other areas (see Zellner, 1962; Srivastava and Giles, 1987). The benefit of this model is that the ISUR estimators utilize the information present in the cross regression (or equations) error correlation and hence it is more efficient than other estimation methods such as the univariate and multinomial discrete choice techniques. The variance inflation factor (VIF) test (Baltagi, 2013) is used to detect potential multicollinearity, because the number of independent variables is high. In addition, the Breusch-Pagan (BP) test (Breusch and Pagan, 1980) is used to validate the SUR model of adaptation choices (see sureg command in Stata software (StataCorp., 2017)).

Analysis of the influence of adaptive perception on adaptation choice generally suffers from endogeneity, in which the adaptive perception would actually be proxying some other omitted household characteristic that is the real cause of adaptation choices. Fixed effects regression uses households to serve as their own controls, thus eliminating the influence of observable and unobservable differences between households in factors that do not vary over time. Time variant factors that differ across households and are correlated with adaptive perception and adaptation choices can be controlled for through careful selection of covariates.

Our data is not simple random sampling it may give some problems. Cameron and Trivedi (2005) claim that stratified and clustered sample can lead to difference in distribution of among stratum and correlation among households within cluster. However, since our purpose is estimating influence of regressors on regressand rather than predict for population and stratifying is not basing on regressand, the variation of sampling rates can be ignored. Thus, stratification is not the matter, but clustering does.

The correlation among households within cluster is caused by some reasons. First, surveyed households may live in the same block. Second, it is existence of unobserved cluster specific variables that affect all households in cluster. Finally, unobserved variables may impact all households in the same province or region such as policy, culture and climate. Since these unobservable variables may correlate with both dependent and independent variables, the estimators under OLS procedure will be bias and inconsistent. In addition, within cluster correlation among error terms makes estimators under OLS approach inefficient.

There are two ways to solve the impact of these unobserved variables, they are cluster specific random effect (CSRE) and cluster specific fixed effect (CSFE). CSRE model is used in the situation that there is no correlation between unobserved cluster variables and independent variables. However, it is not the case of the current paper since as mentioned above unobserved commune variables are likely to affect both adaptive perceptions and adaptation choices. Thus, CSFE model is needed to be applied because it will subtract cluster-invariant variables, but some tests will be used to test whether CSFE is necessary.

Clustering at province level is not appropriate since there is high heterogeneity within province related to social-economic condition, infrastructure, irrigation system, farming practices and even climate. Similarly, there is also high heterogeneity within district. Meanwhile, commune level gives more homogeneity and correlation among households in agriculture production. Moreover, clusters cannot be too small because they do not give enough information for estimation, each cluster has to have at least two observations. Clustering at commune level can satisfy this condition. Hence, clusters should be communes. Since there are 14 communes and the number of observations in each commune is about 50 on average, it should be classified as many-clusters situation.

The 14 adaptive measures were considered as farmers' adaptive responses to climate change induced natural shocks. These adaptive measures were grouped into four groups: (1) Water use management (Model 1), (2) Adjustments of crops and varieties (Model 2), (3) Adjustments of planting techniques (Model 3), and (4) Adjustments of planting calendar (Model 4). Four types of cluster-specific effects model are written as:

$$WATERUSE_{icj} = \{\beta_{11}.Z_{icj} + \beta_{12}.F_{icj} + \gamma_1.INS_{icj} + \delta_1.INF_{icj} + \eta_1.METE_j + \theta_{11}.PAST_{icj} + \theta_{12}.PERC_{icj} + \alpha_{1cj} + u_{1i} + \varepsilon_{1icj} \geq 0\} \quad (1)$$

$$CROPS_{icj} = \{\beta_{21}.Z_{icj} + \beta_{22}.F_{icj} + \gamma_2.INS_{icj} + \delta_2.INF_{icj} + \eta_2.METE_j + \theta_{21}.PAST_{icj} + \theta_{22}.PERC_{icj} + \alpha_{2cj} + u_{2i} + \varepsilon_{2icj} \geq 0\} \quad (2)$$

$$PLANTINGT_{icj} = \{\beta_{31}.Z_{icj} + \beta_{32}.F_{icj} + \gamma_3.INS_{icj} + \delta_3.INF_{icj} + \eta_3.METE_j + \theta_{31}.PAST_{icj} + \theta_{32}.PERC_{icj} + \alpha_{3cj} + u_{3i} + \varepsilon_{3icj} \geq 0\} \quad (3)$$

$$PLANTINGC_{icj} = \{\beta_{41}.Z_{icj} + \beta_{42}.F_{icj} + \gamma_4.INS_{icj} + \delta_4.INF_{icj} + \eta_4.METE_j + \theta_{41}.PAST_{icj} + \theta_{42}.PERC_{icj} + \alpha_{4cj} + u_{4i} + \varepsilon_{4icj} \geq 0\} \quad (4)$$

Where the script icj denote the i^{th} observation in the c^{th} cluster (commune) and in j^{th} district, $i = 1, 2, ..., 329$, and $c = 1, 2, …, 14$. α_c is cluster specific effect which change across clusters and it is assumed that $\alpha_c \sim [0, \sigma^2_c]$. ε_{ic} is assumed to have zero mean and constant variance. u_i is a household specific fixed effect. We assume that regional differences which control for adaptation variations and across regions are subsumed within the household fixed effect.

The controlling variables include household characteristics (*Z*) (education, gender, age of the household head, household size, household wealth), farm characteristics (*F*) (farm size, farm and nonfarm income, productive assets), institutional factor (*INS*) (access to credit, tenure), infrastructure (*INF*) (distance to input and output markets), climate conditions (*METE*) (sunshine and rainfall), and past climate experiences (*PAST*) (wind storm, drought, flood, untimely rain, pestilent insect, water shortage). The study is interested in the variables related to adaptive perceptions (*PERC*).

3.2. About adaptive perception

Studies in Mekong River Delta find that farmers' perception of climate change corresponds with local climate data (Le Dang et al., 2014; Nguyen and Le, 2012; Nguyen, 2007; McSweeney et al., 2008; EU/MWH, 2006; ADPC/GTZ, 2003). In this study, we consider farmers' perceptions of the changes in terms of nine past climate experiences – wind storm, drought, flood, higher temperature, untimely rains, salt water intrusion, eroded shorelines, pestilent insect, and water shortages.

The adaptive perception in this study is based on asking farmers about their perception of availability of climate change responses. The specific question is: "Have you ever heard anything about the following adaptations?" A list of private adaptive measures to climate change has been developed by following the procedures mentioned in Section 2.3.1. Table 1 provides the variables related to adaptive perception, a brief description of each variable, and its value.

Table 1 shows that, in general, measures such as 'Build/repair cistern' (20%), 'Build/repair well' (19%), and 'Water saving technology' (13%) in water use management are not very commonly perceived. Table 1 also shows that while a high proportion of farmers used perceives of 'Change varieties' (53%) as an adjustment of crops and varieties, a lower proportion of farmers perceives 'Change crops/livestock' (26%), 'Change crop structure' (25%) in response to climate change. While a high proportion of farmers perceives measure of 'Change pesticide/herbicides' (43%) as an adjustment of planting techniques, a lower proportion of farmers perceives 'Change crop cultivation' (28%), 'Change fertilizer input/stimulus' (29%), 'Change crop quantity' (31%), and 'Change farmyard manure' (19%) (Table 1).

Moreover, less proportion of farmers perceives 'Change irrigation schedule' (18%), and 'Change crop rotation' (18%), while even a very low proportion of farmers perceives 'Buy agriculture insurance' (4%), and 'Combination of agriculture and forestry' (2%) (Table 1).

Variable	Description	Mean	Std. Dev.
Water use management			
Build/repair cistern (1: Yes; 0: No)	Knowing about 'build/repair cistern'	0.20	0.40
Build/repair well (1: Yes; 0: No)	Knowing about 'build/repair well'	0.19	0.39
Water saving technology (1: Yes; 0: No)	Knowing about 'water saving technology'	0.13	0.34
Adjustments of crops and varieties			
Change varieties (1: Yes; 0: No)	Knowing about 'change varieties'	0.53	0.50
Change crops/livestock (1: Yes; 0: No)	Knowing about 'change crops/livestock'	0.26	0.44
Change crop structure (1: Yes; 0: No)	Knowing about 'change crop structure'	0.25	0.44
Adjustments of planting techniques			
Change crop cultivation (1: Yes; 0: No)	Knowing about 'change crop cultivation'	0.28	0.45
Change fertilizer/stimulus (1: Yes; 0: No)	Knowing about 'change fertilizer/stimulus'	0.29	0.46
Change pesticides/herbicides (1: Yes; 0: No)	Knowing about 'change pesticides/herbicides'	0.43	0.50
Change crops quantity (1: Yes; 0: No)	Knowing about 'change crops quantity'	0.31	0.46
Change farmyard manure (1: Yes; 0: No)	Knowing about 'change farmyard manure'	0.19	0.39
Adjustments of planting calendar			
Change irrigation schedule (1: Yes; 0: No)	Knowing about 'change irrigation schedule'	0.18	0.38
Change crop rotation (1: Yes; 0: No)	Knowing about 'change crop rotation'	0.18	0.38

Source: Authors' estimation from climate change survey in the Mekong River Delta (2017); N=329

Table 1: Summary statistics of farmers' adaptive perception.

3.3. Outcome variables

A list of private adaptive responses (measures) to climate change was initially developed from the literature (Bradshaw et al., 2004; Bryan et al., 2009; Deressa et al., 2009; Hassan and Nhemachena, 2008; Thomas et al., 2007). To ensure the appropriateness, these measures were raised for discussion in focused group discussions. Typical farmers, participants of the focus grouped discussions, were asked to choose the measures that have been used or available in their areas. The same request was given to agricultural province-level officers interviewed. The adaptive measures had finally been refined by the pre-tests before they were actually included in the questionnaire.

In general, Table 2 shows that measures such as 'Build/repair cistern' (5%), 'Build/repair well' (9%), and 'Water saving technology' (3%) in water use management are not very commonly used. The limited use of these adaptations may be attributed to need for more capital.

Table 2 also indicates that while a high proportion of farmers uses measure of 'Change varieties' (40%) as an adjustment of crops and varieties, a lower proportion of farmers uses 'Change crops/livestock' (9%), 'Change crop structure' (7%) in response to climate change. Local farmers may be lacking skills, motivation and opportunities for other crops and/or livestock.

As shown in Table 2, while a high proportion of farmers uses measure of 'Change pesticide/herbicides' (31%) as an adjustment of planting techniques, a lower proportion of farmers uses 'Change crop cultivation' (14%), 'Change fertilizer input/stimulus' (16%), 'Change crop quantity' (13%), and 'Change farmyard manure' (4%) in response to climate change. These adaptations may be associated with the less expense and ease of access by farmers than that of adjustments of crops and varieties.

Variable	Mean	Std. Dev.
Water use management		
Build/repair cistern (1: Yes; 0: No)	0.05	0.23
Build/repair well (1: Yes; 0: No)	0.09	0.28
Water saving technology (1: Yes; 0: No)	0.03	0.16
Adjustments of crops and varieties		
Change varieties (1: Yes; 0: No)	0.4	0.49
Change crops/livestock (1: Yes; 0: No)	0.09	0.28
Change crop structure (1: Yes; 0: No)	0.07	0.26
Adjustments of planting techniques		
Change crop cultivation (1: Yes; 0: No)	0.14	0.34
Change fertilizer/stimulus (1: Yes; 0: No)	0.16	0.37
Change pesticides/herbicides (1: Yes; 0: No)	0.31	0.46
Change crops quantity (1: Yes; 0: No)	0.13	0.34
Change farmyard manure (1: Yes; 0: No)	0.04	0.19
Adjustments of planting calendar		
Change irrigation schedule (1: Yes; 0: No)	0.07	0.26
Change crop rotation (1: Yes; 0: No)	0.07	0.26

Source: Authors' estimation from climate change survey in the Mekong River Delta (2017); N=329

Table 2: Summary statistics of farmers' adaptation choices.

Less proportion of farmers use 'Change irrigation schedule' (7%), and 'Change crop rotation' (7%) in response to climate change (Table 3). This is probably because farmers' access to climate change information is rather limit.

3.4. Confounding variables

Cluster variant household-level explanatory variables that could be correlated with outcome variables with adaptation choices have also been obtained from the dataset to serve as controls in the fixed effects regression including household characteristics (education, gender, age of the household head, household size, household wealth), farm characteristics (farm size, farm and nonfarm income, productive assets), institutional factor (access to credit, tenure), infrastructure (distance to input and output markets), and experience of past climate (wind storm, drought, flood, untimely rain, pestilent insect, water shortage) (Table 3). We use climate conditions (such as sunshine and rainfall) to capture regional differences.

Variable	Mean	Std. Dev.
Household characteristics		
Male-headed household (male: 1; female: 0)	0.89	0.31
Years of education by household head (years)	6.23	3.34
Marital status of household head (married: 1; other: 0)	0.90	0.30
Household size (persons)	4.19	1.40
Farm characteristics		
Production asset index	0.01	1.32
Land area (log)	0.45	1.22
Proportion of cultivation income in total income (%)	0.27	2.31
Proportion of aquaculture income in total income (%)	0.20	0.44
Proportion of non-agriculture income in total income (%)	0.24	0.44
Institutional factor		
Access to loan (1: Yes; 0: No)	0.21	0.41
Proportion of land with Land Right Certificate	0.95	0.18
Infrastructure		
Distance from plot(s) to house (km)	0.69	1.69
Distance from plots(s) to nearest commune road (km)	2.97	3.92
Climate conditions		
Total hours of sunshine (hours)	2313.83	237.32
Total level of rainfall (mm)	1503.56	450.83

Source: Authors' estimation from climate change survey in the Mekong River Delta (2017); N=329

Table 3: Summary statistics on household-level covariates (to be continued).

Variable	Mean	Std. Dev.
Past climate experiences on		
Wind storm (1: Yes; 0: No)	0.15	0.35
Drought (1: Yes; 0: No)	0.23	0.42
Higher temperature (1: Yes; 0: No)	0.25	0.43
Flood (1: Yes; 0: No)	0.19	0.39
Untimely rain (1: Yes; 0: No)	0.23	0.42
Salt water intrusion (1: Yes; 0: No)	0.04	0.19
Eroded shorelines (1: Yes; 0: No)	0.02	0.12
Pestilent insect (1: Yes; 0: No)	0.70	0.46
Water shortages (1: Yes; 0: No)	0.08	0.27

Source: Authors' estimation from climate change survey in the Mekong River Delta (2017); N=329

Table 3: Summary statistics on household-level covariates (continuation).

Following Filmer and Pritchett (2001), principal component analysis (PCA) is used to assign weights to each production asset. The overall production asset index is calculated by applying the following formula:

$$w_j = \sum_{i=1}^{k} \left[b_i \left(a_{ji} - x_i \right) \right] / s_i$$

where w is the production asset index, b is the weights from PCA, a is the production asset value, x is the mean production asset value, and s is the standard deviation of the production assets.

Results and discussion

Despite the fact that the majority of the farmers interviewed claimed that they have perceived at least one change in climatic attributes, some of the farmers who perceived climate change did not respond by taking adaptation measures. Here it is argued that farmers who perceive and responded (or did not respond) share some common characteristics, which assist in better understanding the reasons underlying their response (failure to respond) as captured by the ISUR probit model.

The R^2 and F test of four ISUR models are in Table 4. The R^2 for all models indicated that the statistically significant explanatory variables can explain around 33 to 44 percentage of the variation of farmers' adaptation assessments. Breusch-Pagan test for independent equations were highly significant with values less than 0.00001, implying that equations are correlated. Goodness-of-fit test indicates that four of five models fit the data well. No multicollinearity problems were detected as the variance inflation factor (VIF) for all explanatory variables were less than 1.47.

	Water use management	Adjustments of crops and varieties	Adjustments of planting techniques	Adjustments of planting calendar
	(1)	(2)	(3)	(4)
R squared	0.32	0.44	0.41	0.38
Breusch-Pagan test for independent equations (Chi squared and *p* value)	210.00 (0.0000)	273.10 (0.0000)	259.54 (0.0000)	267.48 (0.0000)
Goodness-of-fit test (Pearson chi-square and *p* value)	297.10 (0.6006)	326.22 (0.1822)	375.78 (0.0024)	165.66 (1.0000)
Test for multicollinearity (mean VIF)	1.41	1.35	1.47	1.36

Source: Authors' estimation from climate change survey in the Mekong River Delta (2017)

Table 4: Model summary.

The marginal effects of coefficients in the four ISUR regression models are presented in Table 5. Bootstrap estimates were conducted. The paper uses bias corrected bootstrapped (n =1000) results because they have been shown to perform the best with regards to power and Type I error results (Briggs, 2006), particularly for smaller sample sizes (Preacher and Hayes, 2008).

With respect to household characteristics, male headed household has more probability of specifically adapting to climate change which is revealed by the fact that a change from being headed by a female household to male increases the probability of adapting water use management measures by 11.7 percentage points, *ceteris paribus* (column 1 – Table 5). This result is in line with the argument that male-headed households are often considered to be more likely to get information about new technologies and take risky businesses than female headed households (Asfaw and Admassie, 2004; Tenge and Hella, 2004).

A one-year increase in the education of the head of the household will have the impact of raising the probability of making adjustments of planting techniques to climate change by about 1.2 percentage points, *ceteris paribus* (column 3 – Table 5). This is in line with studies of Maddison (2007), Lin (1991), and Igoden, Ohoji, and Ekpare (1990). Although a series of adaptive measures has been used by many households, the above findings may imply causes of inefficient adaptation in local areas. Poor education can be one possible cause.

A one-person increase in the household size will have the impact of decreasing the probability of making adjustments of planting techniques to climate change by around 2.8 percentage points, *ceteris paribus* (column 3 – Table 5).

Our results indicate that farm system types alone may not determine climate change's responses; these systems are also imbedded with institutional factors, infrastructure, climate conditions and varying climate experiences as well. With respect to farm characteristics, farming household with higher proportion of aquaculture income has less chances of making adjustments of crops and varieties to climate change by 17.5 percentage points, *ceteris paribus* (column 2 – Table 5), and has more chances of changing water use management by 8.12 percentage points, *ceteris paribus* (column 1 – Table 5).

With respect to institutional factors, farmer with access to credit has higher chances of adapting to changing climatic conditions as found in Nicholas and Gina (2012), and Nhemachena and Hassan (2007). Household with access to credit will have the impact of raising the probability of making adjustments of planting calendar to climate change by 13.5 percentage points, *ceteris paribus* (column 4 – Table 5). According to Nhemachena and Hassan (2007), access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with the various adaptation options they might want to take. In addition, household with higher proportion of land with Land Right Certificate will have the impact of raising the probability of changing water use management by 19.5 percentage points, *ceteris paribus* (column 1 – Table 5). With more financial and other resources at their disposal farmers are able to change their management practices in response to changing climatic and other factors.

Regarding to infrastructure, farmer with limiting access to market (as proxied by the distance from plot(s) to nearest commune road) has higher probability of adjustments of crops and varieties to changing climatic conditions by 1.52 percentage points, *ceteris paribus* (column 2 – Table 5). With access to markets farmers are easily able to buy new crop varieties, new irrigation technologies, and other important inputs they may

	Water use management	Adjustments of crops and varieties	Adjustments of planting techniques	Adjustments of planting calendar
	(1)	(2)	(3)	(4)
Household characteristics				
Male-headed household	0.117**	-0.0347	0.0758	0.0252
	-0.0559	-0.0931	-0.106	-0.0592
Years of education by household head	0.00408	-0.00237	0.0117*	-0.00237
	-0.00457	-0.00661	-0.00713	-0.0049
Marital status of household head	-0.0537	0.000957	-0.124	-0.0487
	-0.0683	-0.0955	-0.106	-0.0593
Household size	-0.00427	-0.0025	-0.0279*	-0.00938
	-0.0109	-0.016	-0.0167	-0.0123
Farm characteristics				
Land area (log)	0.0164	0.0336	0.0194	0.0056
	-0.0174	-0.0245	-0.0261	-0.0158
Production asset index	0.00152	-0.0127	0.00873	-0.0135
	-0.0152	-0.0171	-0.0196	-0.0153
Proportion of cultivation income (%)	-0.00187	-0.00471	0.00264	-0.000346
	-0.0201	-0.0251	-0.0261	-0.0242
Proportion of aquaculture income (%)	0.0812*	-0.175***	-0.0609	-0.0269
	-0.0493	-0.0618	-0.0643	-0.0323
Proportion of non-agriculture income (%)	0.0402	0.0574	-0.0027	0.0783*
	-0.0396	-0.052	-0.0663	-0.042
Institutional factor				
Access to loan	0.0195	-0.00157	0.0948	0.135***
	-0.042	-0.0599	-0.058	-0.0419
Proportion of land with Land Right Certificate (%)	0.195*	0.205	0.0936	0.0834
	-0.104	-0.156	-0.167	-0.112
Infrastructure				
Distance from plot(s) to house	0.00651	-0.0278*	-0.00393	0.000549
	-0.0126	-0.0159	-0.0139	-0.0083
Distance from plots(s) to nearest commune road	-0.0113**	0.0152*	-0.00357	-0.00321
	-0.00459	-0.00808	-0.00623	-0.00373
Climate conditions				
Total hours of sunshine	6.05E-06	-0.000121	5.90E-05	-7.99E-05
	-0.000107	-0.00013	-0.000137	-8.90E-05
Total level of rainfall	0.000117**	0.000133**	7.20E-05	4.01E-05
	-4.73E-05	-6.32E-05	-6.57E-05	-3.76E-05
Past climate experiences on				
Wind storm	0.00787	-0.0356	-0.00877	-0.0786
	-0.0519	-0.0665	-0.0694	-0.0498
Drought	-0.0191	-0.0449	-0.0721	0.0609
	-0.0478	-0.0563	-0.056	-0.0522
Flood	0.0361	0.036	0.0546	0.0711
	-0.0493	-0.0618	-0.0651	-0.0449
Untimely rain	-0.0238	0.167***	0.0199	0.0156
	-0.0425	-0.0545	-0.0568	-0.0481
Pestilent insect	-0.0626	-0.0866	-0.0162	-0.0398
	-0.0398	-0.0547	-0.0568	-0.0395
Water shortages	-0.0659	-0.146	0.00995	0.156**
	-0.0593	-0.0903	-0.102	-0.0732

Note: Bootstrap (with *n* =1000) standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$; $N = 329$
Source: Authors' estimation from climate change survey in the Mekong River Delta (2017)

Table 5: Marginal effects of adaptive perception on adaptive measures (to be continued).

	Water use management	Adjustments of crops and varieties	Adjustments of planting techniques	Adjustments of planting calendar
	(1)	(2)	(3)	(4)
Farmers' Adaptive perception on				
Water use management				
Build/repair cistern	0.118 (0.0986)			
Build/repair well	0.476*** (0.0892)			
Adjustments of crops and varieties				
Change varieties		0.576*** (0.0525)		
Change crops/livestock		0.0553 (0.0798)		
Change crop structure		0.0644 (0.0832)		
Adjustments of planting techniques				
Change crop cultivation			0.0626 (0.0765)	
Change fertilizer/stimulus			0.0765 (0.0690)	
Change pesticides/ herbicides			0.459*** (0.0576)	
Change crops quantity			0.245*** (0.0688)	
Adjustments of planting calendar				
Change irrigation schedule				0.354*** (0.103)
Change crop rotation				0.304*** (0.0998)
Observations	329	329	329	329
R^2	0.318	0.44	0.409	0.385

Note: Bootstrap (with *n* =1000) standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; N = 329
Source: Authors' estimation from climate change survey in the Mekong River Delta (2017)

Table 5: Marginal effects of adaptive perception on adaptive measures (continuation).

need to change their practices to suit the forecasted and prevailing climatic conditions as mentioned by Nhemachena and Hassan (2007). Thus, when limitation in access to market exists, farmers may choose to adjust crops and varieties within the current budget constraints.

Farmer with limiting access to market (as proxied by the distance from plot(s) to nearest commune road) has less probability of changing water use management by 1.13 percentage points, *ceteris paribus* (column 1 – Table 5). In addition, farming household with plots in longer distance from house will have the less probability of making adjustments of crops and varieties to climate change by 2.78 percentage points, *ceteris paribus* (column 2 – Table 5). Overall, the improvement of both the accessibility and usefulness of local services is deemed a necessity for adaptation strategies.

With respect to climate conditions, annual average precipitation is positively related to some type of adaptations. Increasing rainfall increases the probability of conducting water use management measures (column 1 – Table 5) and adapting adjustments of crops and varieties (column 2 – Table 5) by nearly 0.01 percentage points in each case, ceteris paribus. The probable reason for the positive relationship between average annual precipitation and adaptation could be due to the fact that agriculture in the Mekong River Delta faces flood so commonly and increasing precipitation will be harmful for agricultural production.

ISUR estimates show that past climate experiences increase the probability of uptake of adaptation measures as shown in Niles et al. (2015), Nicholas and Gina (2012), and Maddison (2007). In general, farmer who is aware of changes in climatic conditions has higher chances of taking adaptive measures in response to observed changes. Specifically, increasing untimely rain increases the probability of farmers changing their management practices, in particular, adjustments of crops and varieties (including changes in varieties, crops/livestock, and crop structure) by 16.7 percentage points, *ceteris paribus* (column 2 – Table 5). Resulting water shortages leads to adjustments of planting calendar, including changes in irrigation schedule, and crop rotation (as mentioned by Niles et al. (2015)) by 15.7 percentage points, *ceteris paribus* (column 4 – Table 5). Generally, if perception of climate change induced natural shocks are the most salient for farmers, it likely has significant implications for assessing how short-term responses can influence long-term adaptations and the subsequent policies that may be needed to accompany such actions (Carlo et al., 2015; Le Dang et al., 2014;

Park et al., 2012). In addition, because climate variability in higher temperature and accompanied by drought, untimely rain, and water shortages, irrigation investment needs from the viewpoint of Public - Private Partner (PPP) should be reconsidered to allow farmers increased water control to counteract adverse impacts from climate variability and change.

Our main concerns are about the effects of farmers' adaptive perception. ISUR estimates show that farmers' adaptive perception increases the probability of uptake of adaptation measures. In general, farmer who is aware of possible adaptive measures has higher chances of taking adaptive measures in response to observed changes. Specifically, knowing about 'build/repair well' increases the probability of farmers to choose water use management measures by 47.6 percentage points, *ceteris paribus* (column 1 – Table 5). With respect to adjustments of crops and varieties, knowing about 'change varieties' increases the probability of farmers changing their management practices, in particular, adjustments of crops and varieties (including changes in varieties, crops/livestock, and crop structure) by 57.6 percentage points, *ceteris paribus* (column 2 – Table 5). Regarding adjustments of planting techniques, knowing about 'change pesticides/herbicides' increases the probability of farmers conducting adjustments of planting techniques (including changes in crop cultivation, fertilizer/stimulus, pesticides/herbicides, crop quantity, and farmyard manure) by 45.9 percentage points, *ceteris paribus* (column 3 – Table 5). And in regard to adjustments of planting calendar, knowing about 'change crops quantity' also increases the probability of farmers conducting adjustments of planting techniques (including changes in crop cultivation, fertilizer/stimulus, pesticides/herbicides, crop quantity, and farmyard manure) by 24.5 percentage points, *ceteris paribus* (column 3 – Table 5). Knowing about 'change crop rotation' leads to adjustments of planting calendar, including changes in irrigation schedule, and crop rotation by 30.4 percentage points, *ceteris paribus* (column 4 – Table 5).

Conclusion

This study was based on farm-level analysis of the influence of farmers' adaptive perception on adaptation to climate change induced natural shocks in the Mekong River Delta of Viet Nam. This research has shown that the majority of farmers used adaptive measures that mostly related to their farming practices such as (1) water use management (including: build/repair cistern, build/repair well, and water saving technology), (2) adjustments of crops and varieties (including changes in varieties, crops/livestocks, and crop structure), (3) adjusting planting techniques (such as changes in crop cultivation, fertilizer/stimulus, pesticides/herbicides, crop quantity, and farmyard manure) and (4) adjusting planting calendar (such as changes in irrigation schedule, and crop rotation). The adaptive measures farmers followed were those that they perceived climate change induced natural shocks such as wind storm (typhoon), drought, flood, higher temperature, untimely rain, salt water intrusion, eroded shorelines, pestilent insect, and water shortages.

This paper explores the influence of adaptive perception on adaptive measures using an ISUR probit model, especially distinguishing commonly-known factors with adaptive perception. The model allows for the simultaneous identification of the factors of all adaptation options, thus limiting potential problems of correlation between the error terms. Correlation results between error terms of different equations were significant (positive) indicating that various adaptation options tend to be used by farmers in a complementary fashion, although this could also be due to unobserved farm-level socioeconomic and other factors. ISUR probit results confirm gender of the farm head being male, education of the farm head, household size, proportion of incomes from aquaculture and non-agriculture activities, availability of credit, access to market, and rainfall have significant impact on choices of adaptation to climate change. Our paper makes a novel contribution to the literature by considering adaptive perceptions as important factors of private adaptive choices, after controlling past climate experiences as well. Results indicate that adaptive perceptions are among the most important factors of farm-level adaptation.

Findings from our study may provide useful information for policy makers as well as development agencies on responses to climate change in Viet Nam. First, findings from the influence of adaptive perception associated with adaptation choices can be useful inputs for policies to response to climate change and weather shocks. Our findings may also provide important implications for other emerging and transition economies similar to Viet Nam and/or regions from developing countries with conditions of natural resources familiar to the Mekong River Delta of Viet Nam.

Sources and quality of information can be of important consideration due to the potential influences on farmers' past climate experiences and their adaptation assessments. Additionally, awareness creation on climate change and adaptation methods should be focused. On top of that, improvement of both the accessibility and usefulness of local services, such as credit and infrastructure, are deemed a necessity for successful adaptation strategies in the Mekong River Delta. Other policy options could also be suggested, including: strengthening education level of farmers, facilitating cheap technologies for farmers, spurring irrigation investment through PPP. Last but not least, government should support some implementations of the land reform such as farmers' cooperation in large-scale production.

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